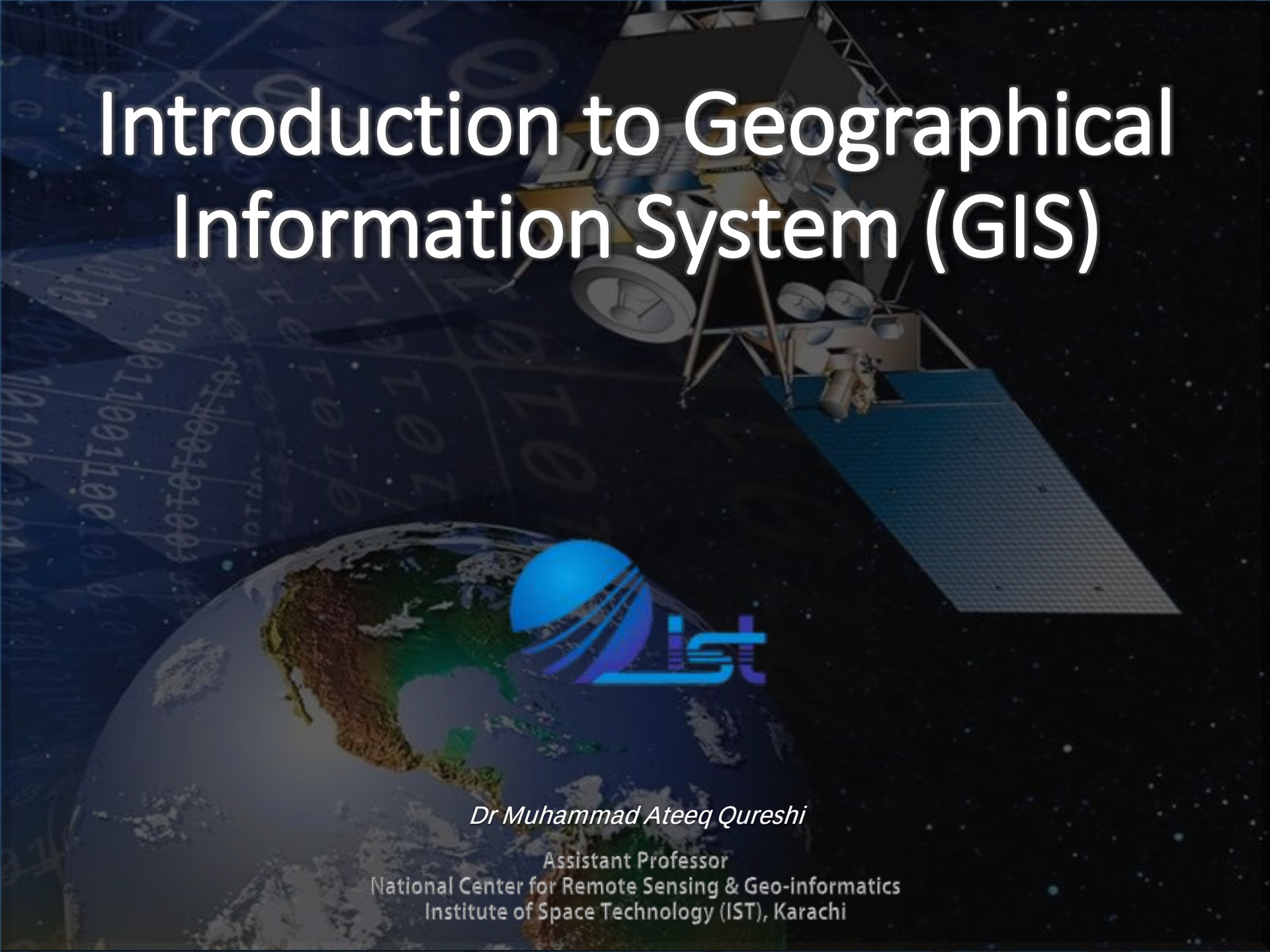
Introduction to Geographical Information System (GIS)



Dr Muhammad Ateeq Qureshi

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National Center for Remote Sensing & Geo-informatics
Institute of Space Technology (IST), Karachi

Introduction of the course

Course Schedule

- Class/Lab
- Day: Every Wednesday
- Time: 05:00 – 09:00 PM

Dr Muhammad Ateeq Qureshi

- *ateeq.qureshi@ist.edu.pk* *OR 0333-3224285*

Purpose of the course

- To learn basics of Geographical Information System
- Hands-on-training of GIS software
- Get to know GIS applications

Topics to be Covered

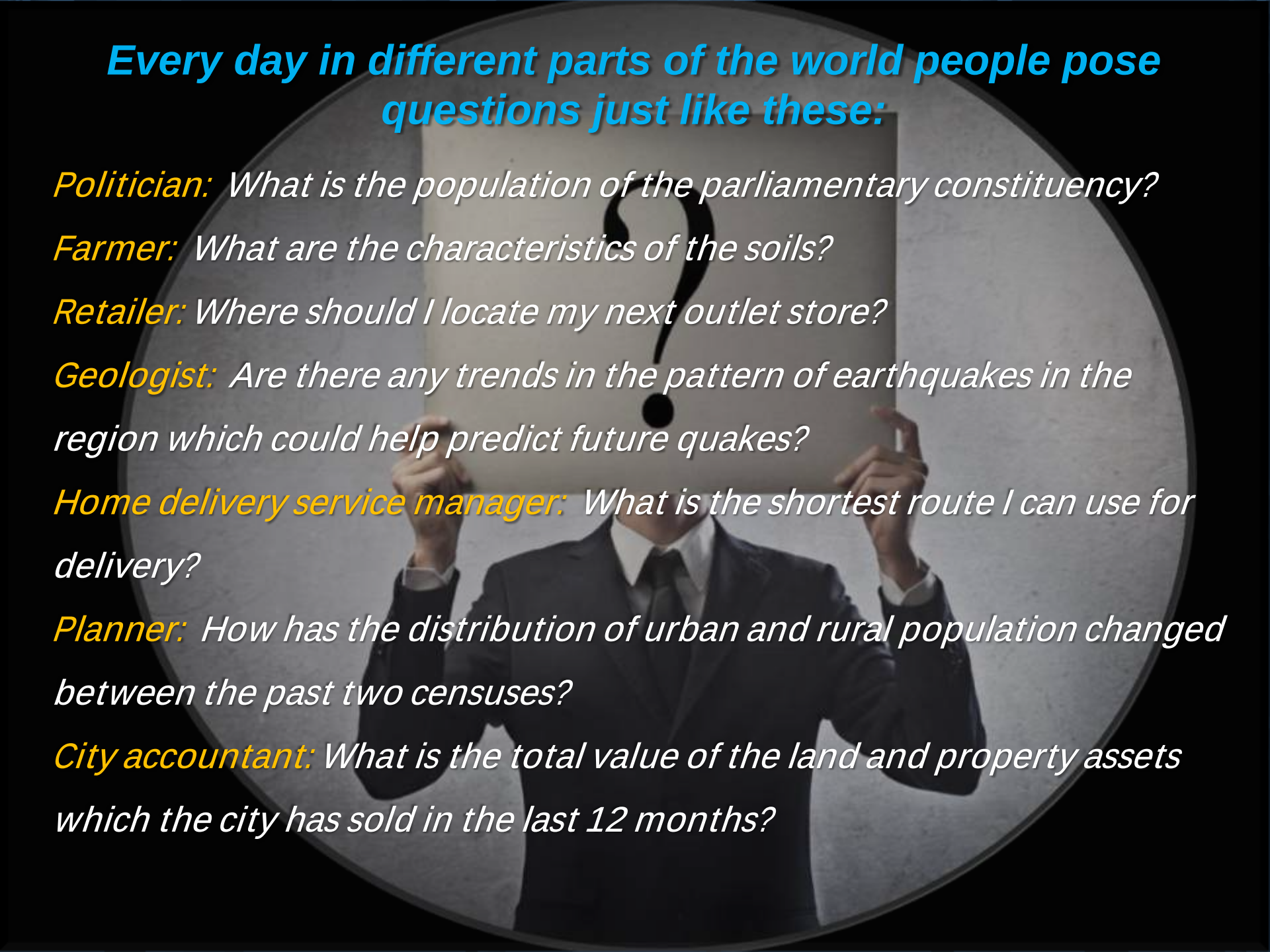
SN	Contents
1	Introduction and Overview of GIS: Introduction, Definition, Basic Components of GIS, General GIS Concepts
2	History and Evaluation of GIS
3	Data Types and Data Models/structures: Raster Data Models, Vector Data Models Conversion Between Raster and Vector Data Models
6	Earth Model: Representing the Earth, Map Projections and Coordinate Systems, Geographic Coordinate System, Projected Coordinate Systems
7	Visualization of Spatial data: Basics of Cartography, GIS presentation, Map Elements, Map scale
8	Map Layout: some Guidelines
9	Spatial Data Queries and Analysis: working with Geoprocessing tools and Analysis Tools
10	GIS Modeling and Modeling Tools: Working with GIS Model
11	Introduction to Global Positioning System (GPS). Field Trip: GPS data collection, downloading, converting to shapefile, georeferencing of base image, etc.
12	Advance Spatial Analysis: Interpolation, Hydrology, Overlay, Zonal Analyses

Labs

- Main focus on using ArcGIS tools and methods
  - Viewing
  - Editing and creating GIS data
  - Queries
  - Geo-processing
  - Geo-referencing
  - Spatial Analysis
  - Modeling
  - Presenting maps (labeling, layouts)

- ✓ *Society is now dependent on computers and computerized information*
- ✓ *Over the past few decades we have developed extremely complex systems for handling and processing data represented in the only form acceptable to computers.*
- ✓ *Unlike most of its predecessors, computer technology for processing information succeeds in part because of its ability to store, transmit, and process an extremely wide range of information types in a generalized way.*
- ✓ *The utility of computer has become so important nowadays, that almost all our activities have some bearing on computers.*
- ✓ *Its ability to quick and efficient processing of the given task has revolutionized our life.*

- ✓ *Spatial Information Technology is the outcome of developments in computer technology.*
- ✓ *Geography, as with for other subjects, stipulates the use of information technology to gain access to additional information sources and to assist in handling, presenting and analyzing spatial information.*
- ✓ *Internet and computerization has opened a vast new potential in the way we perceive, communicate and analyze our surrounding spatial phenomena.*
- ✓ *Data representing the real world can be stored, processed and presented in relatively simplified forms to suit specific needs.*
- ✓ *This provides base for geographical information system.*



Every day in different parts of the world people pose questions just like these:

Politician: What is the population of the parliamentary constituency?

Farmer: What are the characteristics of the soils?

Retailer: Where should I locate my next outlet store?

Geologist: Are there any trends in the pattern of earthquakes in the region which could help predict future quakes?

Home delivery service manager: What is the shortest route I can use for delivery?

Planner: How has the distribution of urban and rural population changed between the past two censuses?

City accountant: What is the total value of the land and property assets which the city has sold in the last 12 months?

All of these questions and many more like them are concerned with geographical patterns and processes on the surface of the Earth

Almost everything that happens or exists occurs *Somewhere.*

Knowing *Where* it happened or existed is critically important

All human activities require knowledge about the Earth

thus *geographic location* is very important

As practitioners of these fields know only too well, answering such questions requires access to geographical information which is characterized by its multidimensional nature (x,y,z coordinates and time), its large volume and high processing cost.

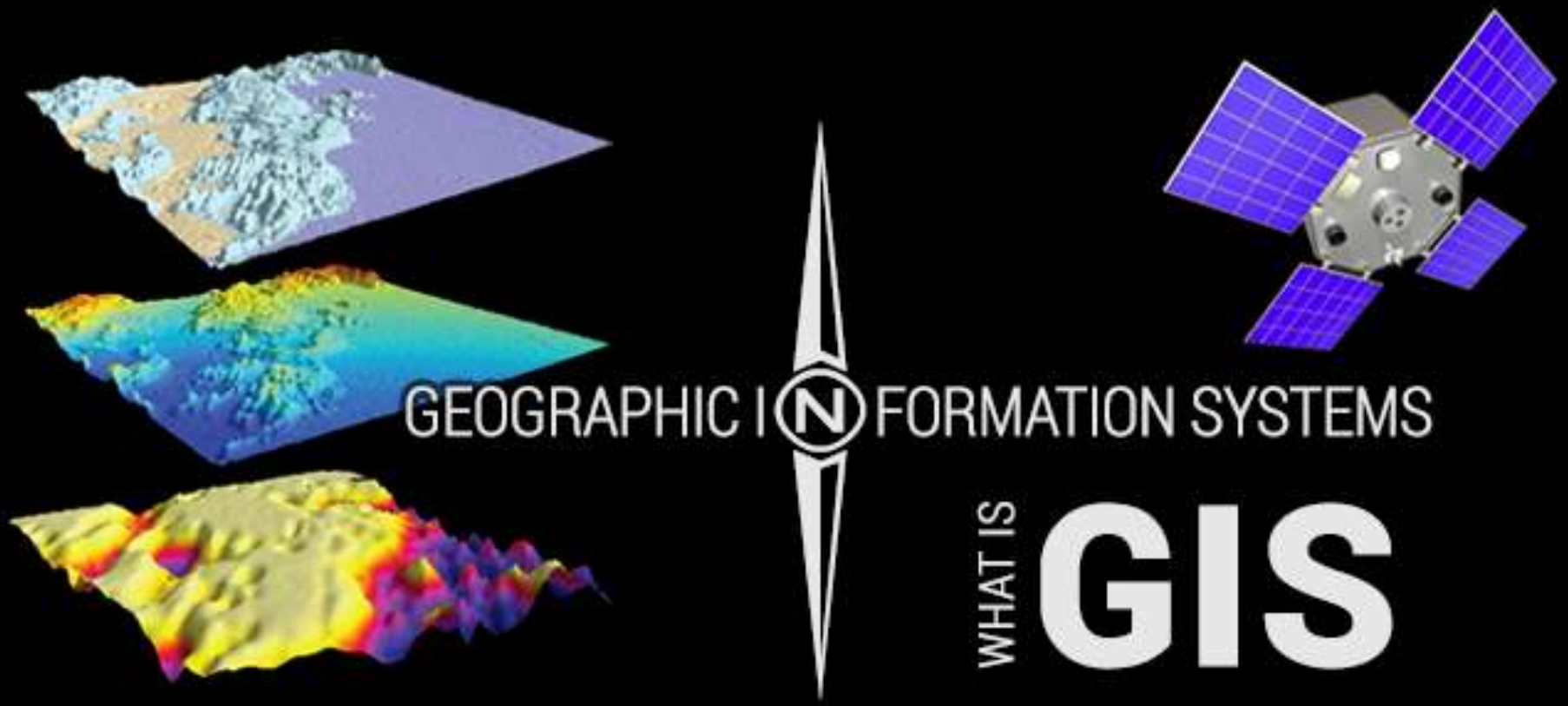
To answer apparently simple geographical questions requires that data from several sources be integrated into a consistent form.

The Art, Science, Engineering, and Technology associated with answering geographical questions is called

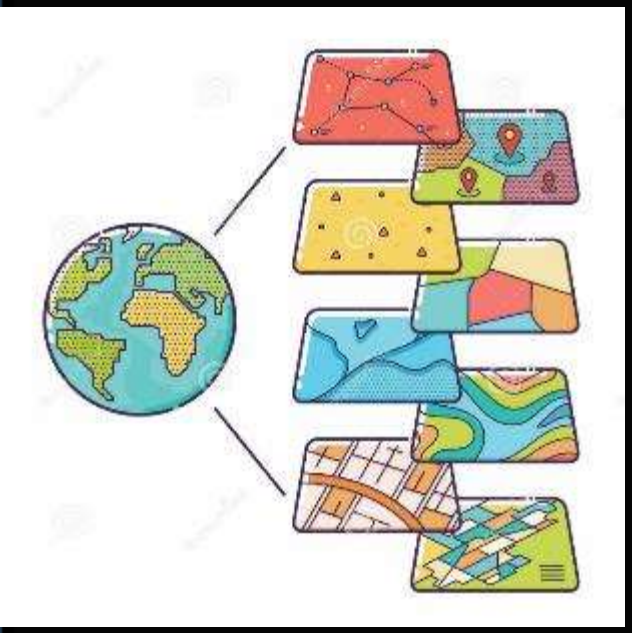
Geographical Information Systems

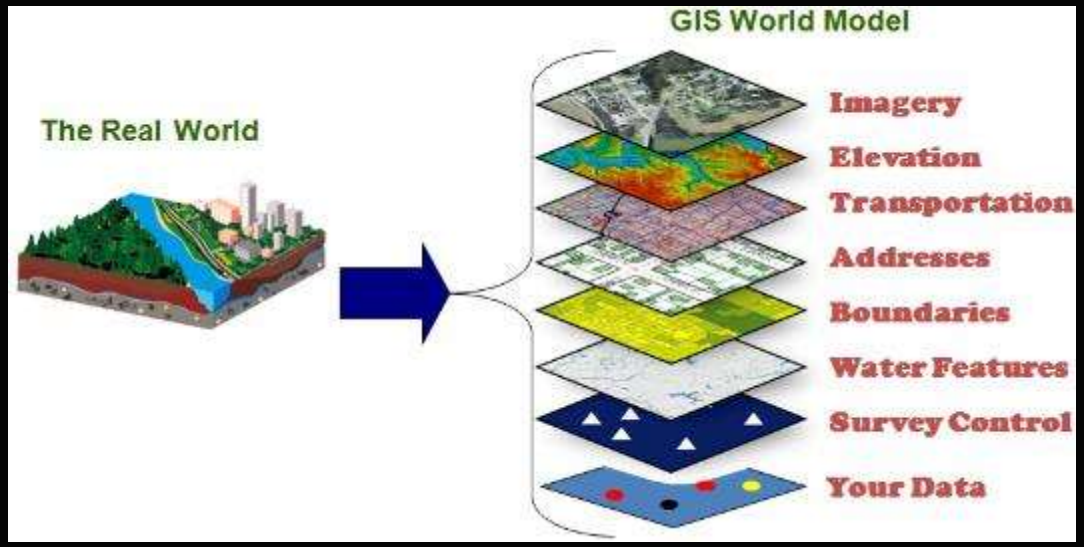
(GIS)

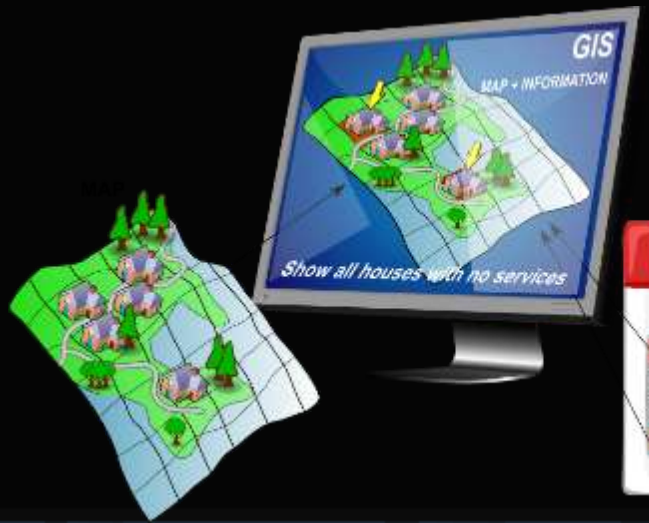
What is GIS?



