

Fundamentals of Geographic Information System

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CONTENTS OF THIS LECTURE PRESENTATION

- Basic concept of GIS
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- Types of GIS data
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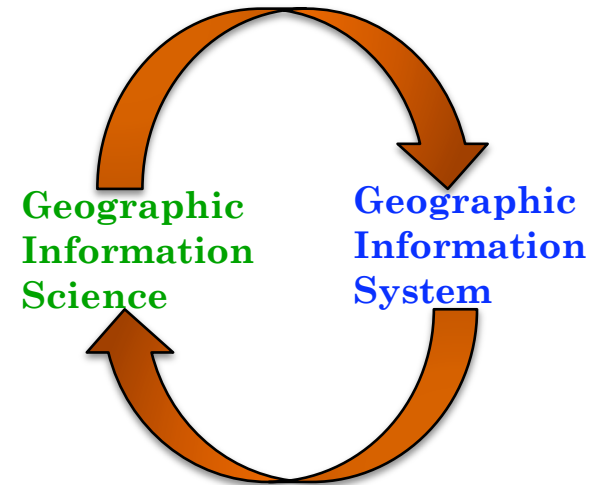
Basic Concept of GIS

BASIC CONCEPT OF GIS ^{1/5}

- **What does GIS stand for?**
 - Geographic Information Science
 - is the science concerned with the systematic and automatic processing of spatial data and information with the help of computers
 - is the theory behind how to solve spatial problems with computers
 - Geographic Information System
 - is a system designed for storing, analyzing, and displaying spatial data
 - is the use of hardware, software, people, procedures, and data

BASIC CONCEPT OF GIS ^{2/5}

- Geographic Information Science
 - presents a framework for using information theory, spatial analysis and statistics, cognitive understanding, and cartography (Longley et al., 2005).
- Geographic Information System
 - focuses on the processes and methods that are used to sample, represent, manipulate and present information about the world (Goodchild, 1992) .



Adopted from Maguire (2010)

“**GI Science** allows us to consider the philosophical, epistemological & ontological contexts of geographic information & **GI Systems** provide the infrastructure, tools and methods for tackling real world problems within acceptable timeframes.”

BASIC CONCEPT OF GIS ^{3/5}

○ Literal Definition

- Geographic relates to the surface of the earth.
- Information is a knowledge derived from study, experience, or instruction.
- System is a group of interacting, interrelated, or interdependent elements forming a complex whole.
- Science is the observation, identification, description, experimental investigation, and theoretical explanation of phenomena.

BASIC CONCEPT OF GIS ^{4/5}

○ **Functional Definition**

- GIS is a system for inputting, storing, manipulating, analyzing, and reporting data.

○ **Component Definition**

- GIS is an organized collection of computer hardware, software, geographic data, procedures, and personnel designed to handle all phases of geographic data capture, storage, analysis, query, display, and output.

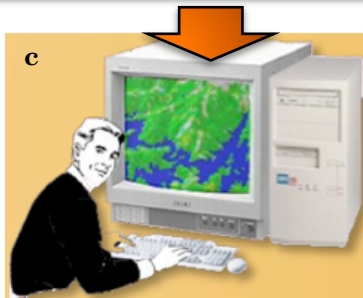
BASIC CONCEPT OF GIS 5/5

○ Functions of GIS

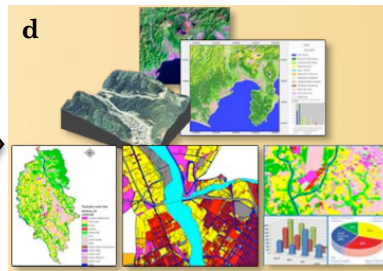
- *Data collection*
 - Capture data
- *Data storing, processing & analysis*
 - Store data
 - Query data
 - Analyze data
- *Output production*
 - Display data
 - Produce output



- Data collection
 - using GPS & RS
 - paper maps are also sources of data

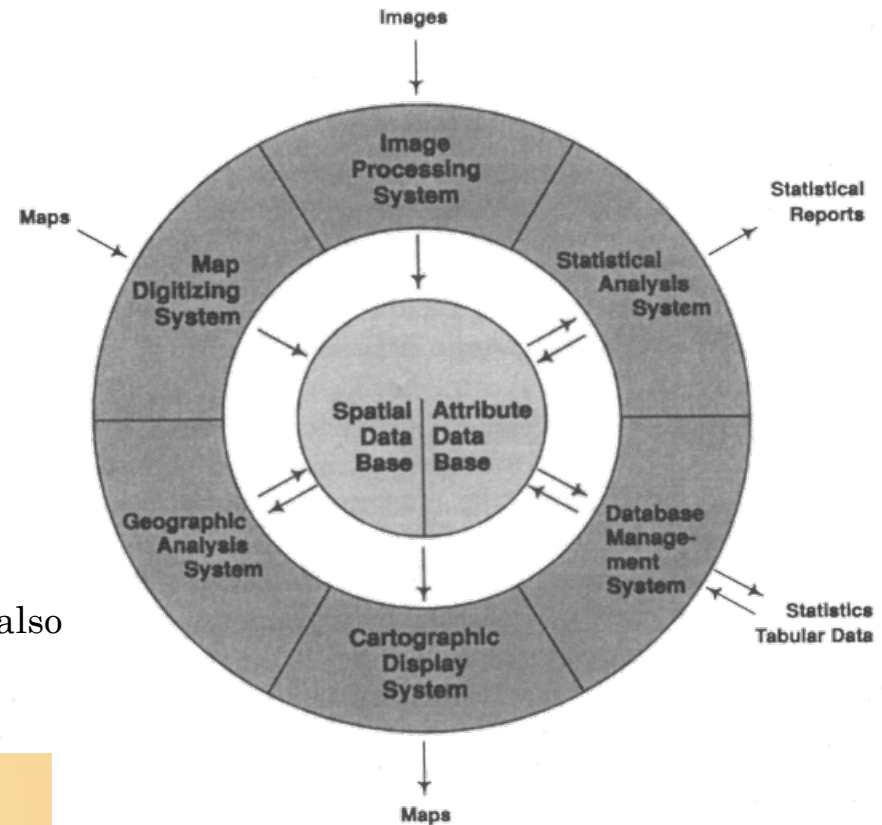


- Data storing, processing & analysis



- Output production
 - statistical report, maps

○ Components of GIS



Source: Schuurman (2004)

Sources (Photos):

- a) <http://www.picsearch.com/pictures/fashion/jewelry/watch%20brands/garmin.html>
- b) b), c), d) Lwin & Murayama (2008)