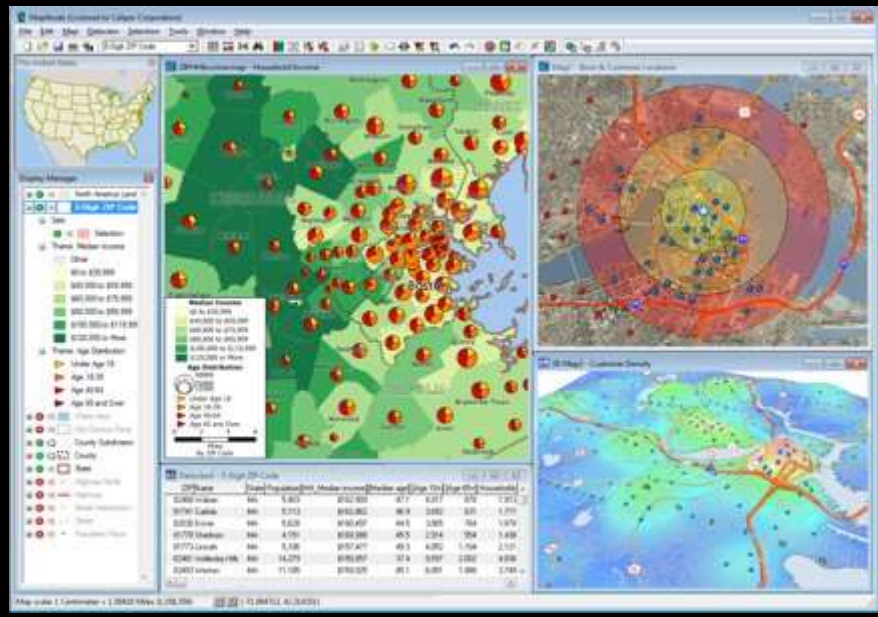
as data analysis & display tools?

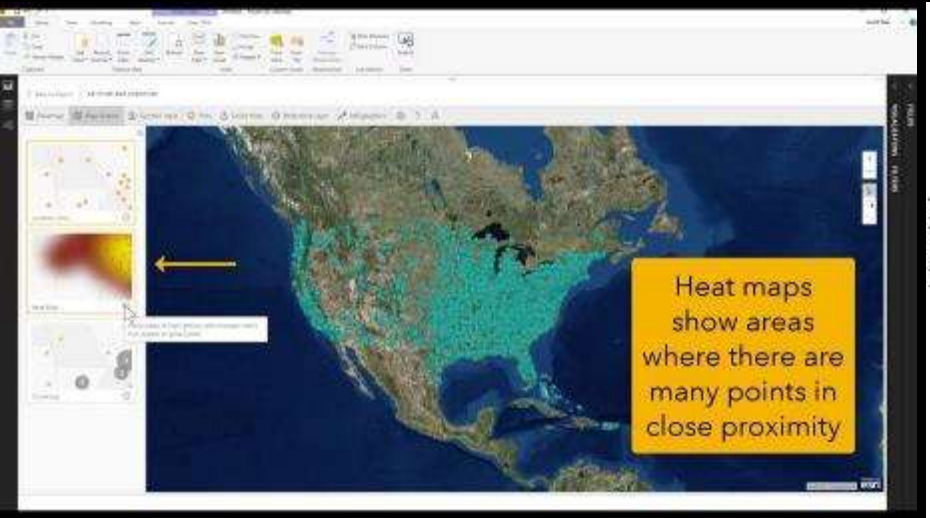


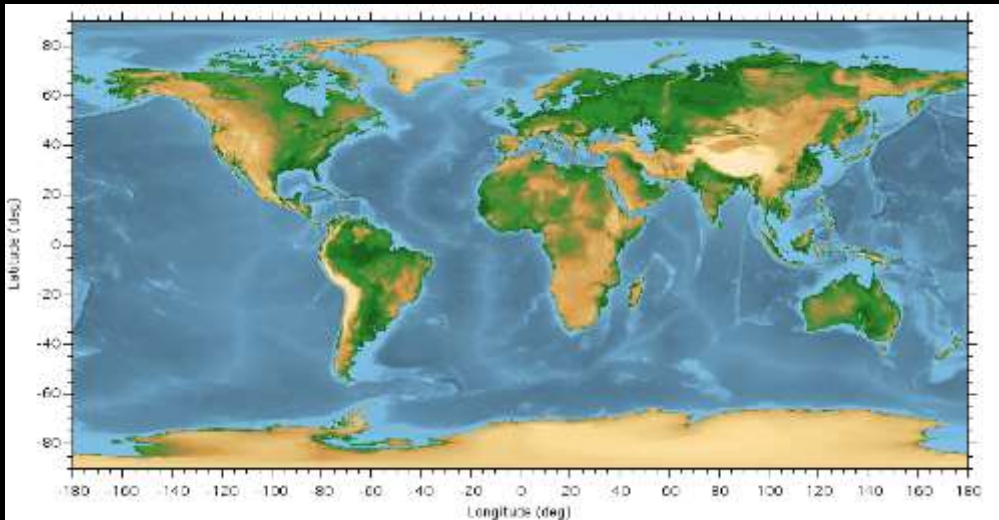




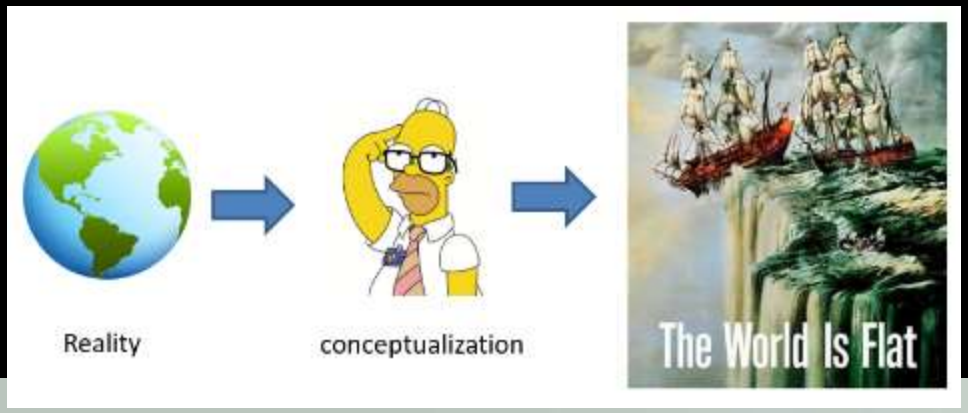
as map-making tools?

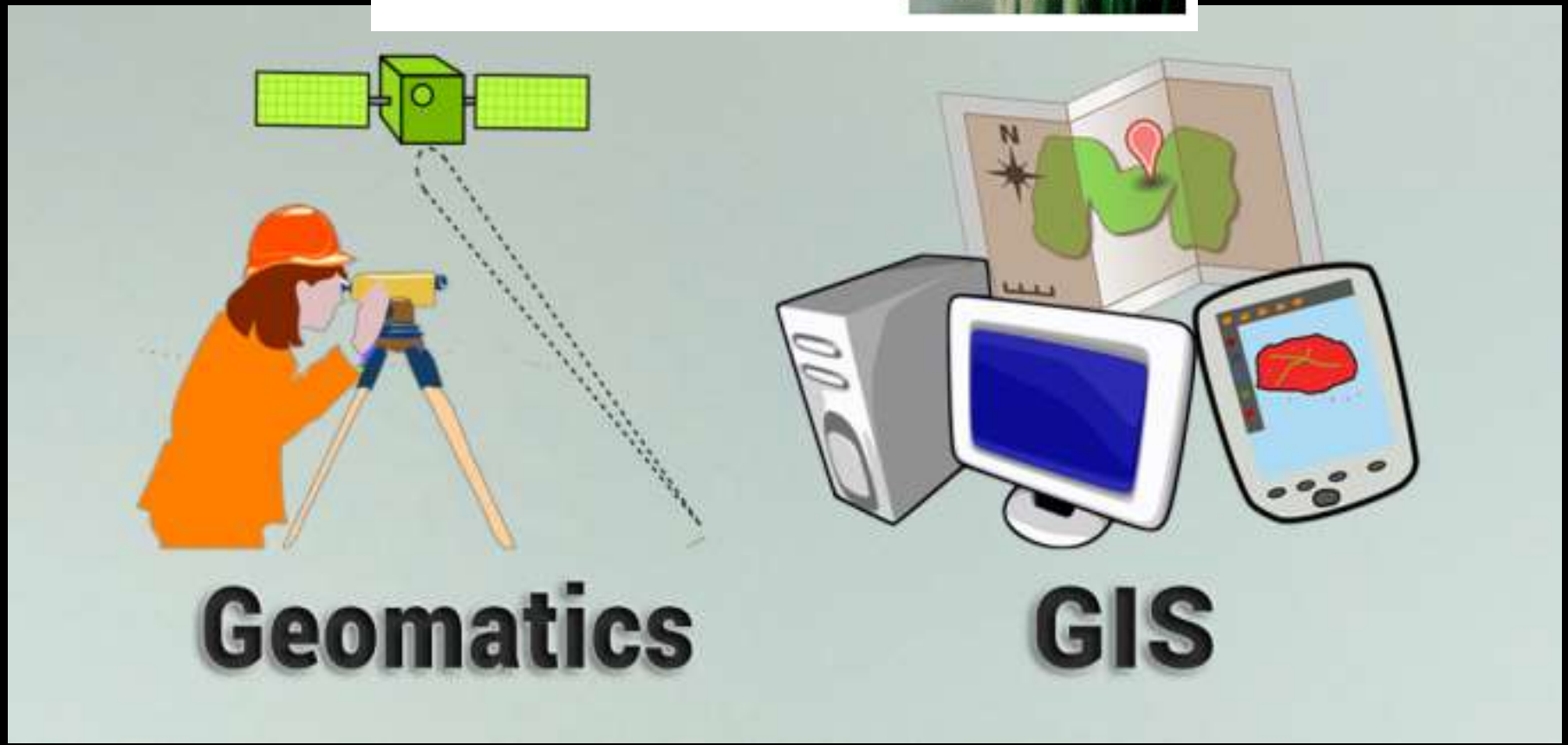






Surveying and Geomatics ?

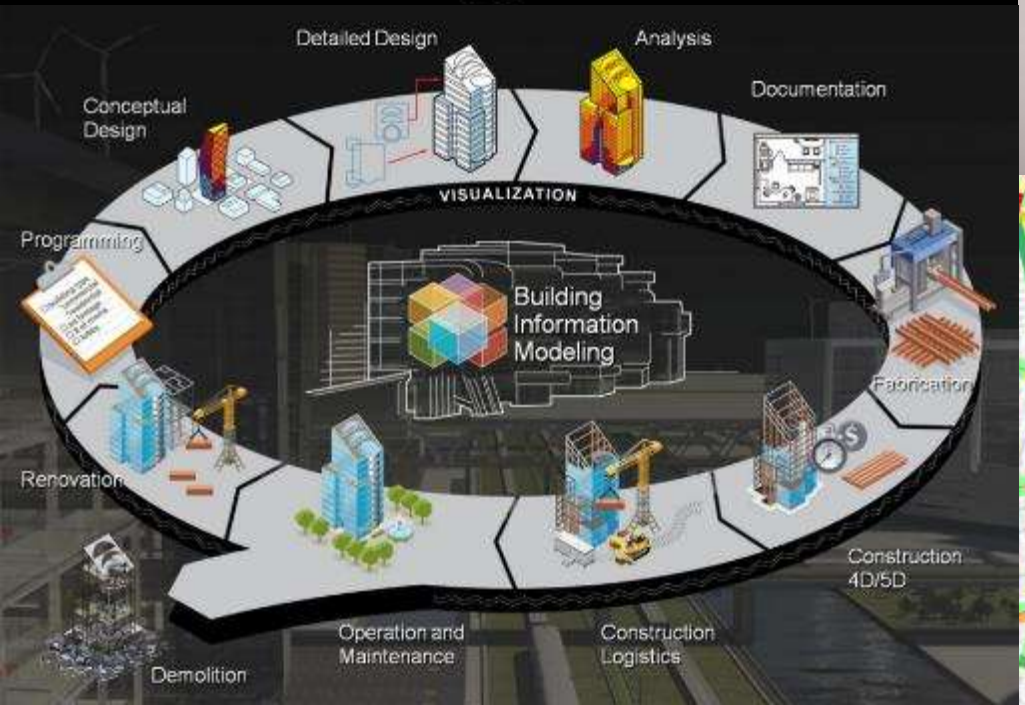




Coherent, multi-purpose ‘thing’ ?

Other roots ?


AMERICAN GEOGRAPHICAL SOCIETY
2050
FALL SYMPOSIUM


Detailed Design
Analysis
Conceptual Design
Documentation
VISUALIZATION
Programming
Building Information Modeling
Fabrication
Renovation
Construction 4D/5D
Operation and Maintenance
Construction Logistics
Demolition

Geographic Information System

A system for Capturing, Storing, Checking, Integrating, Manipulating, Analyzing and Displaying data which are spatially referenced to the Earth

This is normally considered to involve a spatially referenced computer database and appropriate applications software

Geographic Information System

A comprehensive GIS require a means of:

- ✓ *Data input*
- ✓ *Data storage*
- ✓ *Data transformation*
- ✓ *Data reporting*

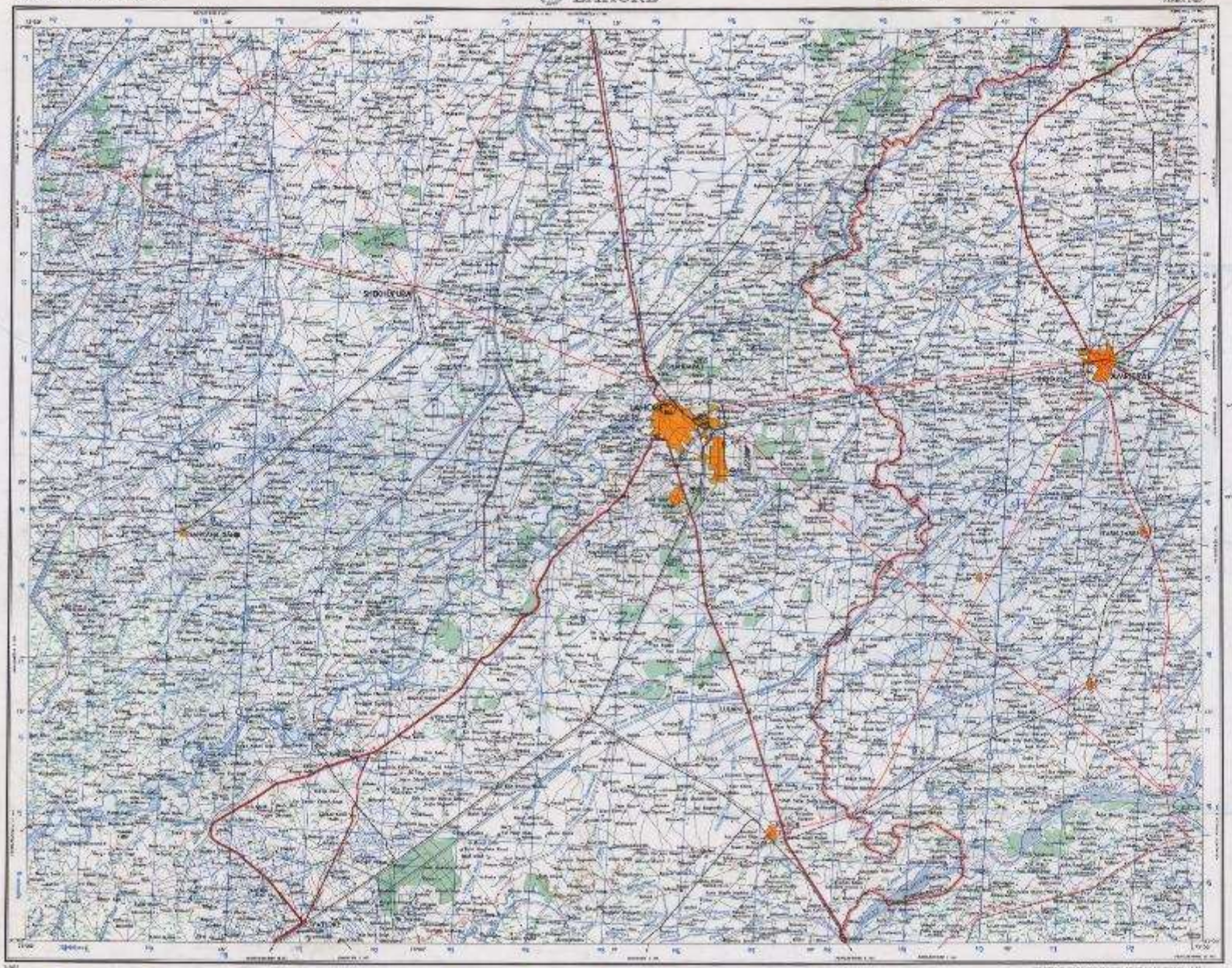
Data input

maps, aerial photos, satellites, surveys, and other sources.

INDIA AND PAKISTAN 1:250,000

LAHORE

NH 43-2



LAHORE, PAKISTAN, INDIA


Let them know
you're on your way


JOHNSON
JOHNSON

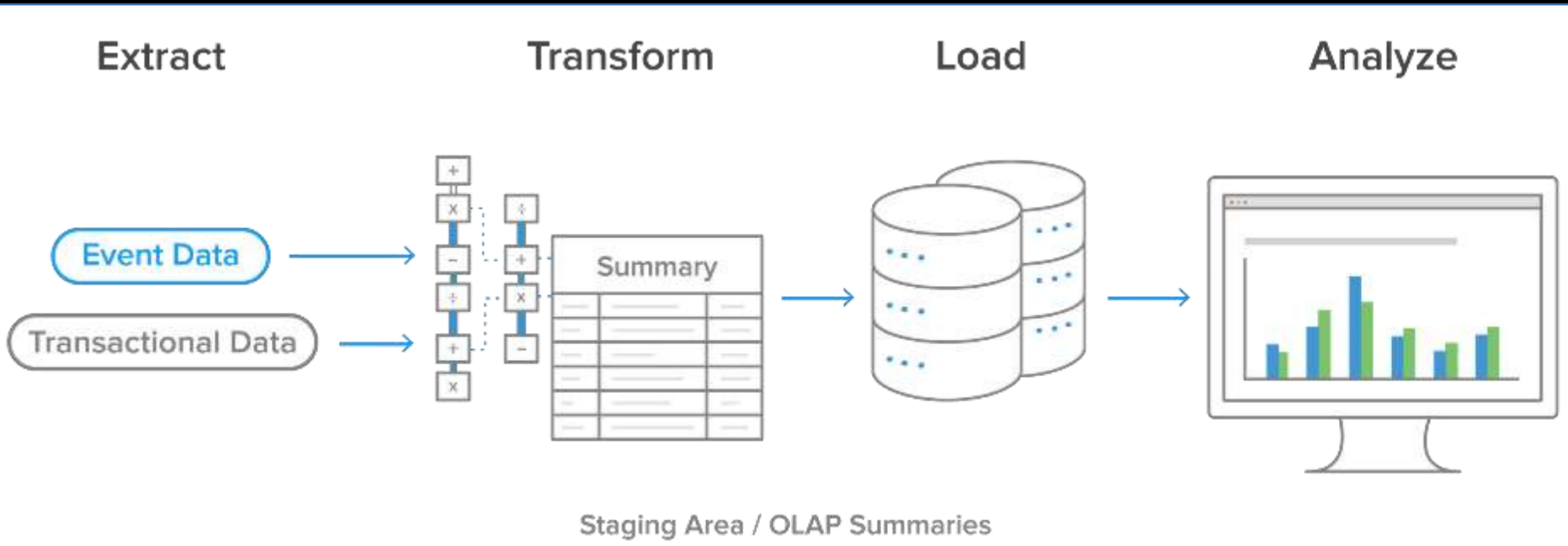
Data storage

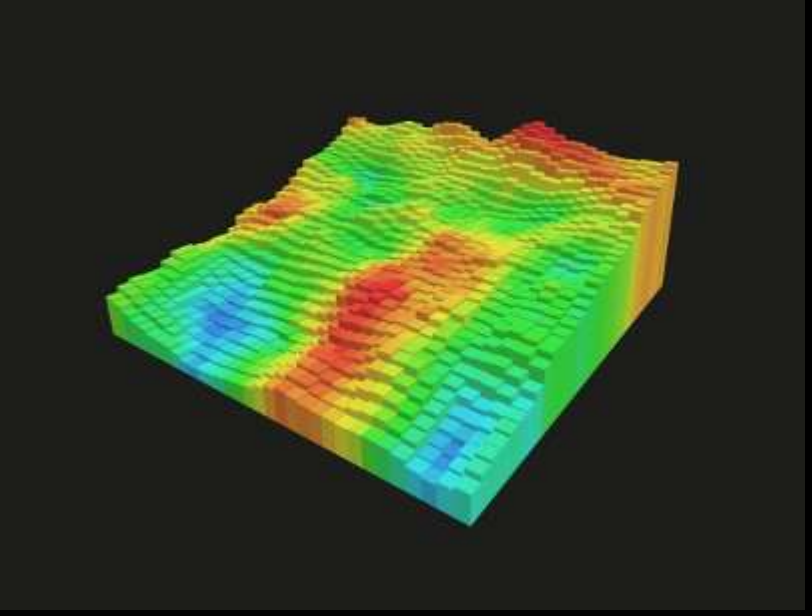
retrieval and query

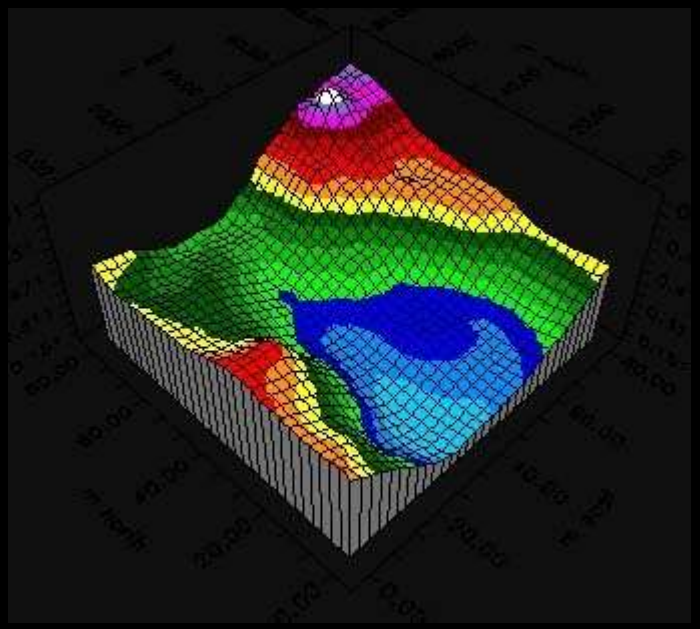

DELL

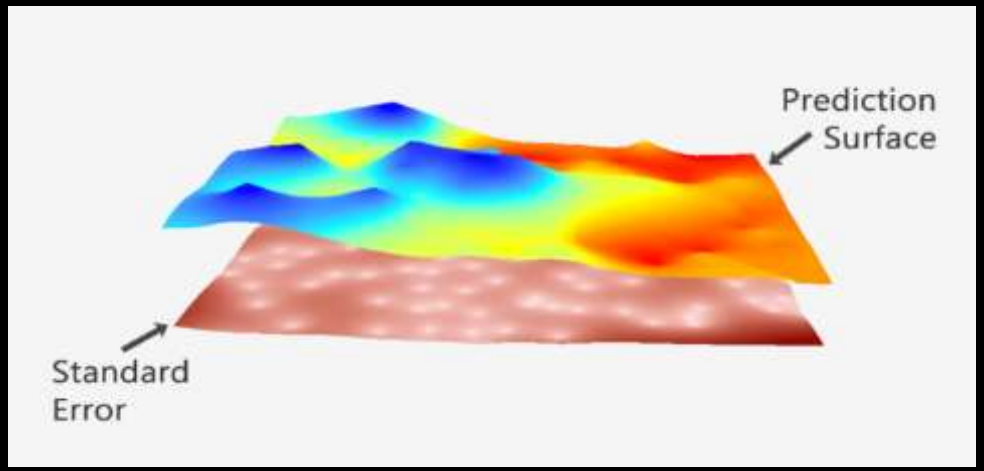
Data transformation

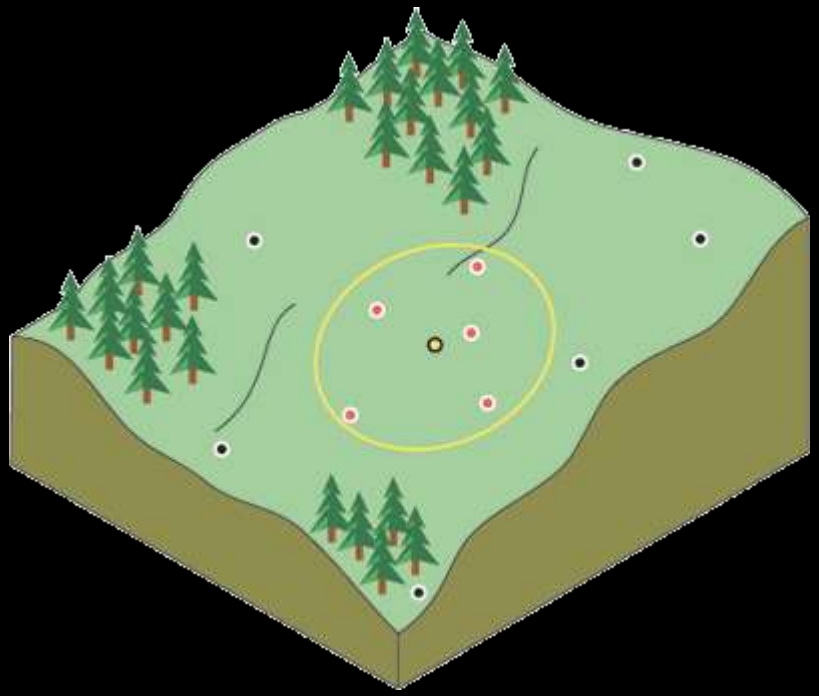
analysis and modelling, including spatial statistics


Extract
Transform
Load
Analyze
Event Data
Transactional Data
Summary
Staging Area / OLAP Summaries





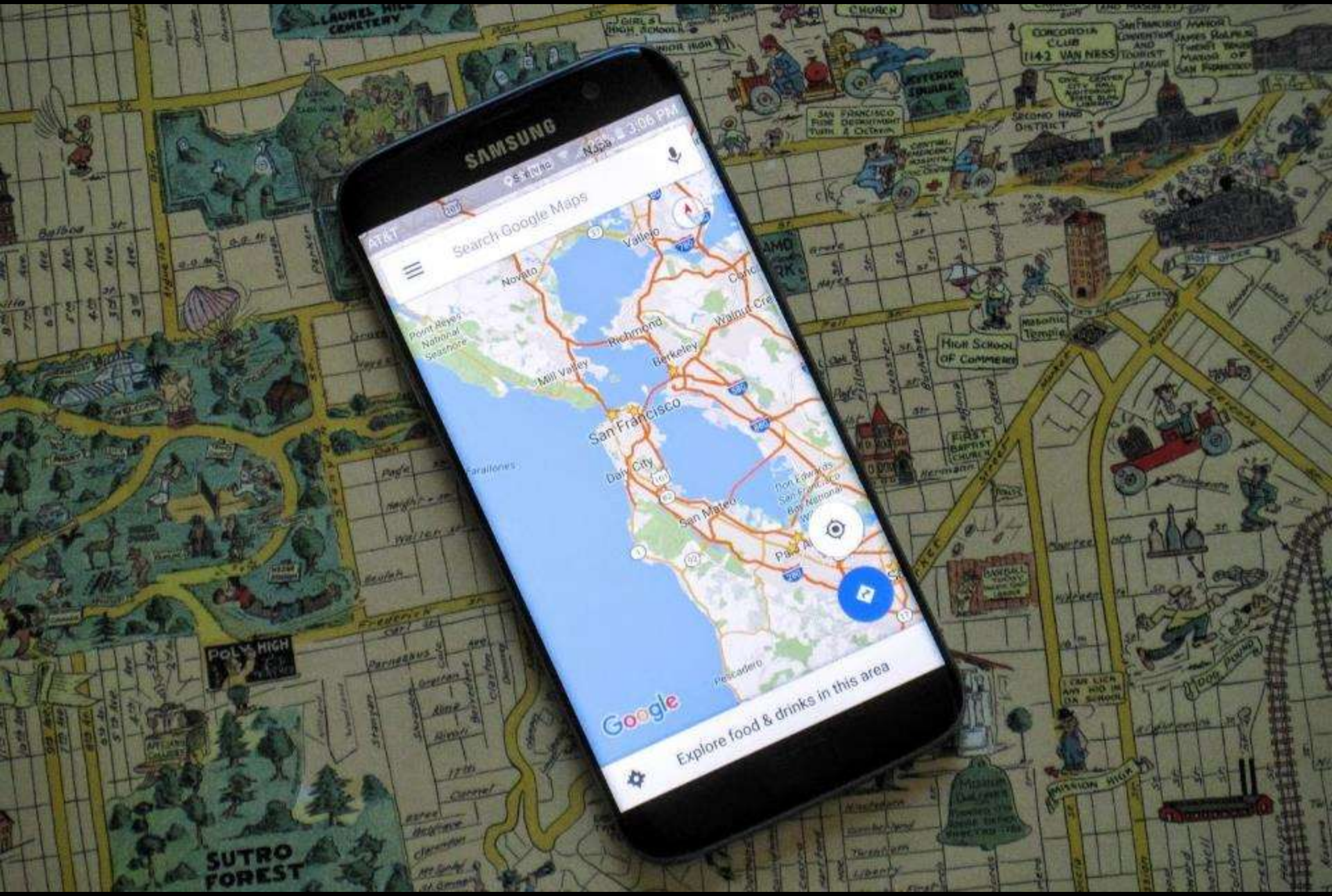

Prediction
Surface
Standard
Error



Data reporting

as maps, reports, and plans

Map shows new data from a report on the economy's advanced


SAMSUNG
AT&T
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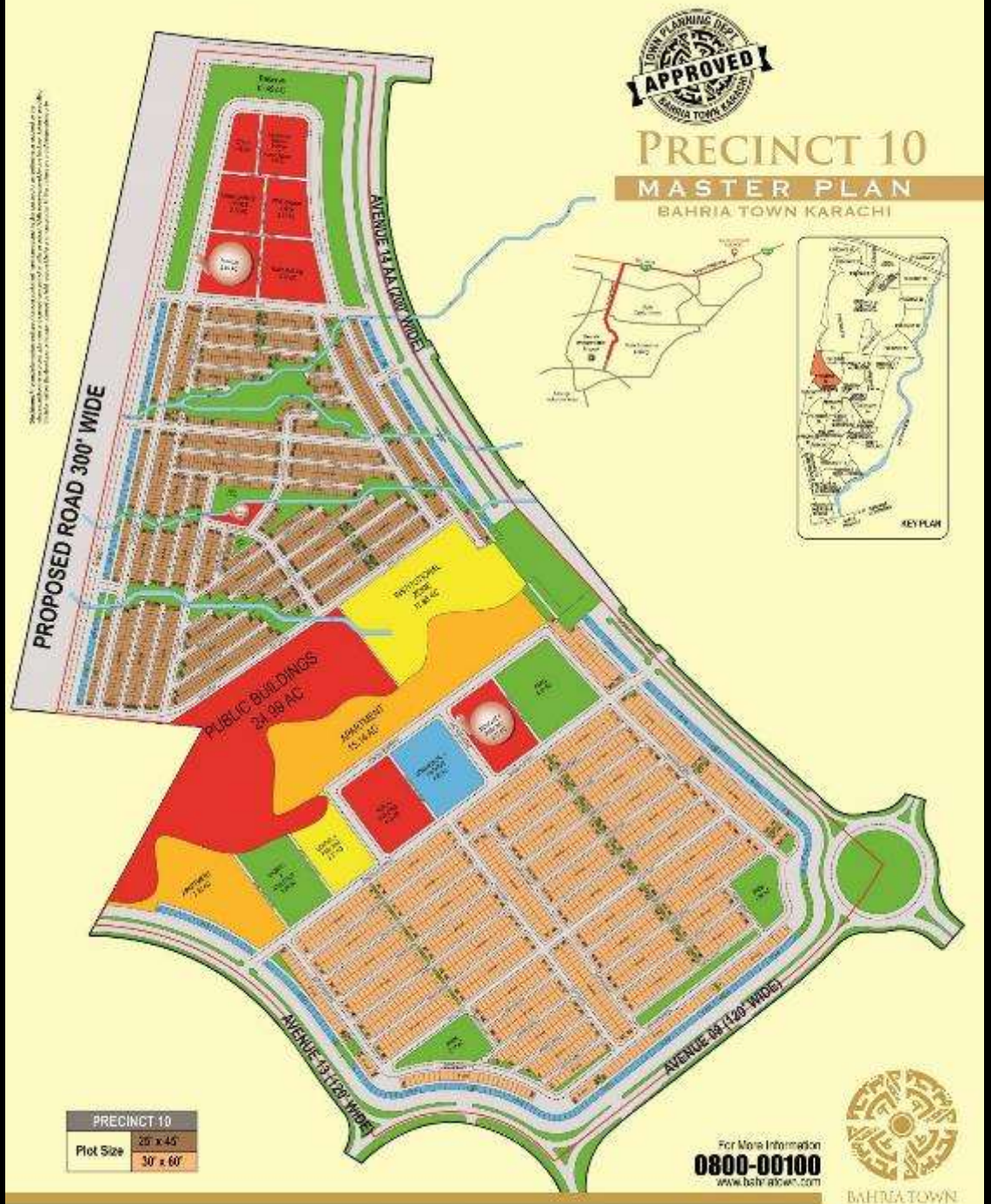
Napa
Vallejo
Novato
Point Reyes National Seashore
Richmond
Berkeley
Walnut Cre
Mill Valley
San Francisco
Daly City
San Mateo
Google
Explore food & drinks in this area
CHURCH
CONCORDIA CLUB 1142 VAN NESS
JEFFERSON SQUARE
SECOND HAND DISTRICT
HIGH SCHOOL OF COMMERCE
FIRST BAPTIST CHURCH
POLY HIGH
SUTRO FOREST
LAUREL HILL CEMETERY
MISSION HIGH


TOWN PLANNING DEPT.
APPROVED
BAHRIA TOWN KARACHI
PRECINCT 10
MASTER PLAN
BAHRIA TOWN KARACHI
PROPOSED ROAD 300' WIDE
AVENUE 13 (120' WIDE)
PUBLIC BUILDINGS 28.09 AC
INSTITUTIONAL
APARTMENT
KEY PLAN
AVENUE 13 (120' WIDE)
AVENUE 03 (120' WIDE)
PRECINCT 10
Plot Size
25' x 45'
30' x 60'
For More Information
0800-00100
www.bahriatown.com
BAHRIA TOWN

Why is GIS Important?