Basic Elements of GIS

BASIC ELEMENTS OF GIS ^{1/7}

- People
- Data
- Software
- Hardware
- Procedures/Methods

Adopted from:
Brooks (undated)

<http://www.mapsofindia.com/gis/gis-components.html>

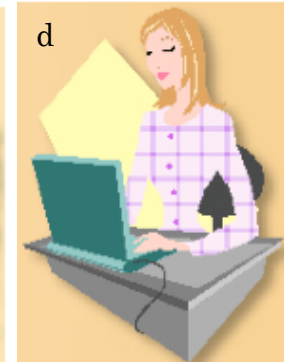
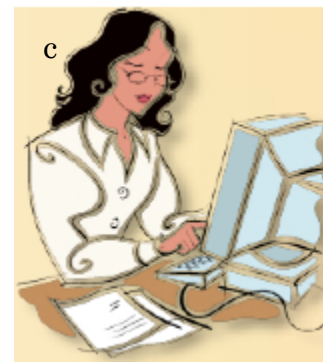
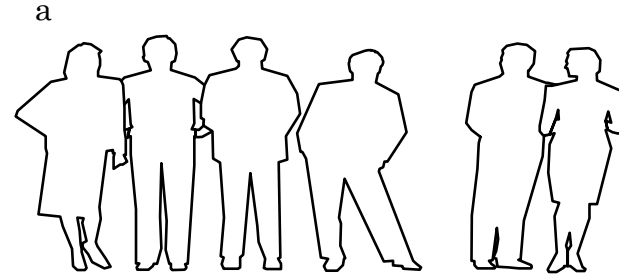
http://bgis.sanbi.org/gis-primer/page_12.htm

http://www.sfu.ca/rdl/GIS/tour/comp_gis.html

BASIC ELEMENTS OF GIS ^{2/7}

○ 1. People

- are the most important part of a GIS
- define and develop the procedures used by a GIS
- can overcome shortcomings of the other 4 elements (data, software, hardware, procedure), but not vice-versa



- Ground truth data collection
- Data storing, processing and analysis

Sources (Photos):

a) Brooks (undated)

b) <http://www.asdi.com/remote-sensing/applications/ground-truthing>

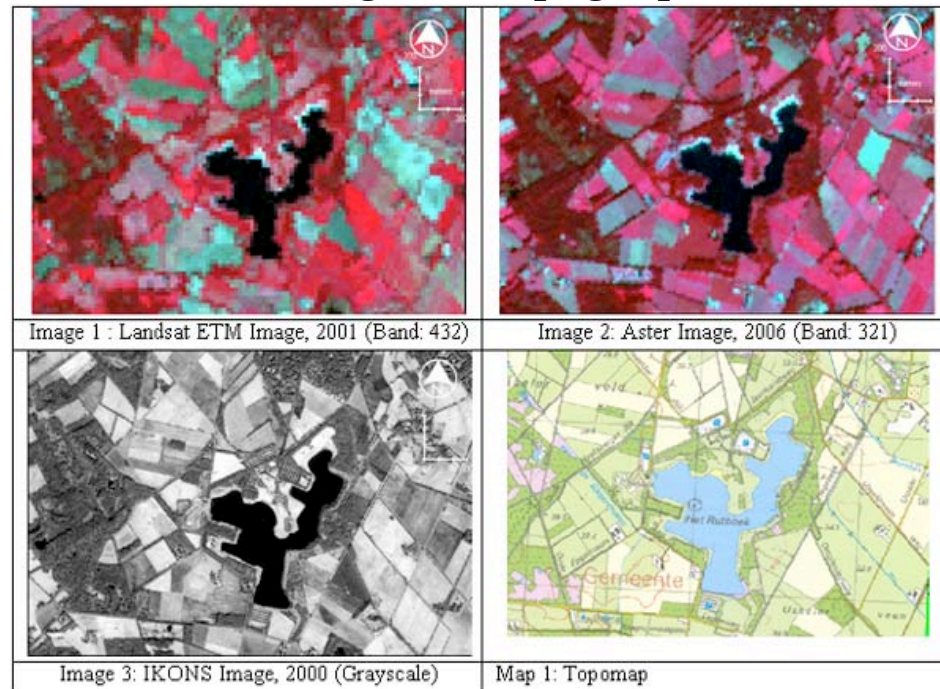
c), d) Lwin & Murayama (2008)

BASIC ELEMENTS OF GIS ^{3/7}

○ 2. Data

- Data is the information used within a GIS
- Since a GIS often incorporates data from multiple sources, its accuracy defines the quality of the GIS.
- GIS quality determines the types of questions and problems that may be asked of the GIS