- ✓ *GIS technology is to geographical analysis what the microscope, the telescope, and computers have been to other sciences….*
- ✓ *It could therefore be the catalyst needed to dissolve the regional-systematic and human-physical dichotomies that have long plagued geography and other disciplines which use spatial information.*
- ✓ *GIS integrates spatial and other kinds of information within a single system — it offers a consistent framework for analyzing geographical data.*

Why is GIS Important?

- ✓ *By putting maps and other kinds of spatial information into digital form, GIS allows us to manipulate and display geographical knowledge in new and exciting ways.*
- ✓ *GIS makes connections between activities based on geographic proximity*
  - ✓ *looking at data geographically can often suggest new insights, explanations.*
  - ✓ *these connections are often unrecognized without GIS, but can be vital to understanding and managing activities and resources.*
  - ✓ *e.g. we can link toxic waste records with school locations through geographic proximity.*

Why is GIS Important?

- ✓ *GIS allows access to administrative records — property ownership, tax files, utility cables and pipes — via their geographical positions.*
- ✓ *Maps are fascinating and so are maps in computers and there is increasing interest in geography and geographic education in recent times.*
- ✓ *GIS gives a high tech feel to geographic information.*

Think about GIS

General Public

A container of maps in digital form

Think about GIS

Decision Makers, Planners

A computerized tool for solving geographic problems

Think about GIS

Managers, Researchers

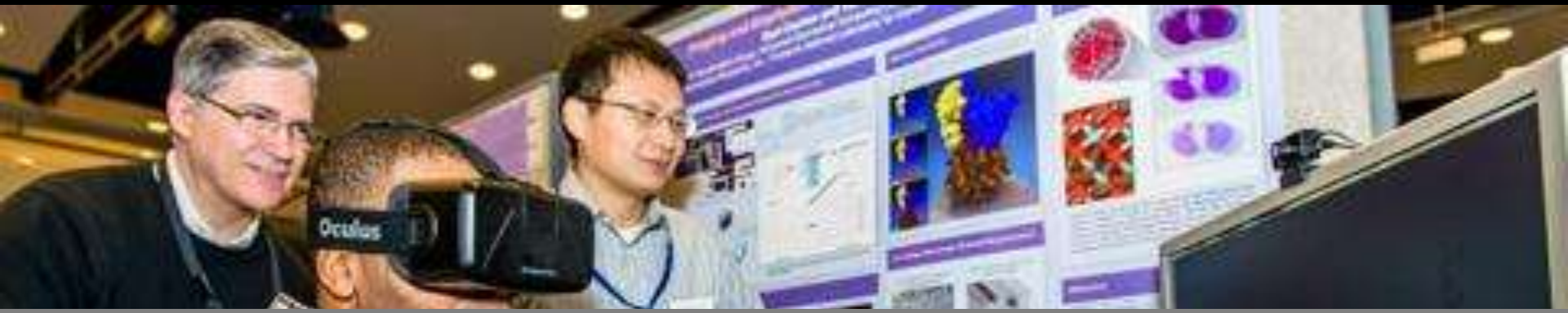
A spatial decision support system

Think about GIS

Utility Managers, Resource Managers

A mechanized inventory of geographically distributed features

Think about GIS



Scientists, Investigators

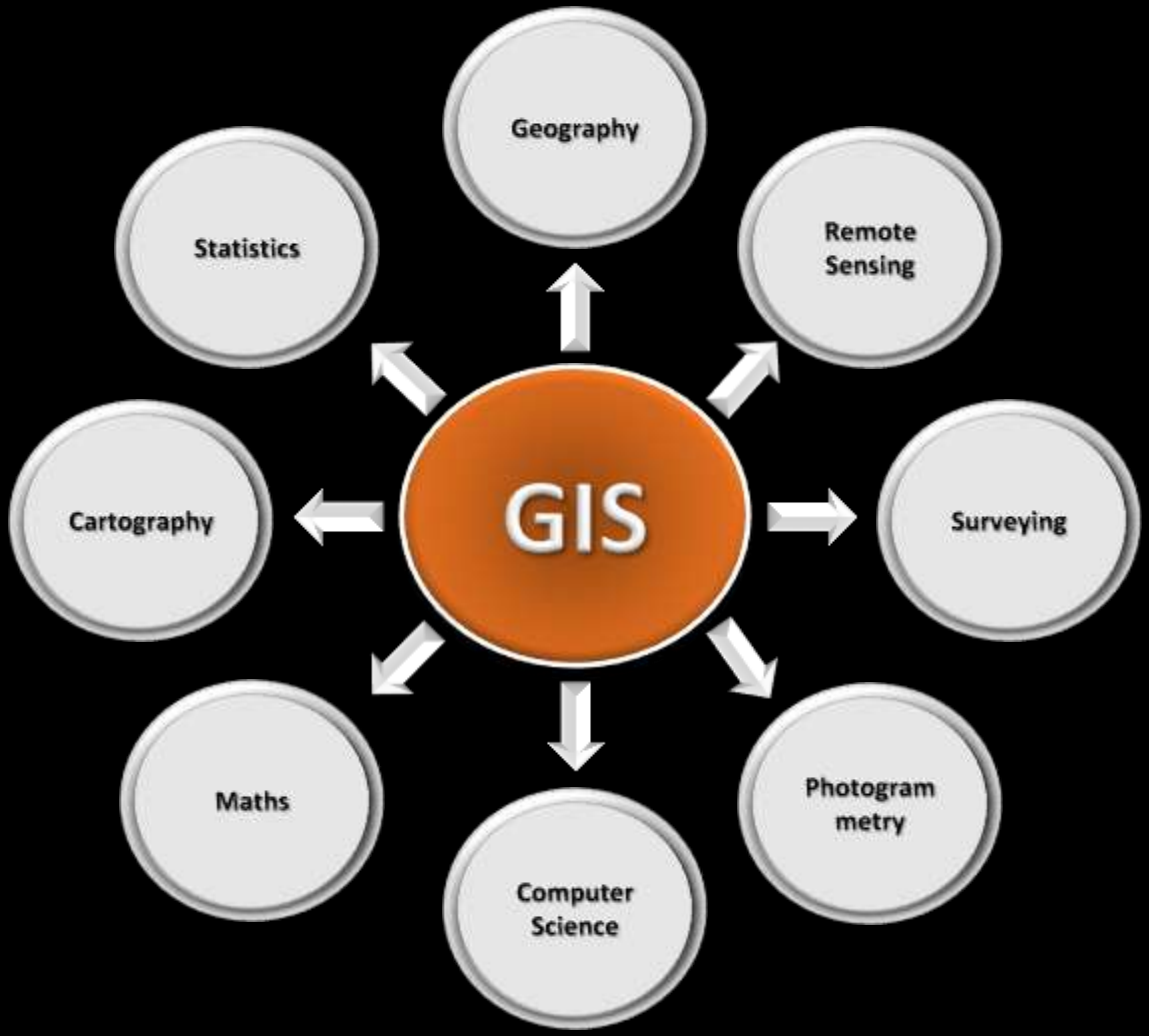
A tool for revealing what is otherwise invisible in geographic information

Think about GIS

Resource Managers, Planners, GIS expert

A tool for performing operations on geographic data that are too tedious if performed by manual methods

Contributing Disciplines



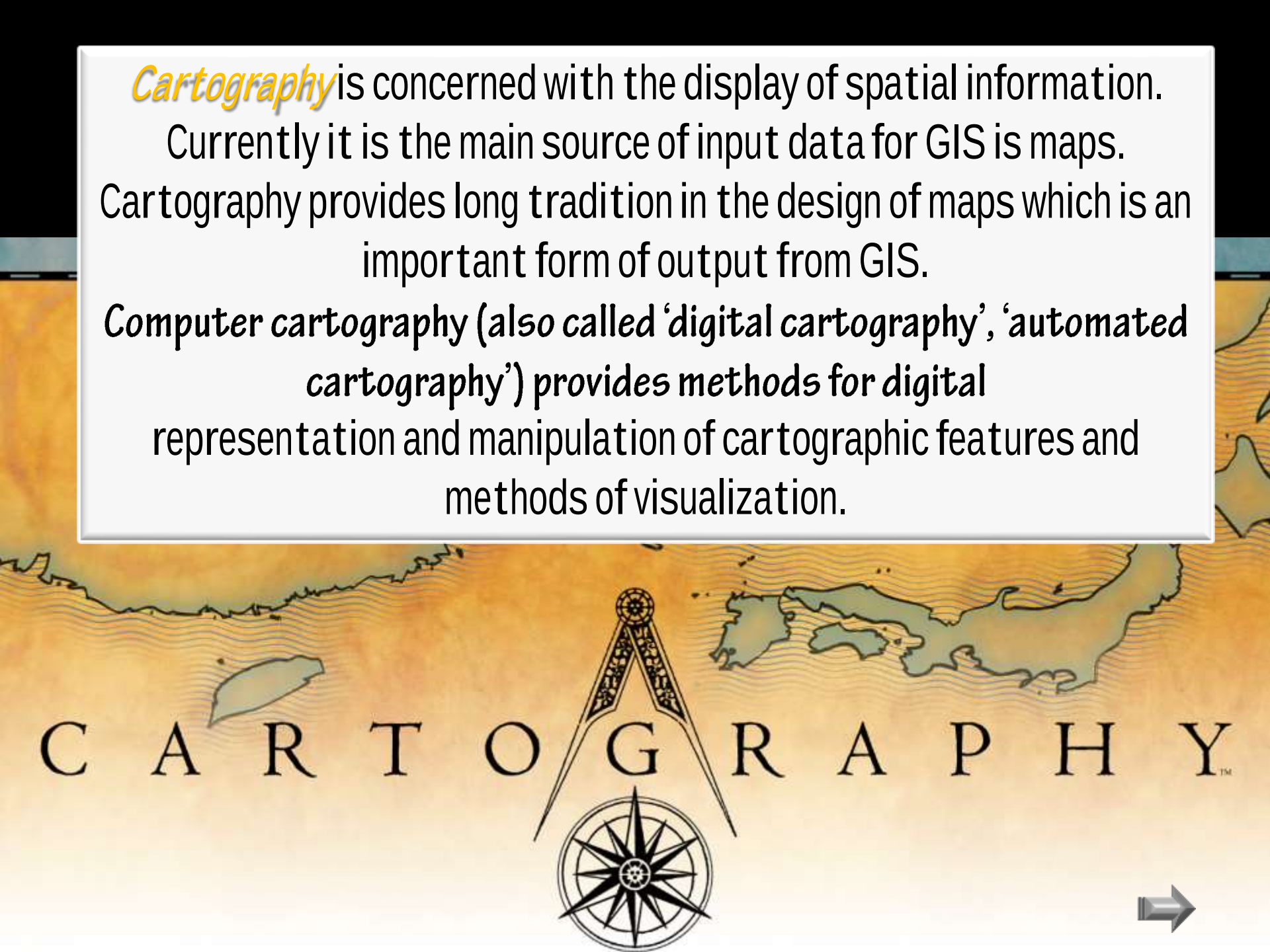
Geography is broadly concerned with understanding the world and **man's place in it.**

Geography has long tradition in spatial analysis.

The discipline of geography provides techniques for conducting spatial analysis and a spatial perspective on research

Cartography is concerned with the display of spatial information. Currently it is the main source of input data for GIS is maps. Cartography provides long tradition in the design of maps which is an important form of output from GIS.

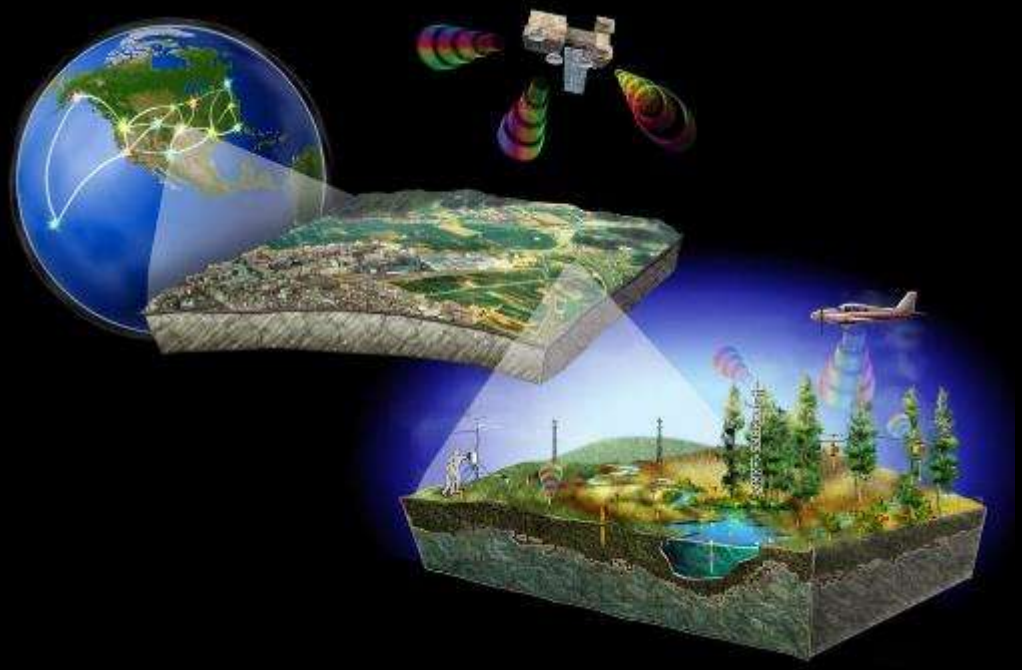
Computer cartography (also called 'digital cartography', 'automated cartography') provides methods for digital representation and manipulation of cartographic features and methods of visualization.