Remote Sensing and topographic data



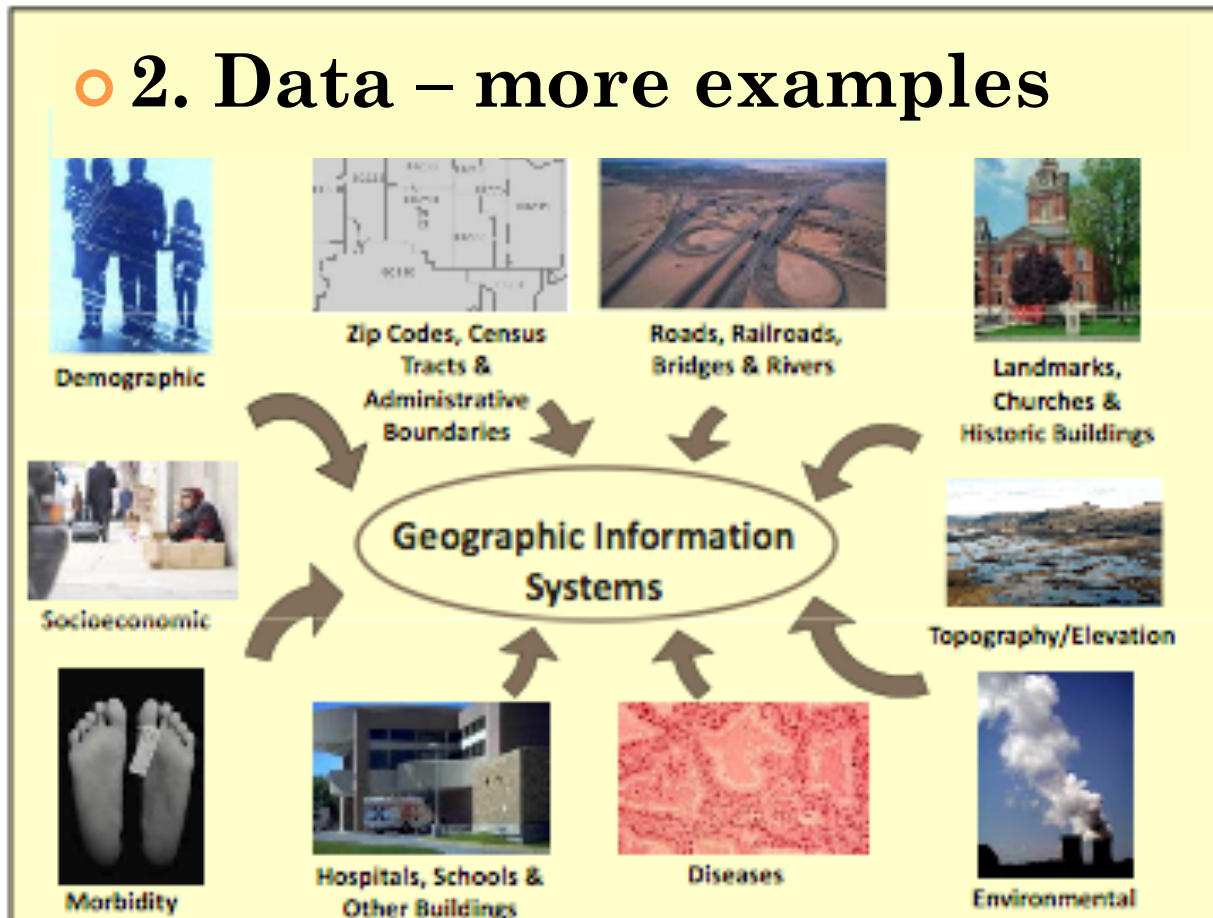
Ground truth data

Obs. Point	GPS Reading		Present Landuse	ETM Image 2001	IKONOS	Topographic Map
	X	Y		Class Name		Legend Class
1	351642	5783025	Forest	Forest	Forest	Forest
18	350985	5783163	Bare Land	Grassland	Grassland	Grassland
17	351000	5782900	Arable Land	Grassland	Grassland	Grassland
20	350700	5783200	Forest	Forest	Forest	Forest
23	351100	5783000	Grassland	Arable Land	Arable Land	Arable Land

Source: Rahman (2009)

BASIC ELEMENTS OF GIS ^{4/7}

○ 2. Data – more examples



BASIC ELEMENTS OF GIS ^{5/7}

○ 3. GIS software

- It encompasses not only to the GIS package, but all the software used for databases, drawings, statistics, and imaging.
- The functionality of the software used to manage the GIS determines the type of problems that the GIS may be used to solve.
- The software used *must* match the *needs* and *skills* of the end user.

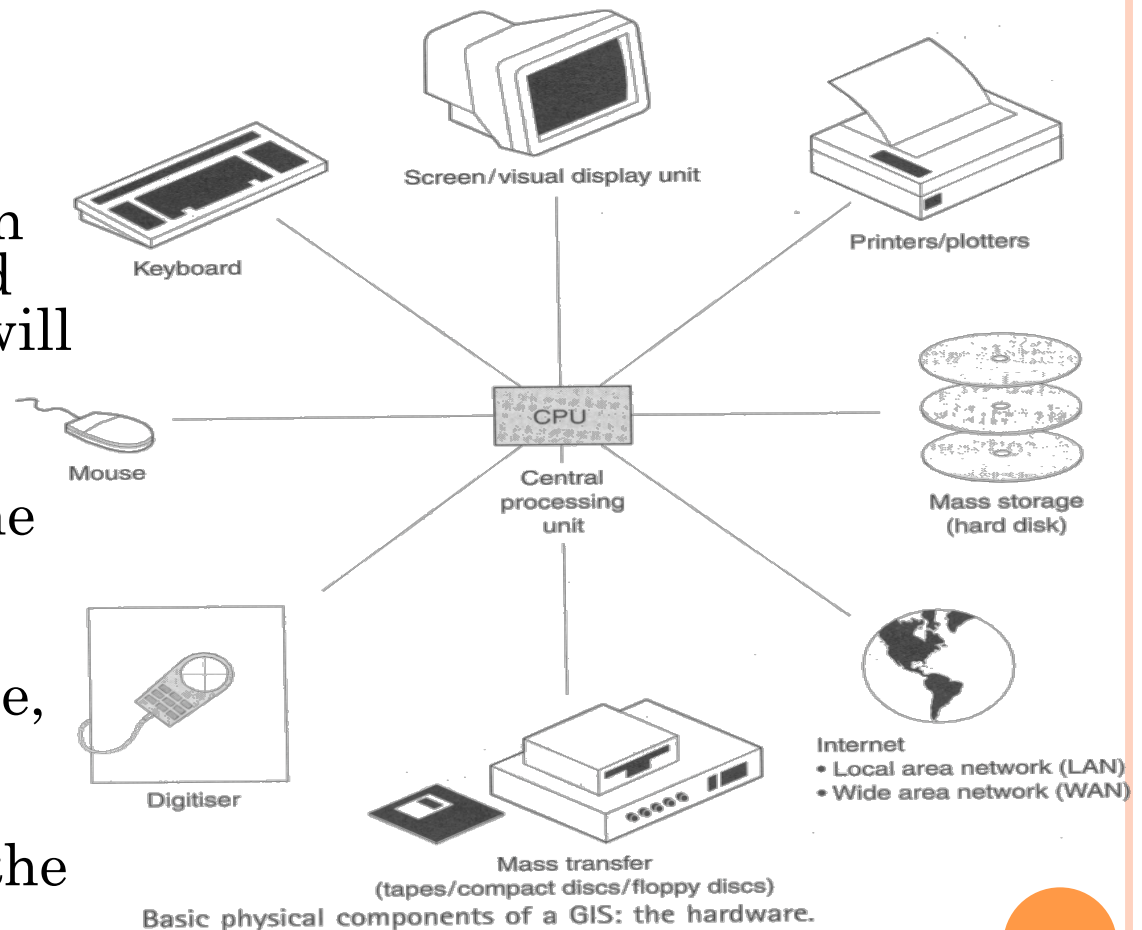
○ Popular GIS Software

- *Vector-based GIS*
 - ArcGIS (ESRI)
 - ArcView
 - MapInfo
- *Raster-based GIS*
 - Erdas Imagine (Leica)
 - ENVI (RSI)
 - ILWIS (ITC)
 - IDRISI (Clark Univ.)

BASIC ELEMENTS OF GIS ^{6/7}

○ 4. Hardware

- The type of hardware determines, to an extent, the speed at which a GIS will operate.
- Additionally, it may influence the type of software used.
- To a small degree, it may influence the types/ personalities of the people working with the GIS.



Source: Schuurman (2004)

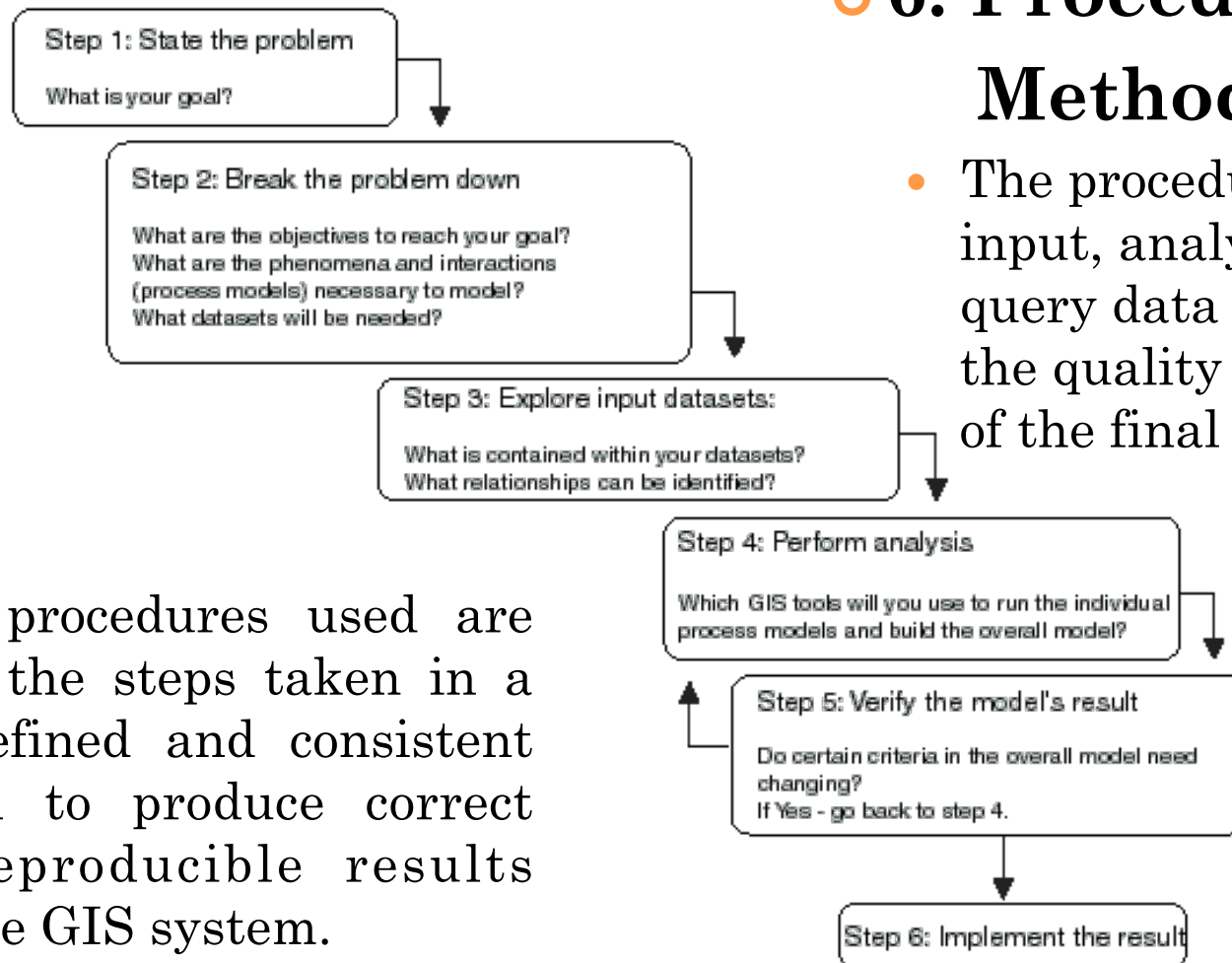
BASIC ELEMENTS OF GIS 7/7

A conceptual model for solving spatial problems

6. Procedures/Methods

- The procedures used to input, analyze, and query data determine the quality and validity of the final product.

- The procedures used are simple the steps taken in a well defined and consistent method to produce correct and reproducible results from the GIS system.



Source: ESRI



Types of GIS Data

TYPES OF GIS DATA 1/3

○ Vector

- In the vector data model, features on the earth are represented as:
 - Points
 - Lines
 - Polygons

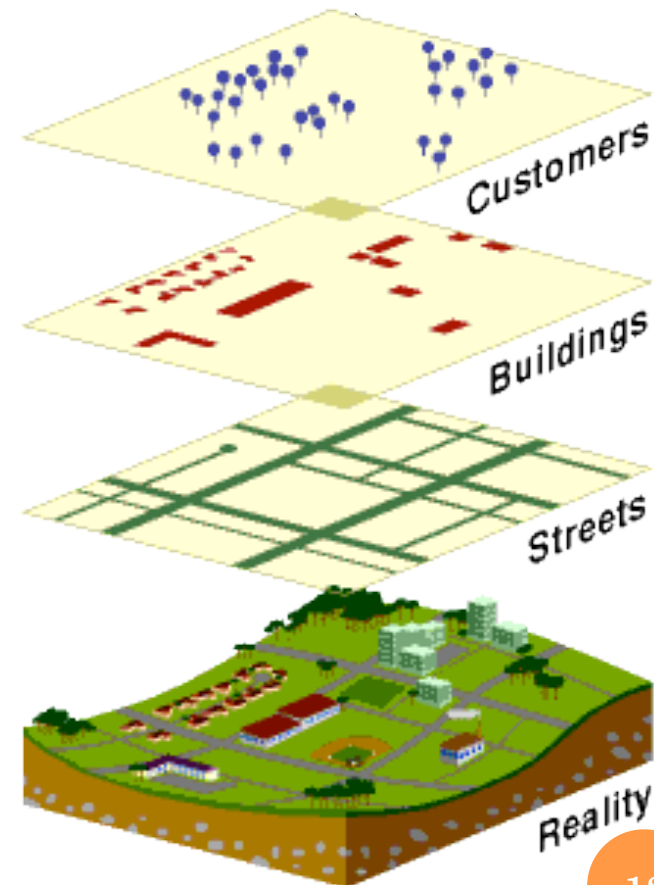
○ Raster

- In the raster data model, a geographic feature like land cover is represented as:
 - single square cells