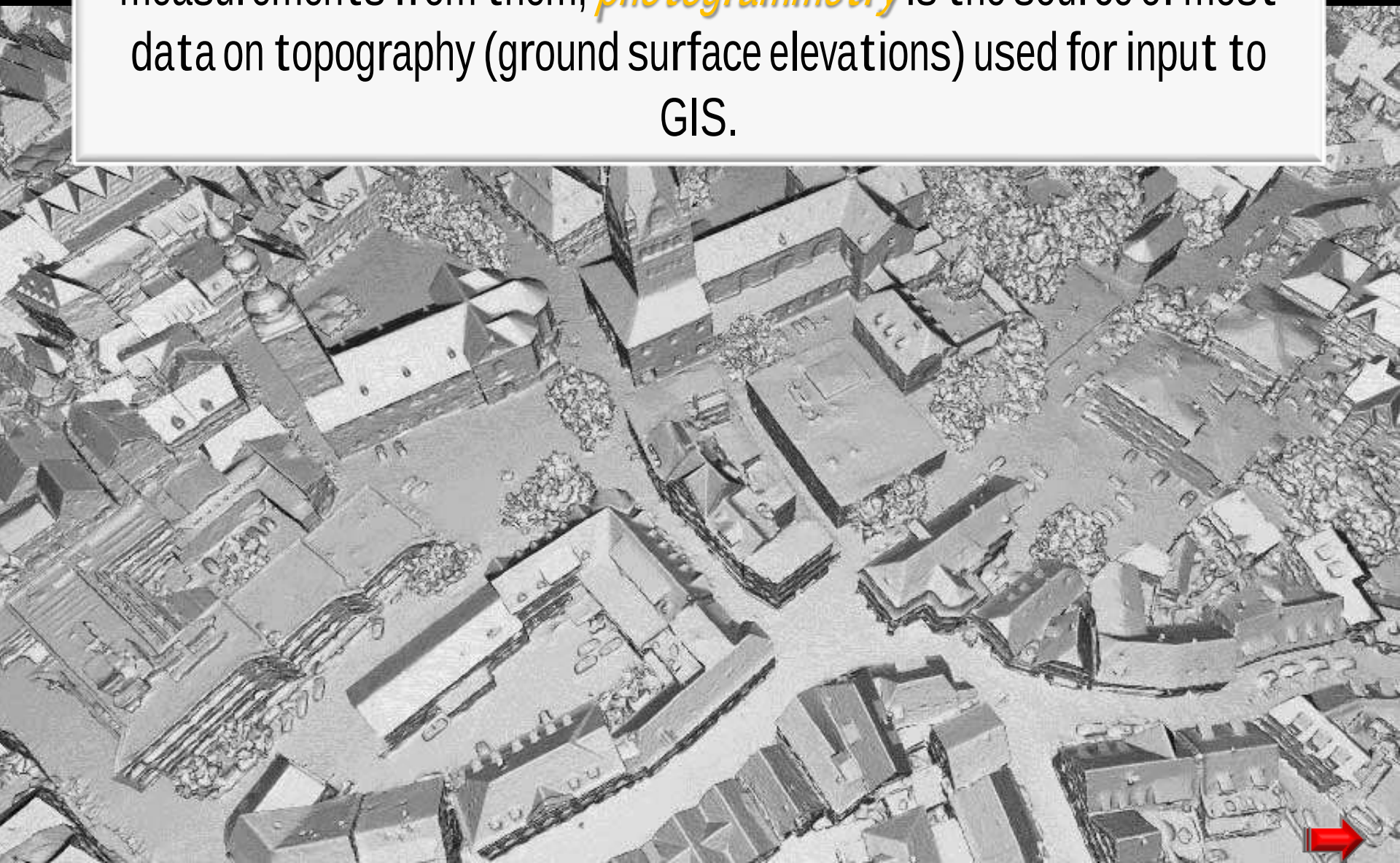
This emerging technique which records images from space and the air are major source of geographical data.

Remote sensing includes techniques for data acquisition and processing anywhere on the globe at low cost, consistent update potential.

The main advantage of it is that interpreted data from a remote sensing system can be merged with other data layers in a GIS.



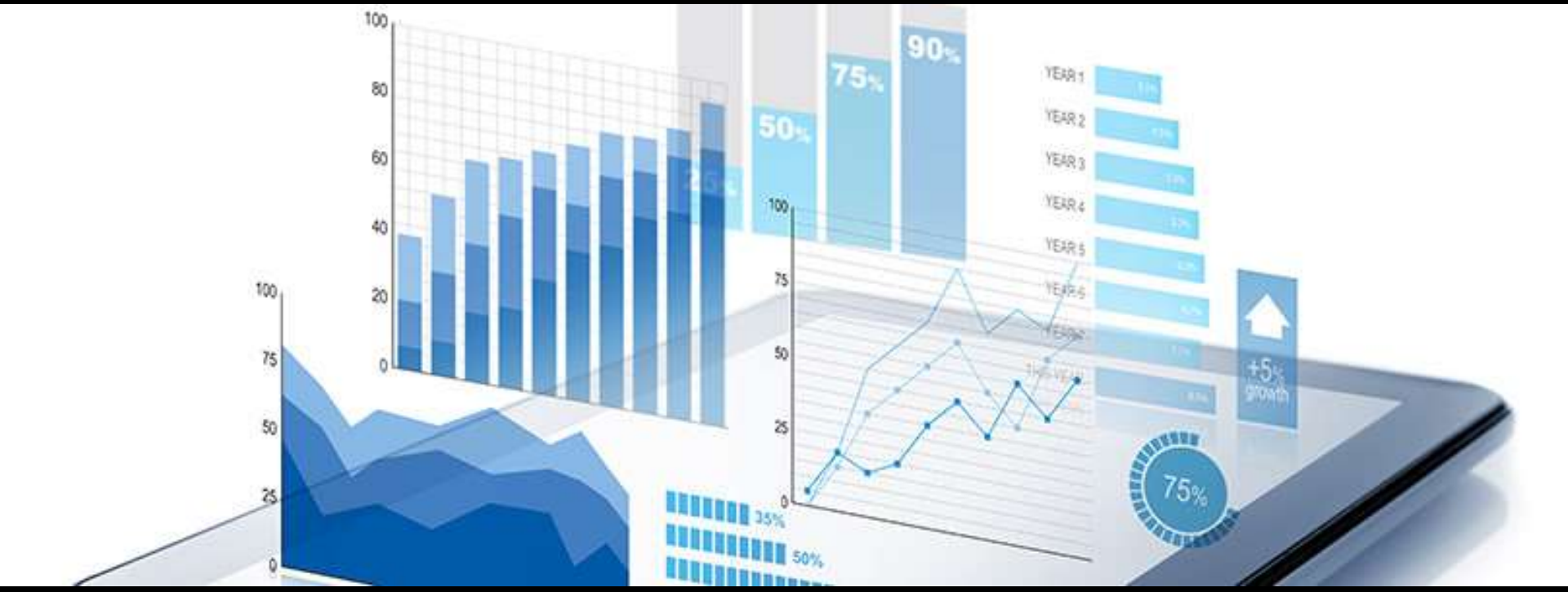
Using aerial photographs and techniques for making accurate measurements from them, *photogrammetry* is the source of most data on topography (ground surface elevations) used for input to GIS.



Surveying is concerned with the measurement of locations of objects **on the Earth's surface, particularly property boundaries.** Surveying provides high quality data on positions of land boundaries, buildings, etc.

Many models built using GIS are statistical in nature, many statistical techniques used for analysis in GIS.

Statistics is important in understanding issues of error and uncertainty in GIS data.



Computer science is one of the main engines for GIS development.

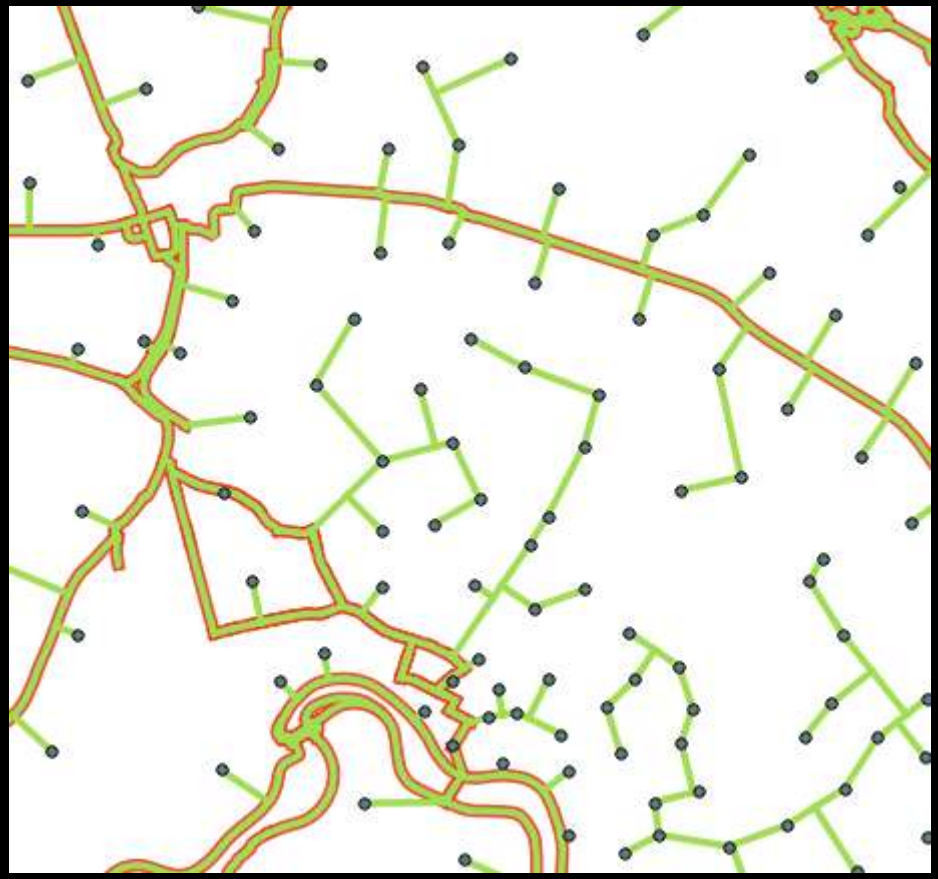
Artificial intelligence (AI) uses the computer to make choices based on available data in a way that is seen to emulate human intelligence and decision-making – computer can act as *an 'expert' in such functions as* designing maps, generalizing map features.

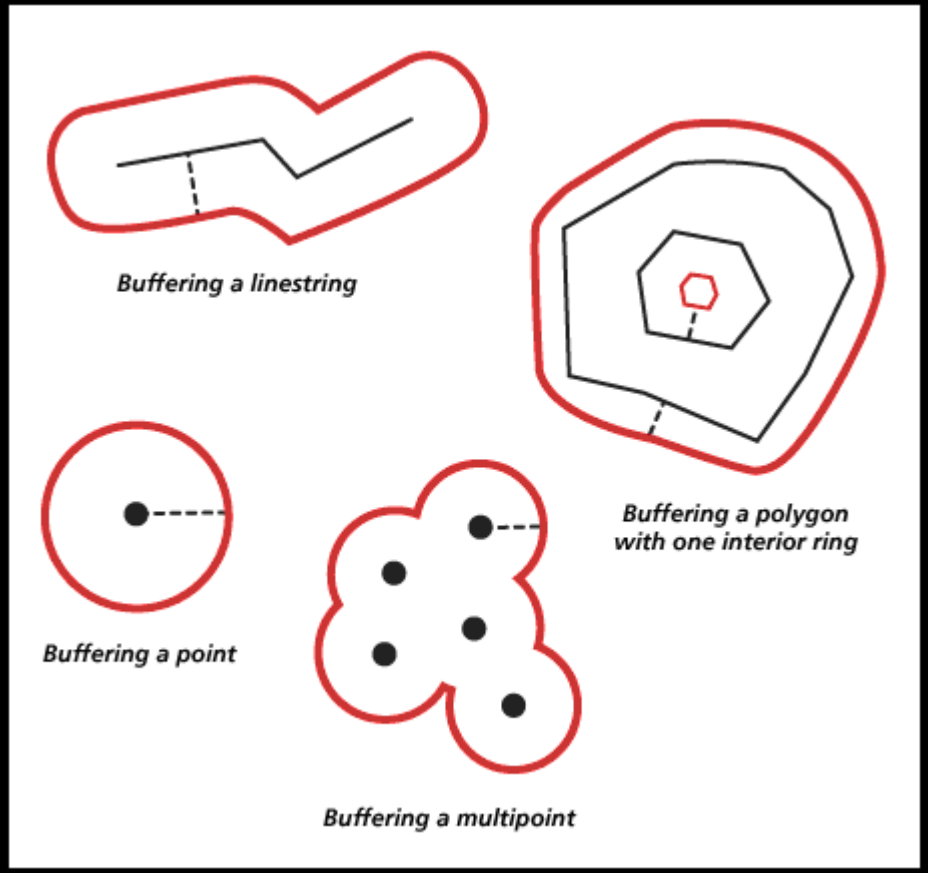
Computer aided design (CAD) provides software, techniques for data input, display and visualization, representation, particularly in 3 dimensions.

Advances in computer graphics provide hardware, software for handling and displaying graphic objects, techniques of visualization.

Similarly, database management systems (DBMS) contribute methods for representing data in digital form, procedures for system design and handling large volumes of data, particularly access and update.

Several branches of *mathematics*, especially geometry and graph theory, are used in GIS system design and analysis of spatial data.





Major Areas of Application of GIS Technology

- ✓ GIS technology, data structures and analytical techniques are gradually being incorporated into a wide range of management and decision-making operations.
- ✓ Numerous examples of applications of GIS are available in many different journals and are frequent topics of presentations at conferences in the natural and social sciences.
- ✓ In order to understand the range of applicability of GIS it is necessary to characterize the multitude of applications in some logical way so that similarities and differences between approaches and needs can be examined.
- ✓ An understanding of this range of needs is critical for those who will be dealing with the procurement and management of a GIS.

Functional classification

- ✓ One way to classify GIS applications is by functional characteristics of the systems; this would include a consideration of characteristics of the data such as themes, precision required and data model.
- ✓ Secondly, GIS a function as which of the range of possible GIS functions does the application rely on? *e.g.* address matching, overlay?
- ✓ Thirdly, a product *e.g.,* does the application support queries, one-time video maps and/or hardcopy maps?
- ✓ A classification based on these characteristics quickly becomes fuzzy since GIS is a flexible tool whose great strength is the ability to integrate data themes, functionality and output.

GIS as a decision support tool

- ✓ Another way to classify GIS is by the kinds of decisions that are supported by the GIS.
- ✓ Decision support is an excellent goal for GIS, however: decisions range from major (which areas in Pakistan are best suited for establishing EPZ with foreign aids?) to minor (which way to turn at next intersection?).
- ✓ Decision support is a good basis for definition of GIS, but not for differentiating between applications since individual GIS systems are generally used to make several different kinds of decisions.

Some Important Areas Where GIS is being used are:

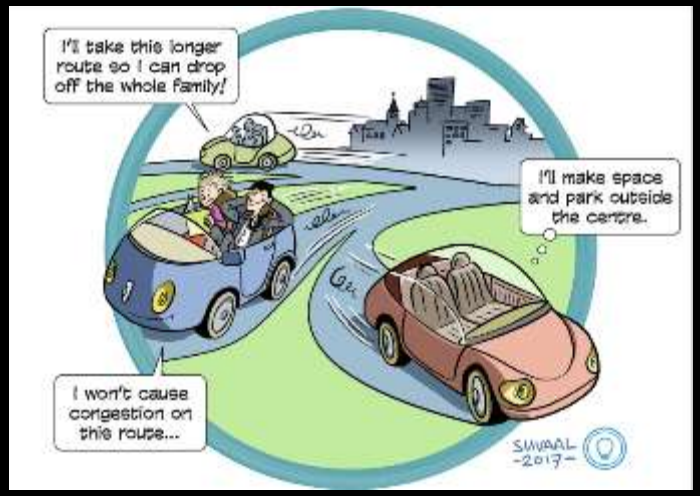
- ✓ *Different Streams of Planning:* Urban planning, housing, transportation planning architectural conservation, urban design, landscape planning etc.
- ✓ *Street Network Based Application:* It is an addressed matched application, vehicle routing and scheduling: location, development and site selection and disaster planning.
- ✓ *Natural Resource Based Application:* Management and environmental impact analysis of wild and scenic recreational resources, flood plain, wetlands, aquifers, forests, and wildlife.

Some Important Areas Where GIS is being used are:

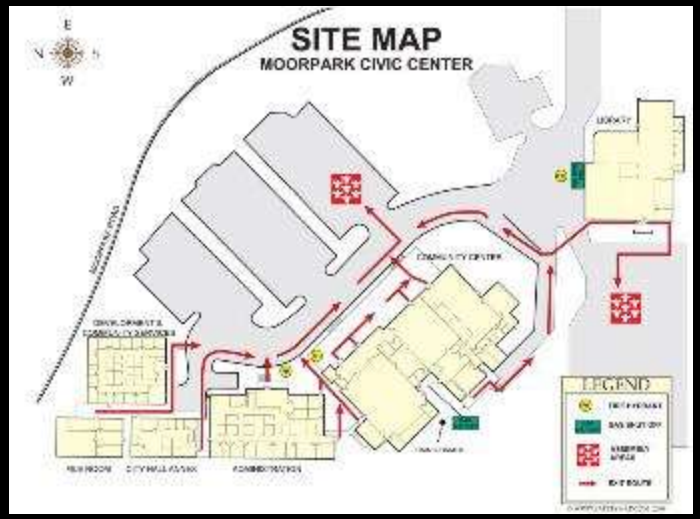
- ✓ *View Shed Analysis:* Hazardous or toxic factories siting and ground water modelling. Wildlife habitat study and migrational route planning.
- ✓ *Land Parcel Based:* Zoning, sub-division plans review, land acquisition, environment impact analysis, nature quality management and maintenance etc.
- ✓ *Facilities Management:* Can locate underground pipes and cables for maintenance, planning, tracking energy use.

Street Network-Based

- ✓ Vehicle routing and scheduling
- ✓ Location analysis, site selection
- ✓ Development of evacuation plans

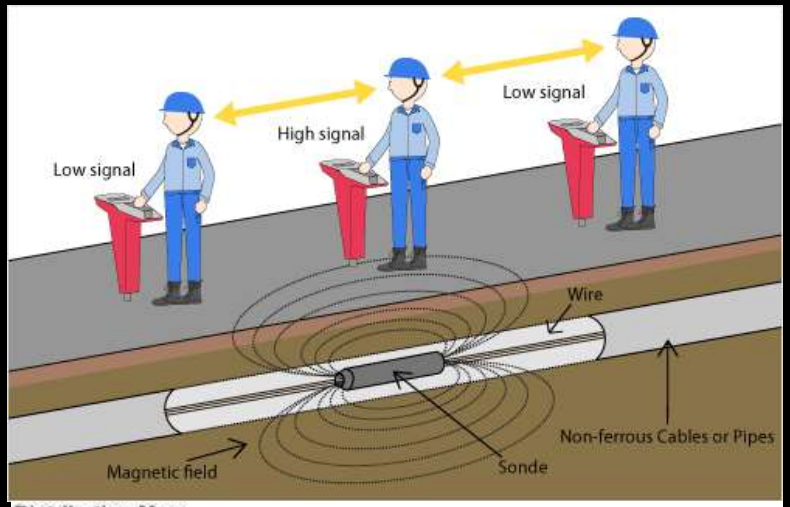


A Site Analysis overview map focuses on specific site options within the ideal location and optimal market.