○ Attribute

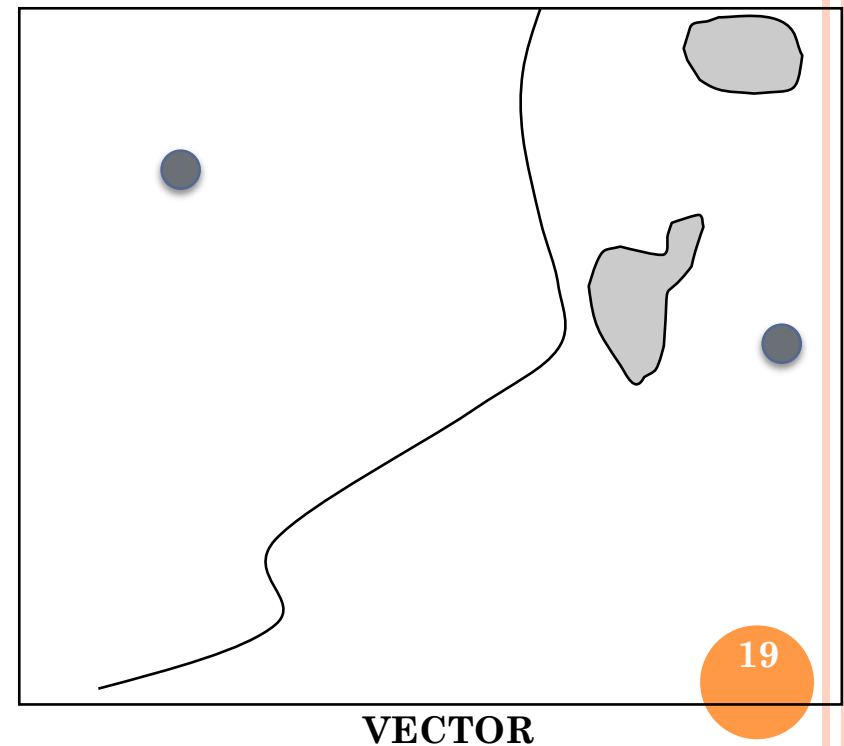
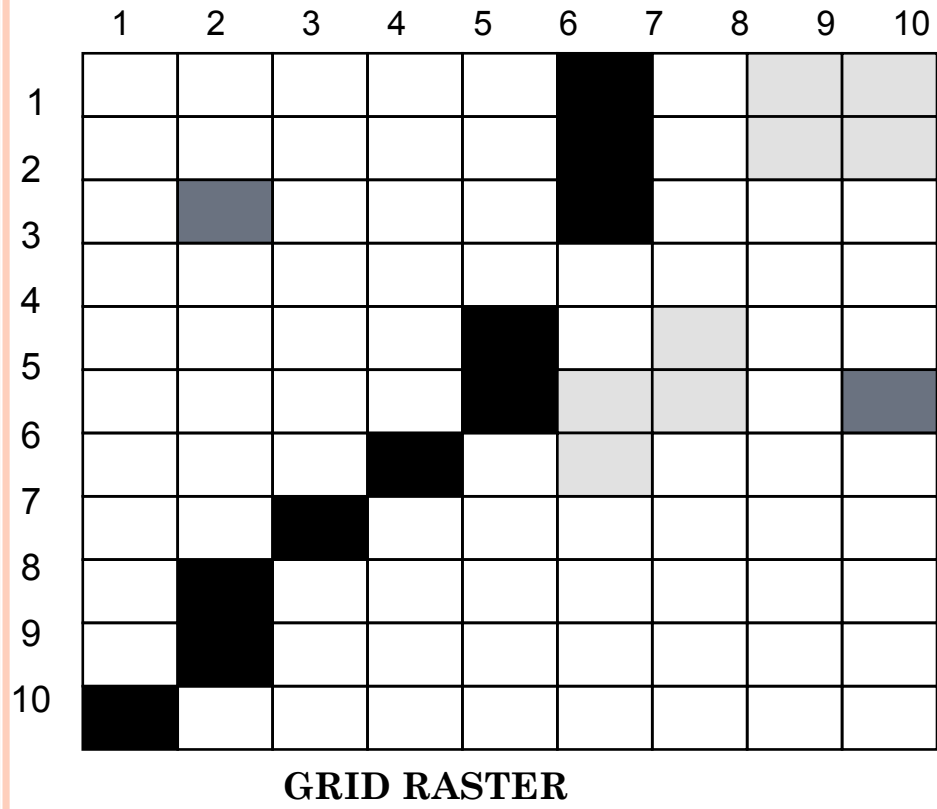
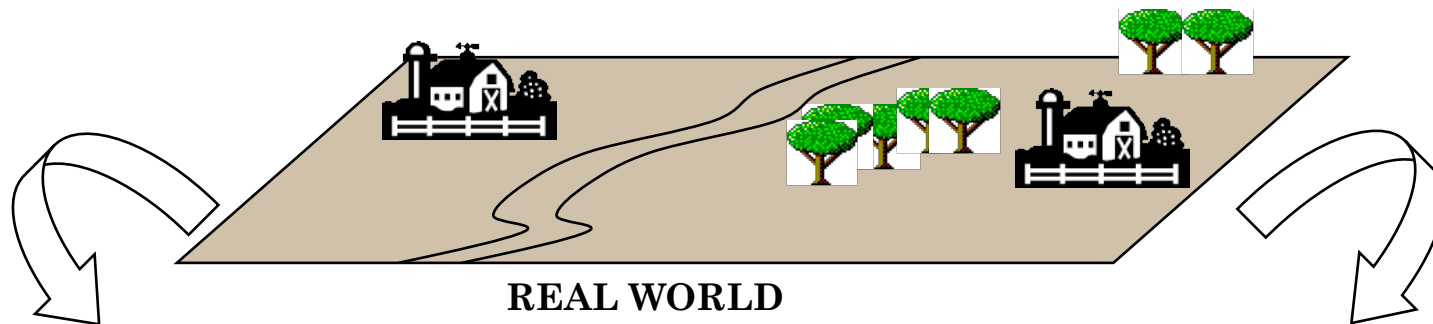
- Attribute values in a GIS are stored as *relational database* tables.
- Each feature (point, line, polygon, or raster) within each GIS layer will be represented as a record in a table.