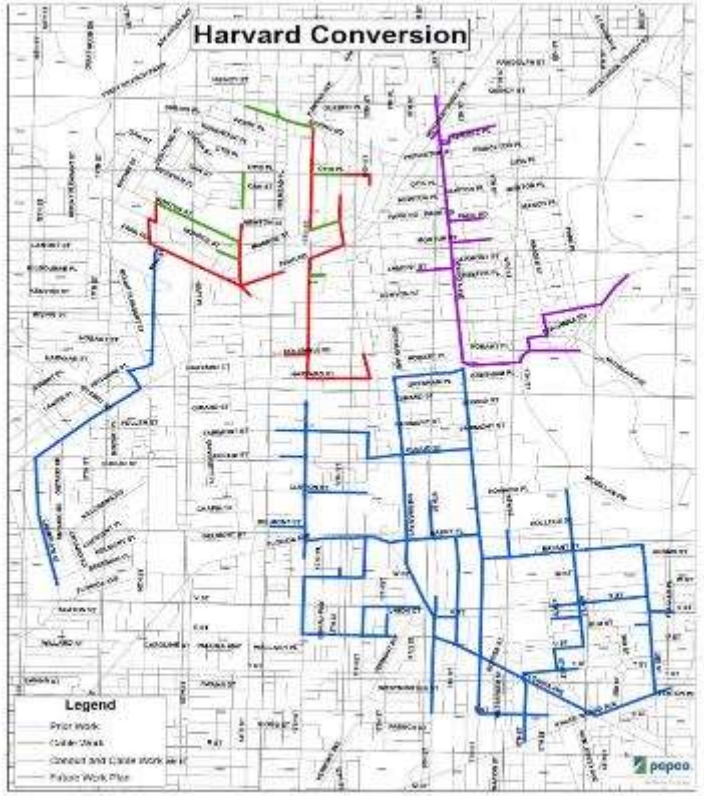


Facilities Management

- ✓ Locating underground pipes cables
- ✓ Balancing loads in electrical networks
- ✓ Planning facility maintenance
- ✓ Tracking energy use



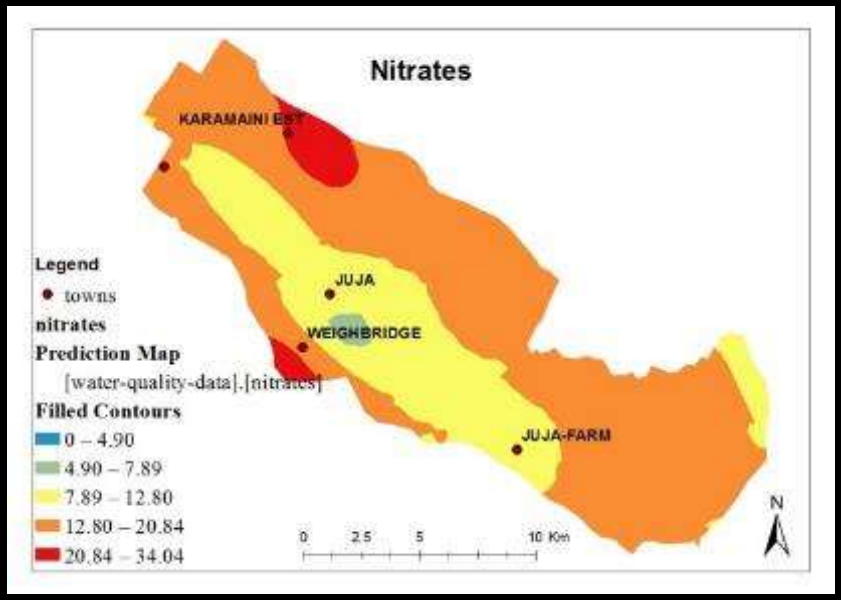
Distribution Map

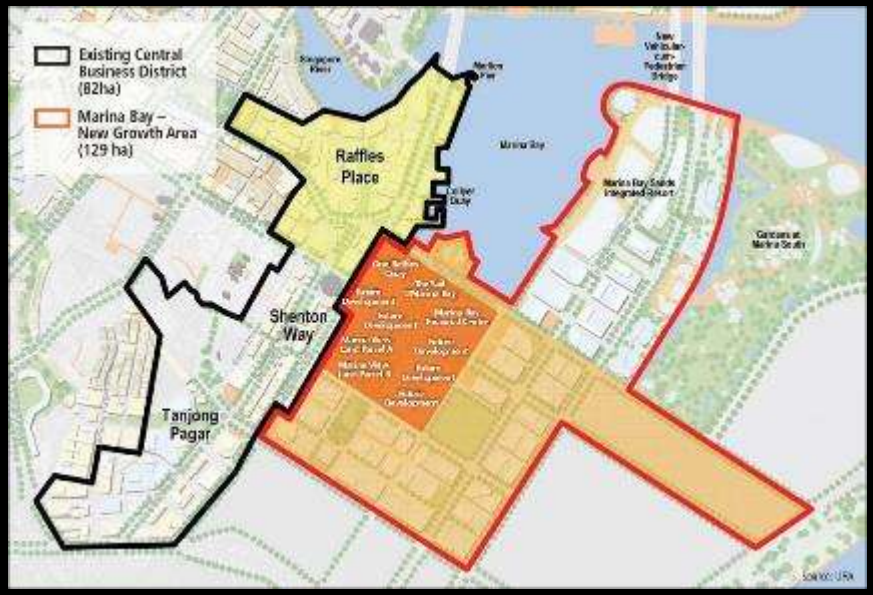


*Construction areas outlined in red.

Land Parcel-Based

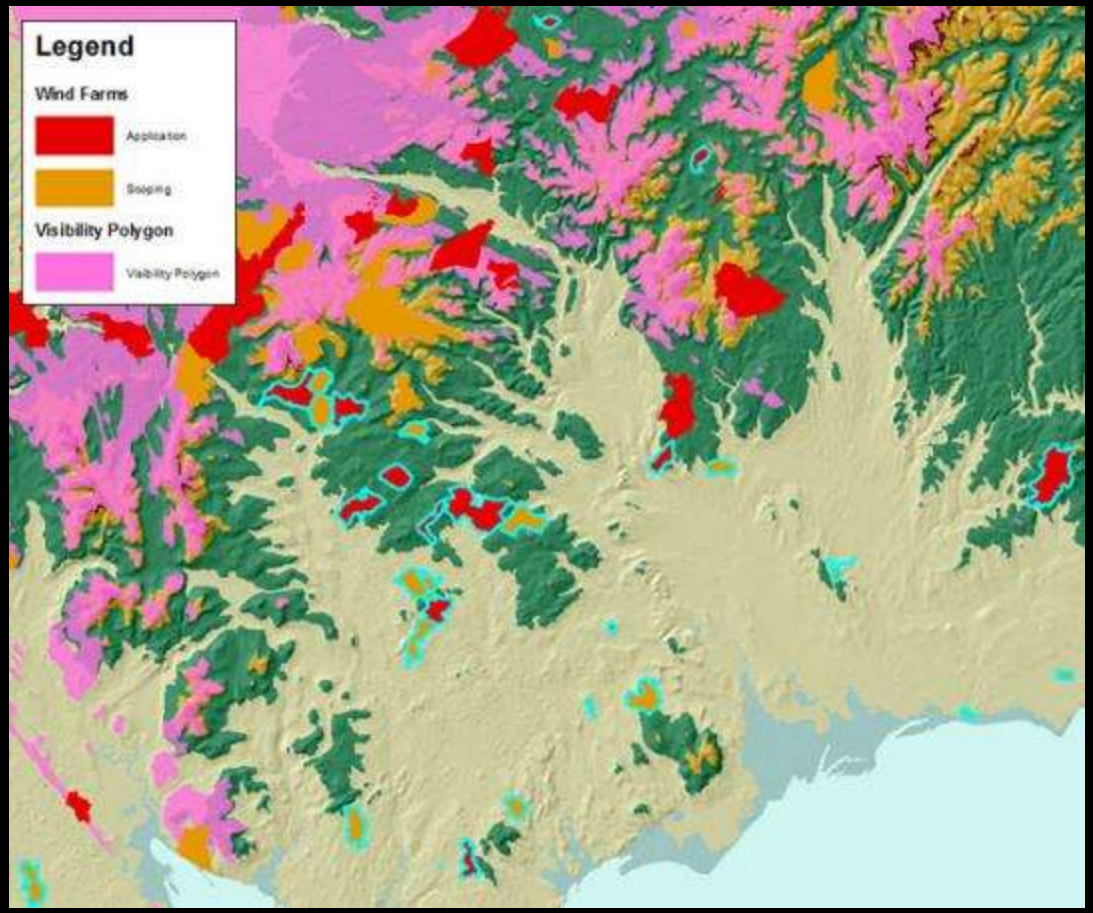
- ✓ Zoning, subdivision plan review
- ✓ Land acquisition
- ✓ Environmental impact statements
- ✓ Water quality management





Environmental Impact Statements

As the threat of climate change increases globally, many countries are turning to renewable energy to reduce carbon dioxide and other greenhouse gas emissions.



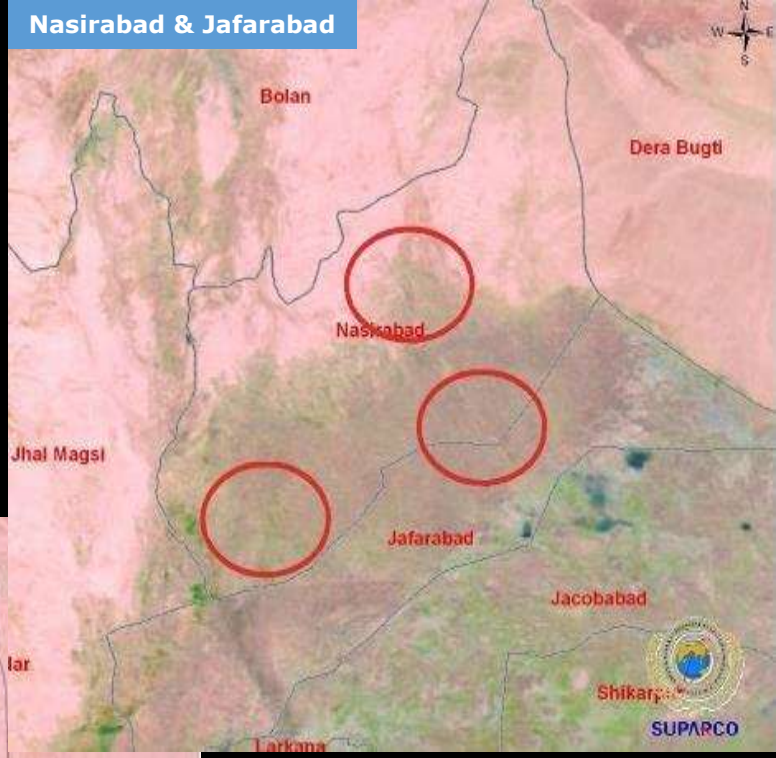
Wind farms are an important source of green energy that are being used to replace electricity derived from fossil fuels, such as coal. While the environmental benefits of replacing fossil fuel-derived energy with wind energy are vast, there can be some environmental concerns with the installation of wind farms in certain areas of ecological importance. The construction of wind farms requires access for large trucks and equipment and can have a temporary but significant impact on the ecosystem.

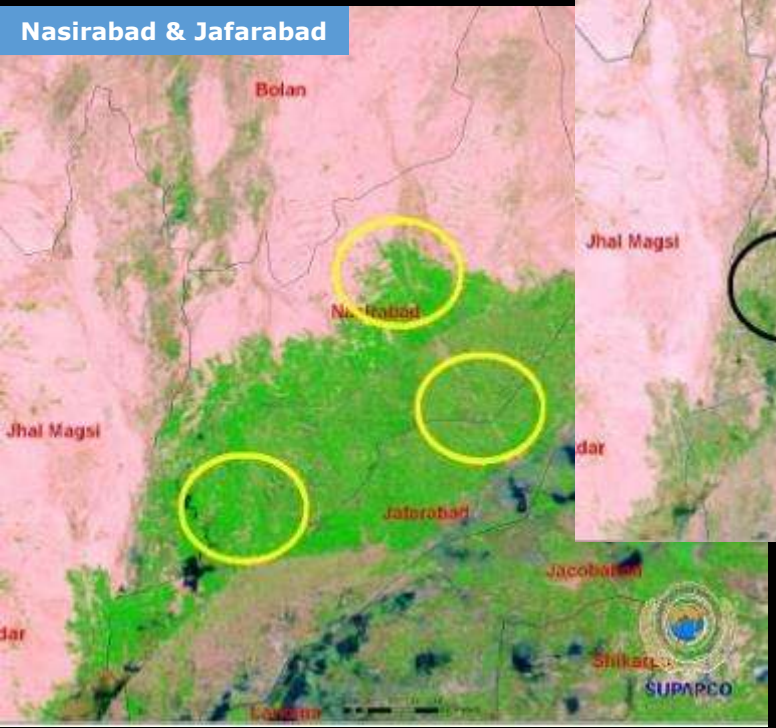
Natural Resource-Based

- ✓ Forest management
- ✓ Habitat, migration routes management
- ✓ Wild and scenic rivers preservation
- ✓ Recreation resources planning
- ✓ Wetland preservation
- ✓ Agricultural lands management
- ✓ Groundwater modelling and contamination tracking

Banana Plantation – Muhammad Pur (Ghotki)

Crop Monitoring

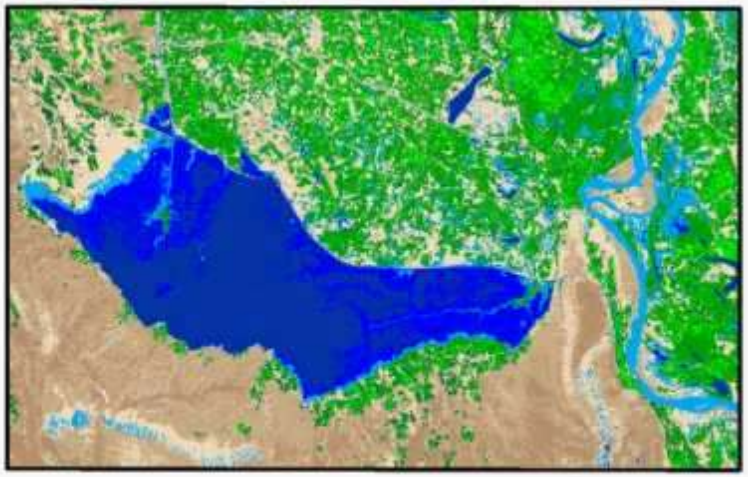




Active Growth Rabi Maturity Rabi Harvesting

Wetland Monitoring

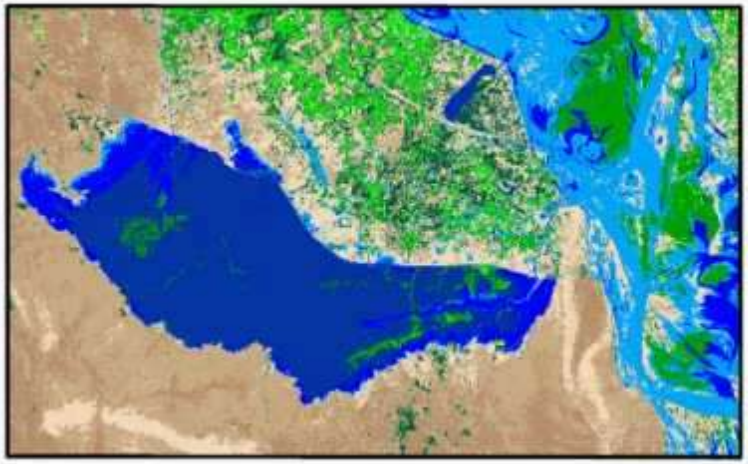
February 1998



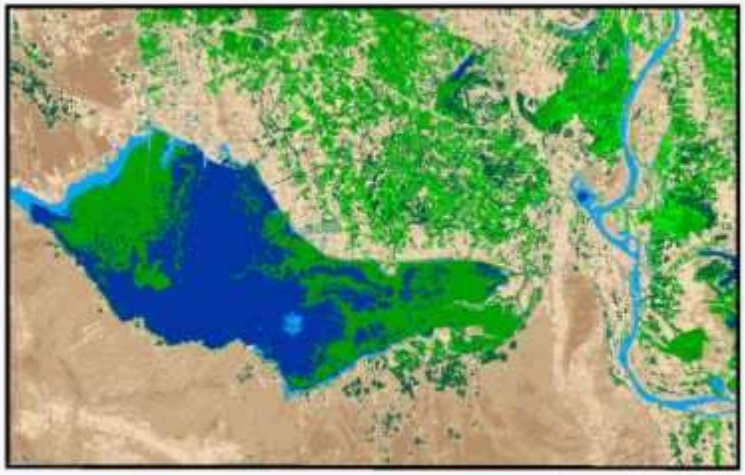
February 1998

Legend :