- A GIS stores information about the world as layers of spatial features (customers, buildings, streets, and so



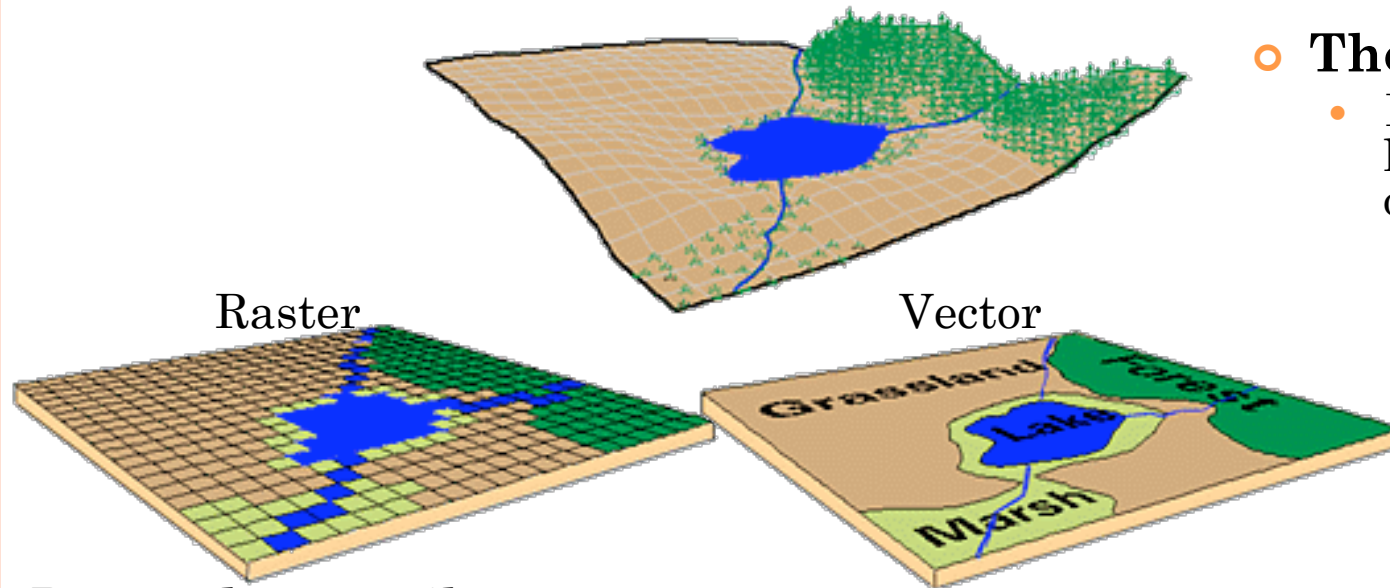
Source: ESRI

TYPES OF GIS DATA 2/3



Source: Brooks (undated)

TYPES OF GIS DATA 3/3



○ The Real World

- In this example, our landscape consists of:
 - Points rolling hills
 - Lines grassland
 - Polygons lake
 - rivers
 - forest stands
 - marsh

Raster data attributes

ROW	COL	LU_CODE
1	1	2
1	2	2
1	3	2
1	4	2
...		
1	19	101

LU_CODE	LAND_COVER	NAME	CELLS
1	forest	Sherwood Forest	100
2	grassland	Marshall Field	150
100	lake	Blue Lake	75
3	marsh	Okeefenokey Swamp	55
101	river	Suwanee River	20

- Each cell has a coordinate representation within the table and a numeric value (i.e., LU_CODE)
- Each LU_CODE is associated with a full description through a *relational* join.

Source: <http://gis.washington.edu/phurvitz/professional/SSI/attrib.html>

Vector data attributes

○ Polygon attributes

AREA	PERIMETER	LU_ID	LU_CODE	NAME
200	500	1	1	Sherwood Forest
1250	10000	2	2	Marshall Field
175	250	3	100	Blue Lake
100	295	4	3	Okeefenokey Swamp

LENGTH	LU_ID	LU_CODE	NAME
45	4	101	Suwanee River
50	5	101	Suwanee River
35	6	101	Suwanee River

○ Line attributes

- Because the vector data represent both linear & polygonal features, there are 2 attribute tables.