- Deep Water
- Turbit Water
- Shallow Water
- Fellow Land
- Dense Vegetation
- Moderate Vegetation
- Sparse Vegetation
- Hillocks

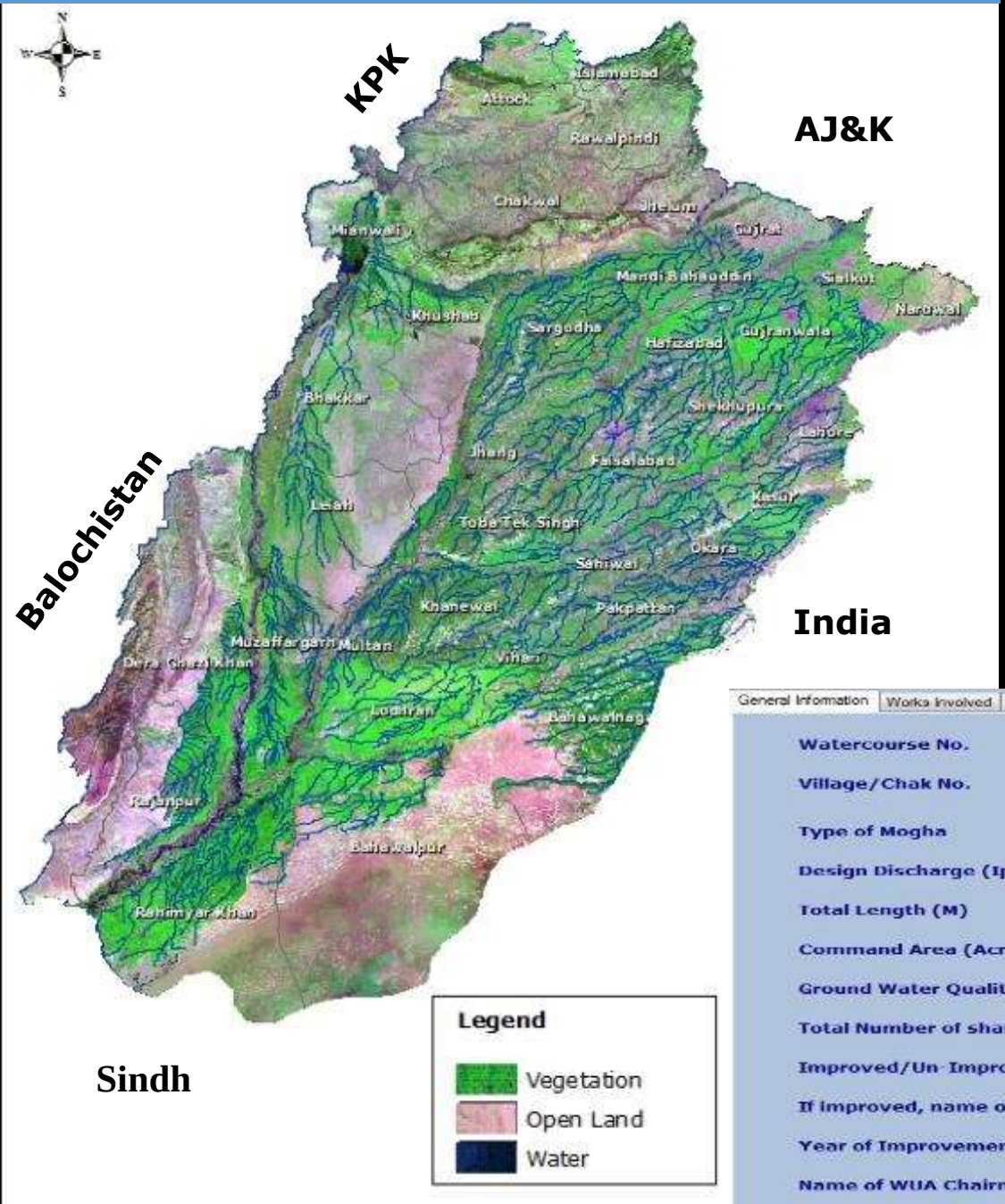


September 1999



November 1999

Irrigation Network of Punjab

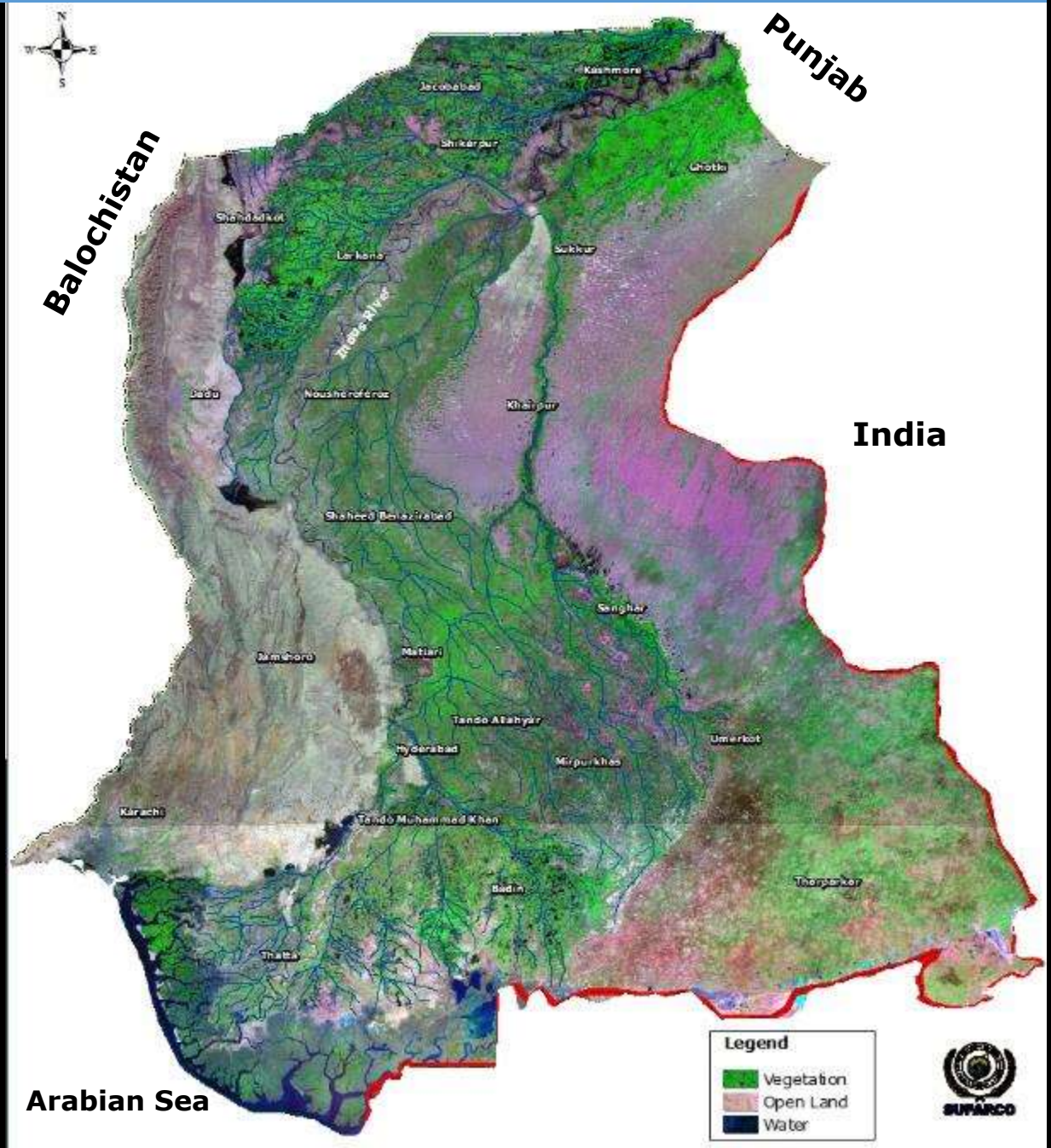


Database of Water Course

General Information | Works Involved | OFWM Interventions/Land Distribution | Designed Data | Reconciled Data

Watercourse No.	47400-R	Source	2-L Disty
Village/Chak No.	79/EB	Tahsil	Arifwala
Type of Mogha	APM	District	Pakpattan
Design Discharge (lps)	100		
Total Length (M)	4710		
Command Area (Acres)	538		
Ground Water Quality (Fresh/Saline)	Saline		
Total Number of share holders	72		
Improved/Un-Improved	Improved		
If improved, name of project	NPIW		
Year of Improvement	2005-06		
Name of WUA Chairman	Farooq		

Irrigation Network of Sindh

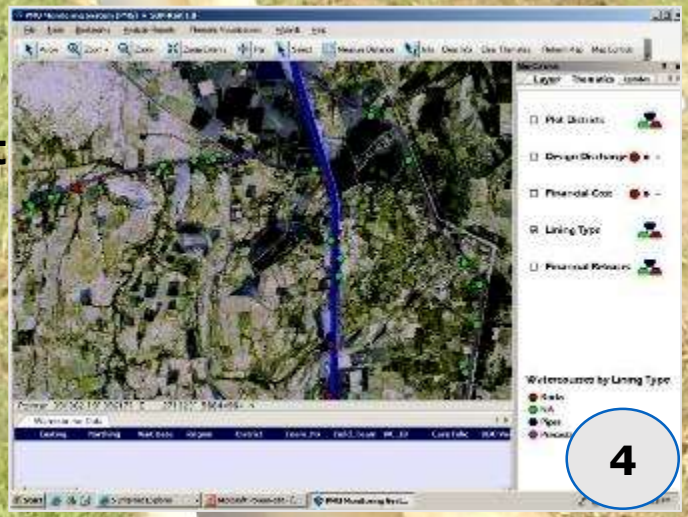


Monitoring System for Irrigation Rehabilitation Process

Sending monitoring report from the watercourse through PDA using SMS /GPRS to servers at PMU HQ

Checking the work at Site

Real time report received at remote Client



Mirani Dam - 2005

Mirani Dam - 2010

Check Dam – Kech District

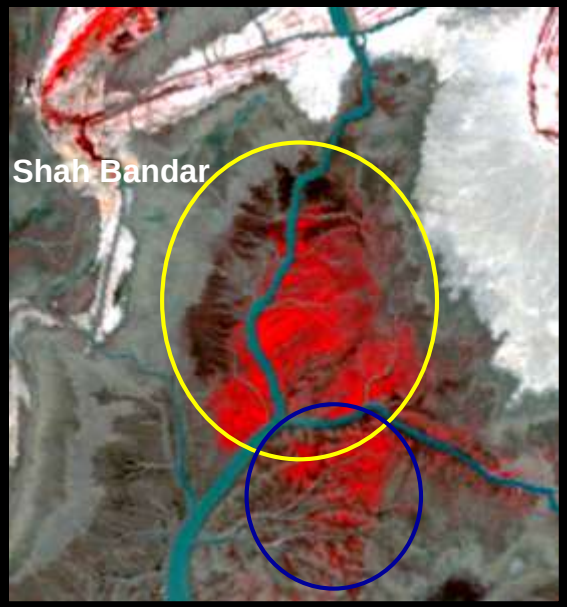
Deforestation

11 April 2004

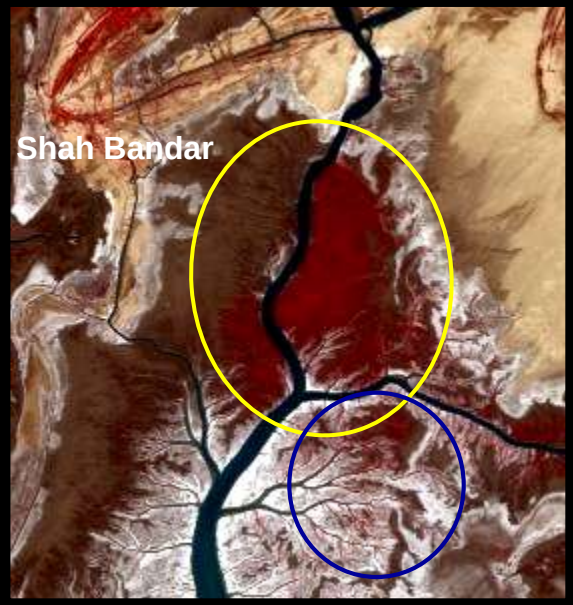
22 Jan 2011

Changes in Mangroves Forest

Landsat TM Image of 1989
Area under Mangroves = 170 Hectares



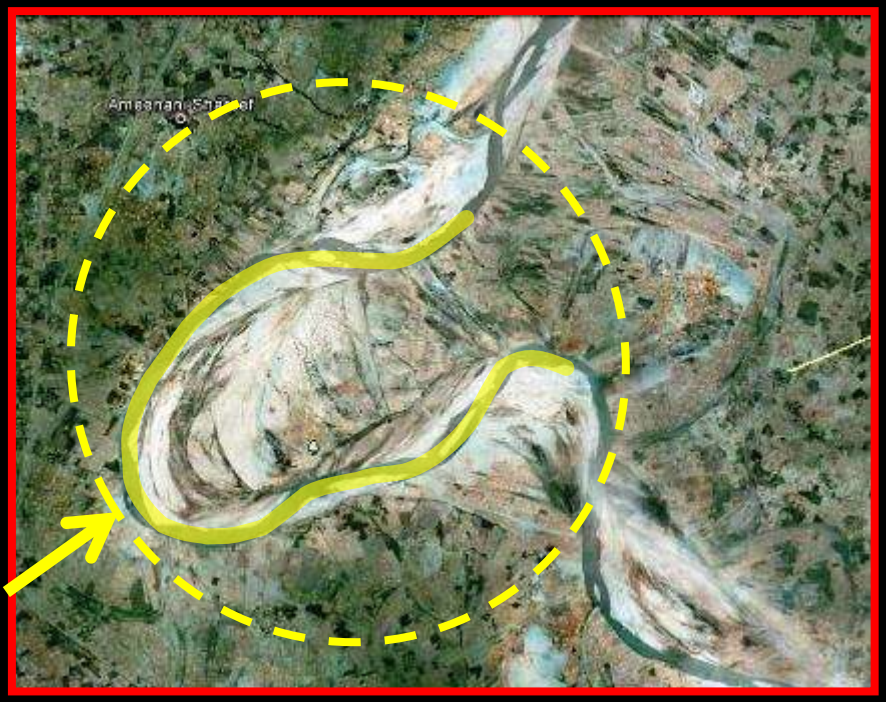
Landsat TM Image of 1998
Area under Mangroves = 810 Hectares



SPOT Image of 2008
Area under Mangroves = 660 Hectares

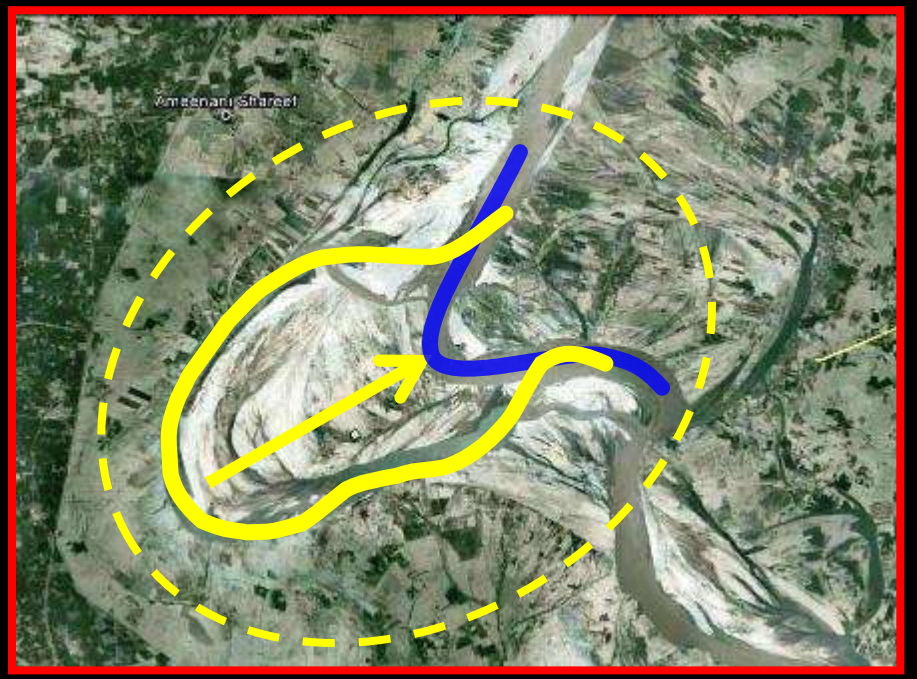
Shortage of fresh water
increase the salinity