Examples of GIS Applications

EXAMPLES OF GIS APPLICATIONS 1/6

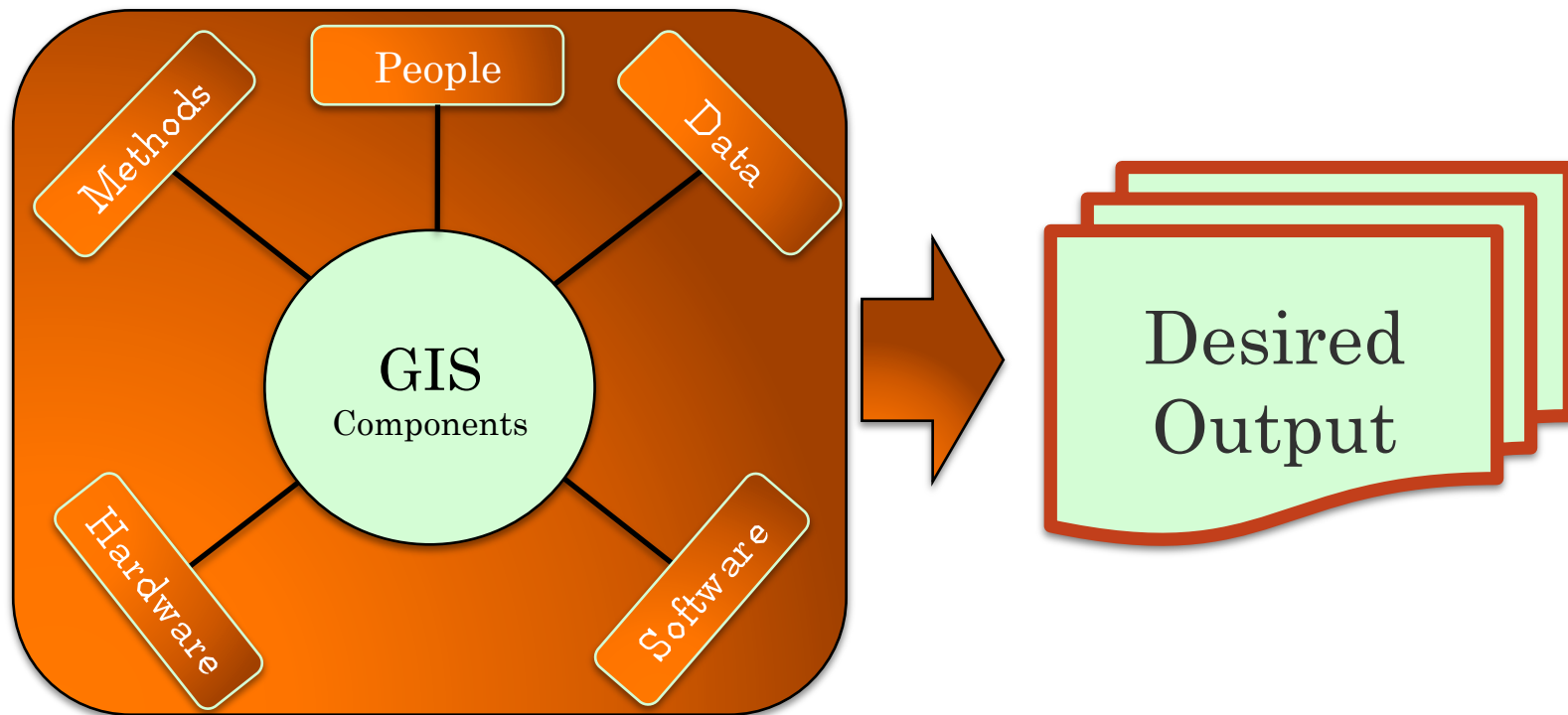
- A Framework for GIS Analysis



Source: ESRI

EXAMPLES OF GIS APPLICATIONS 2/6

- Integrating the five basic elements of GIS to produce the desired output.



Adopted from:

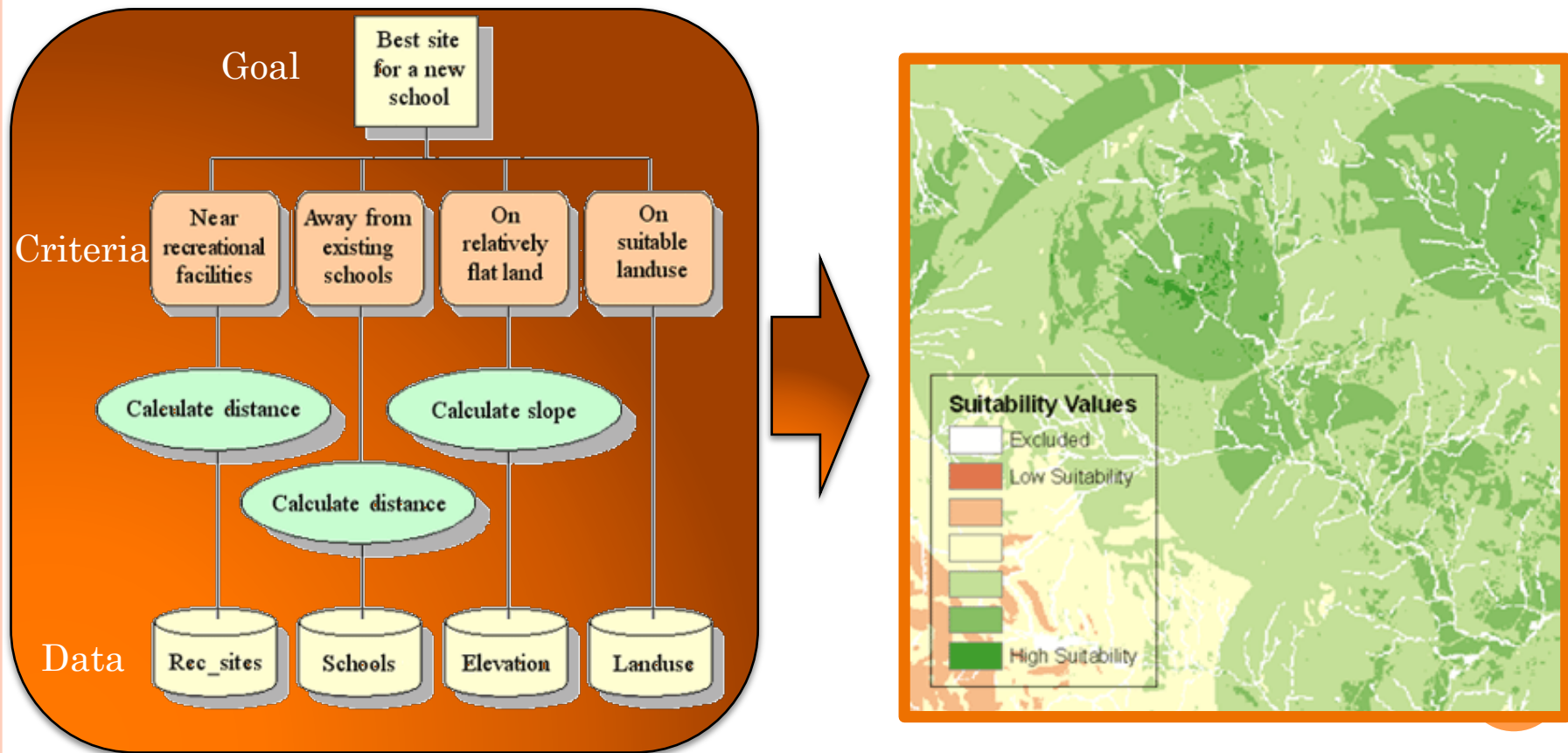
<http://www.mapsofindia.com/gis/gis-components.html>