River Course Changes



27 Feb 2006

27 Aug 2011



Coastal Erosion & Changes in Creeks

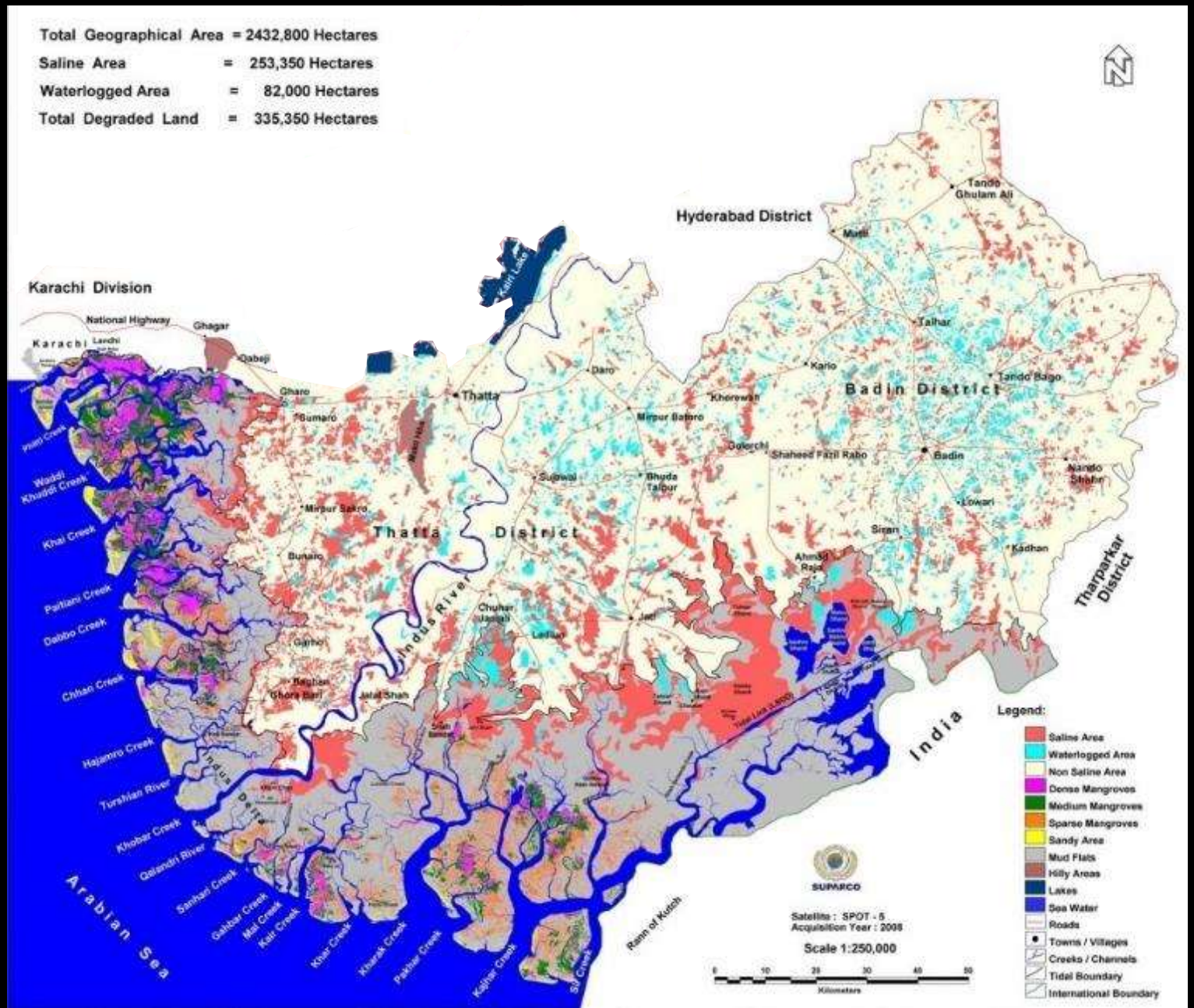
Landsat TM Image of 1989

Landsat TM Image of 1998

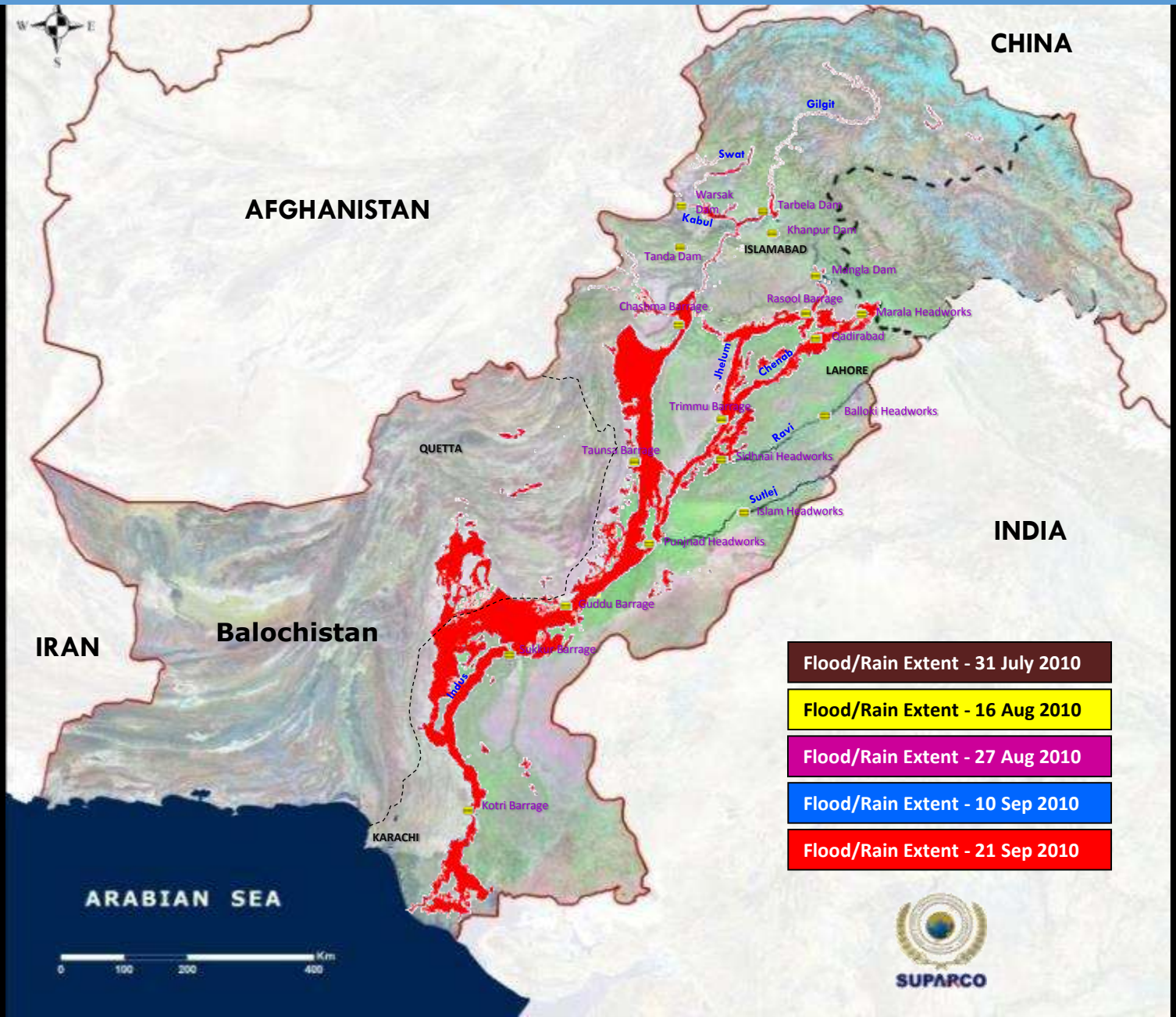
SPOT XS Image of 2008

Dry mud flats showing aridity and high salinity in the Indus Delta region

Land Degradation in Coastal Belt



Flood/Rain 2010



Flash Flooding – Bursting of Shadikor Dam

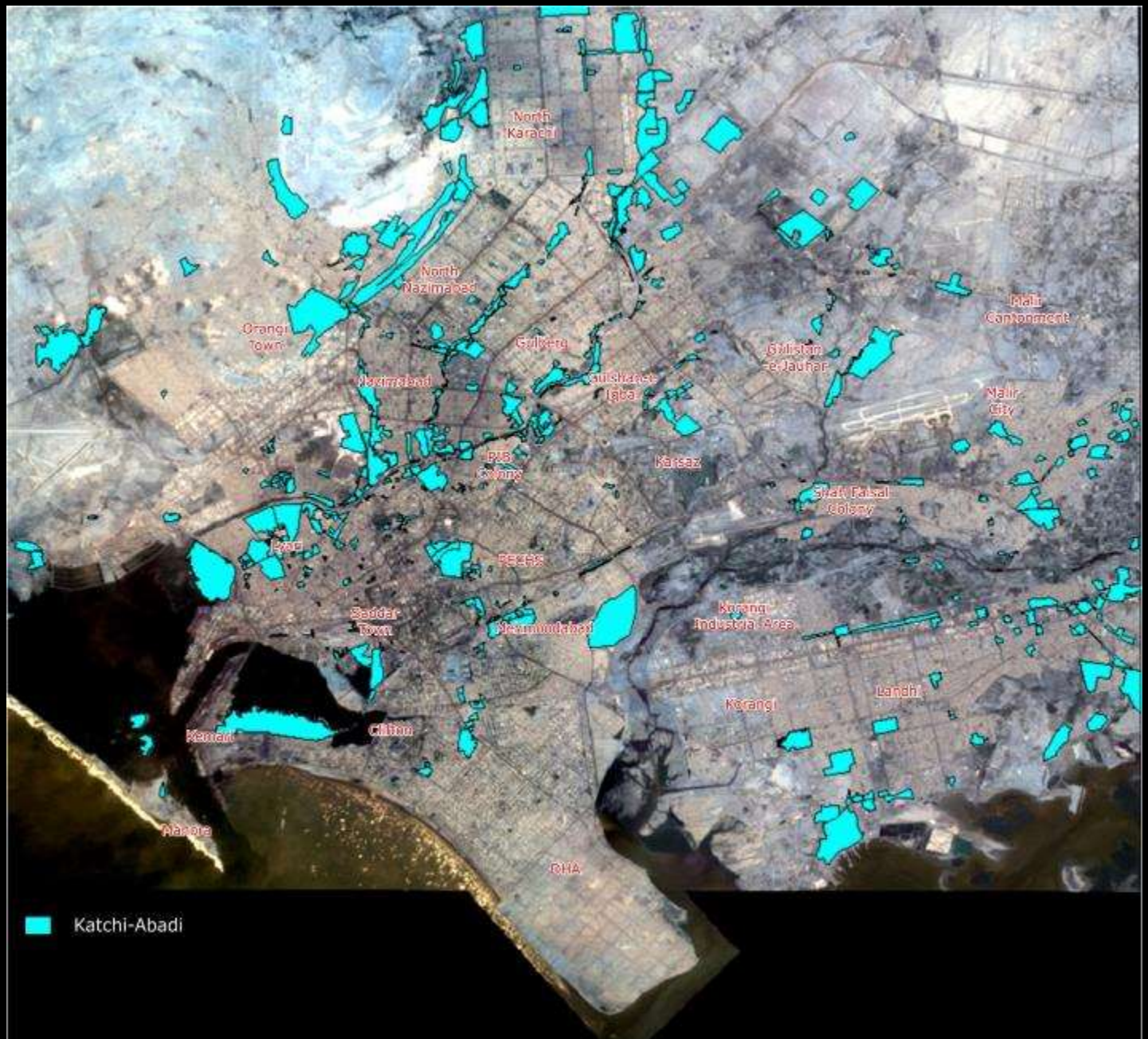
Pre event

Post event

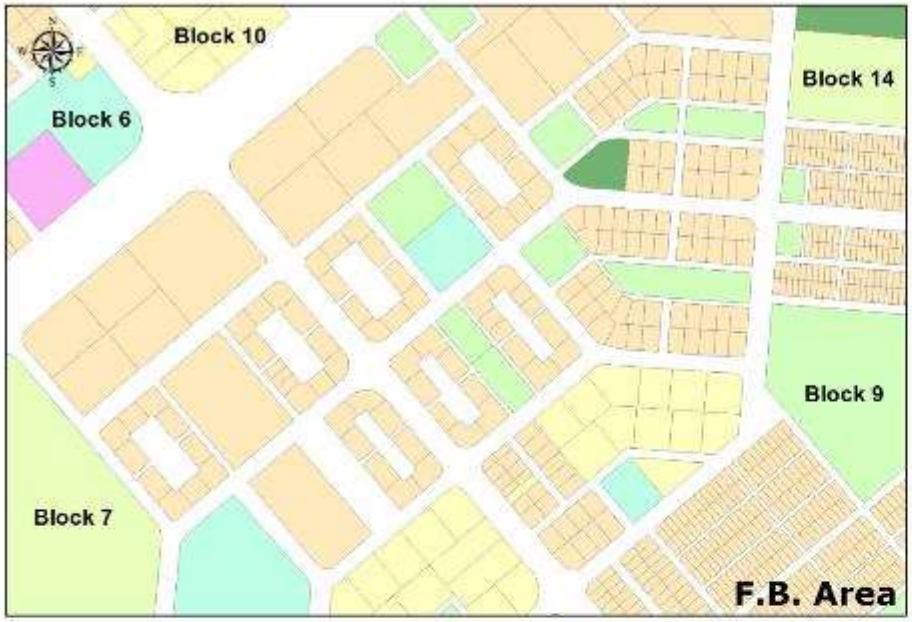
Damaged spill way/wall

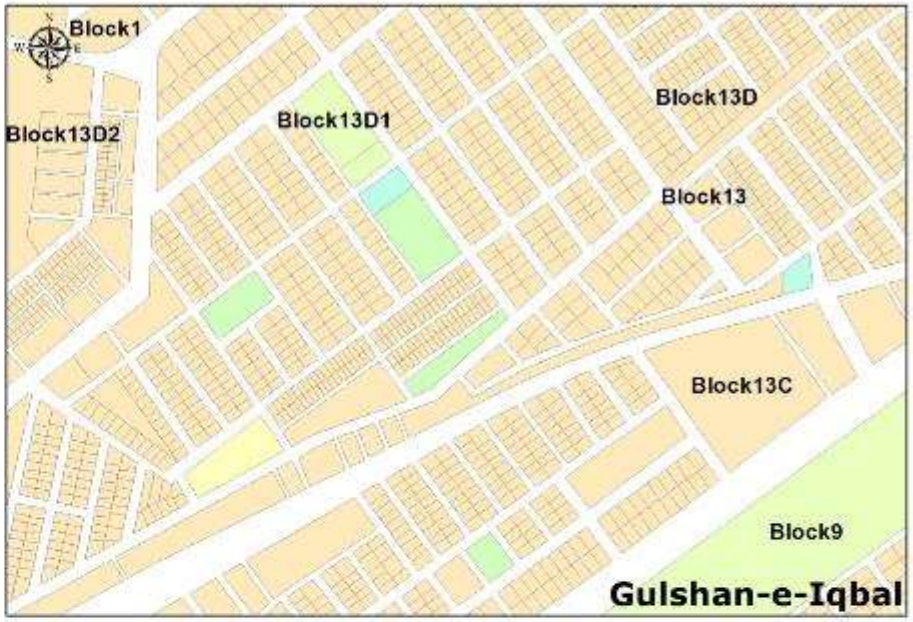
Damaged portions of Pasni – Gawadar Coastal Highway

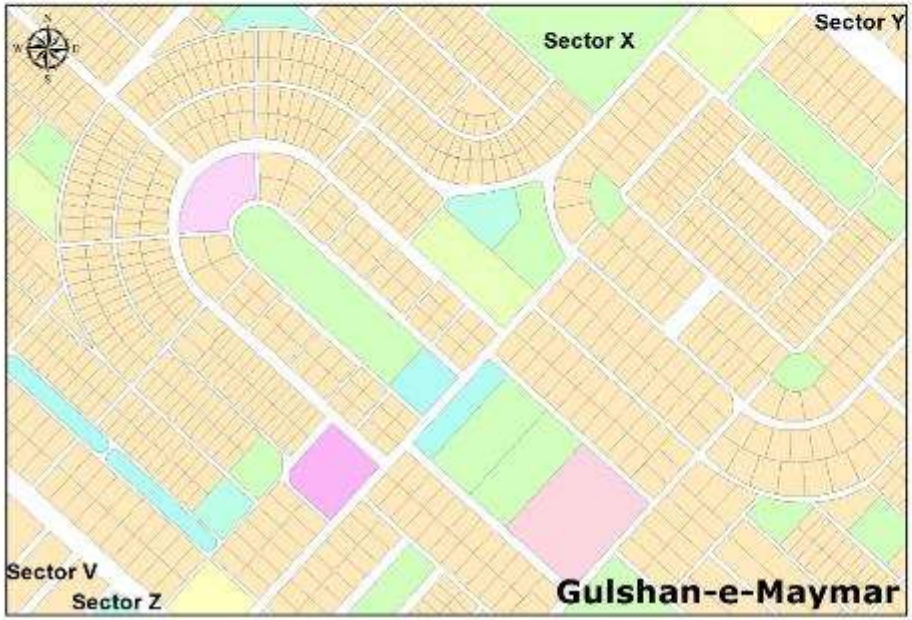
Distribution of slum areas in Karachi



Parcel Mapping of Karachi







Database Fields
OBJECTID
BUILT_UP
STATUS
ADDRESS
PARCEL_TYPE
PARCEL_SUBTYPE
PARCEL_SECTYPE
COVERED AREA
MINOR LOCATION
MAJOR LOCATION
OFF ROAD
DIGITIZER
REMARKS

Landuse (Parcel Type Classes)

- Commercial
- Diplomatic Enclave
- Educational
- Government
- Graveyard
- Health
- Industrial
- Lodging
- Office
- Recreation
- Religious
- Residential
- Transport
- Utility
- Welfare Trust

SUPARCO

Population growth & expansion in suburb of Karachi

22 Jan 2001

17 July 2011

Upgradation of Karachi Circular Railway (KCR)

LEGEND:
KCR Track
PR Boundary
Encroachment (Built-up)
Encroachment (Semi built-up)
Town boundary

Thank You!