http://bgis.sanbi.org/gis-primer/page_12.htm

http://www.sfu.ca/rdl/GIS/tour/comp_gis.html

EXAMPLES OF GIS APPLICATIONS 3/6

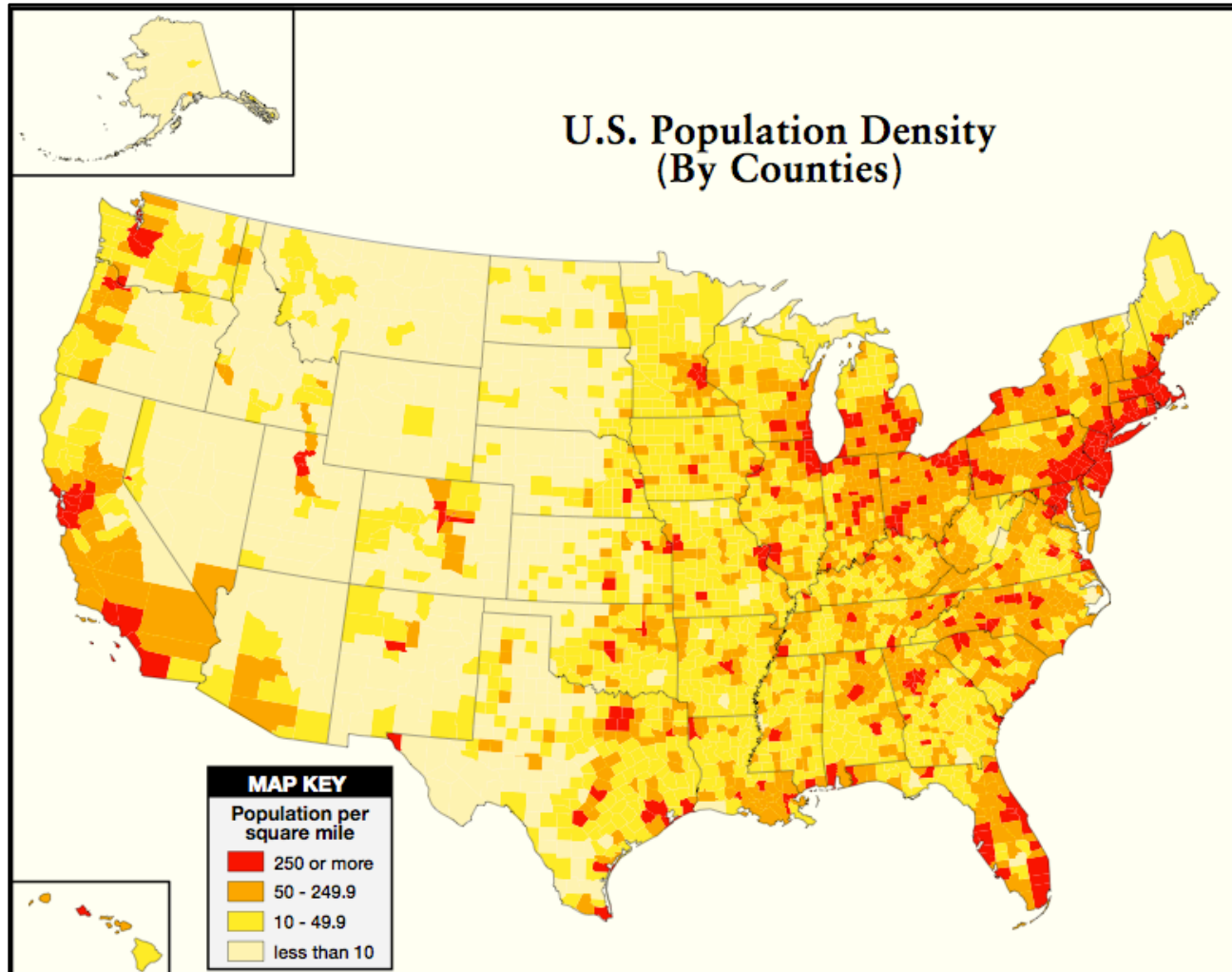
- Suitability analysis for the best site for a new school



Source: ESRI

EXAMPLES OF GIS APPLICATIONS 4/6

○ Mapping population density

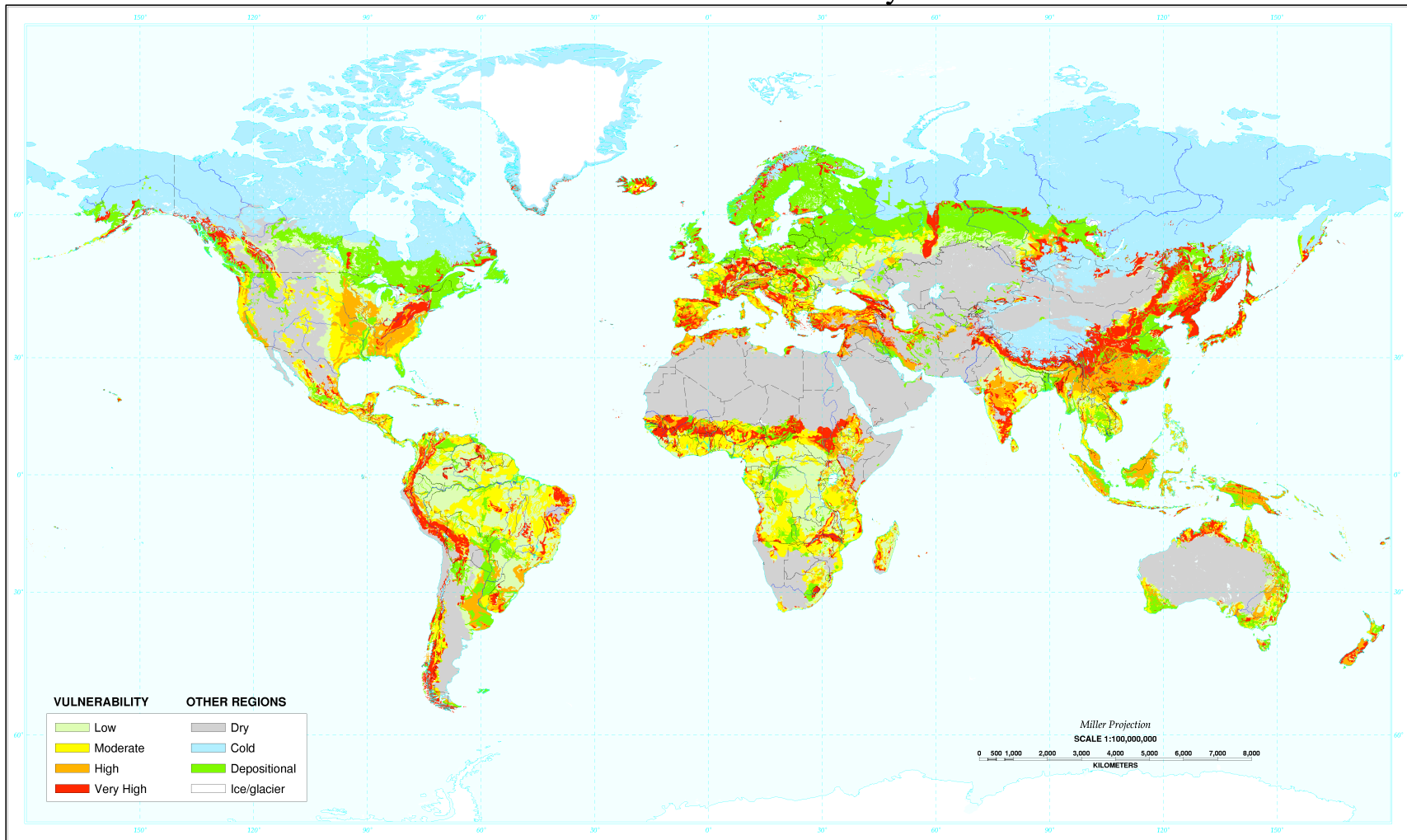


Source: <http://www.census.gov/dmd/www/pdf/512popdn.pdf>

EXAMPLES OF GIS APPLICATIONS 5/6



Water Erosion Vulnerability

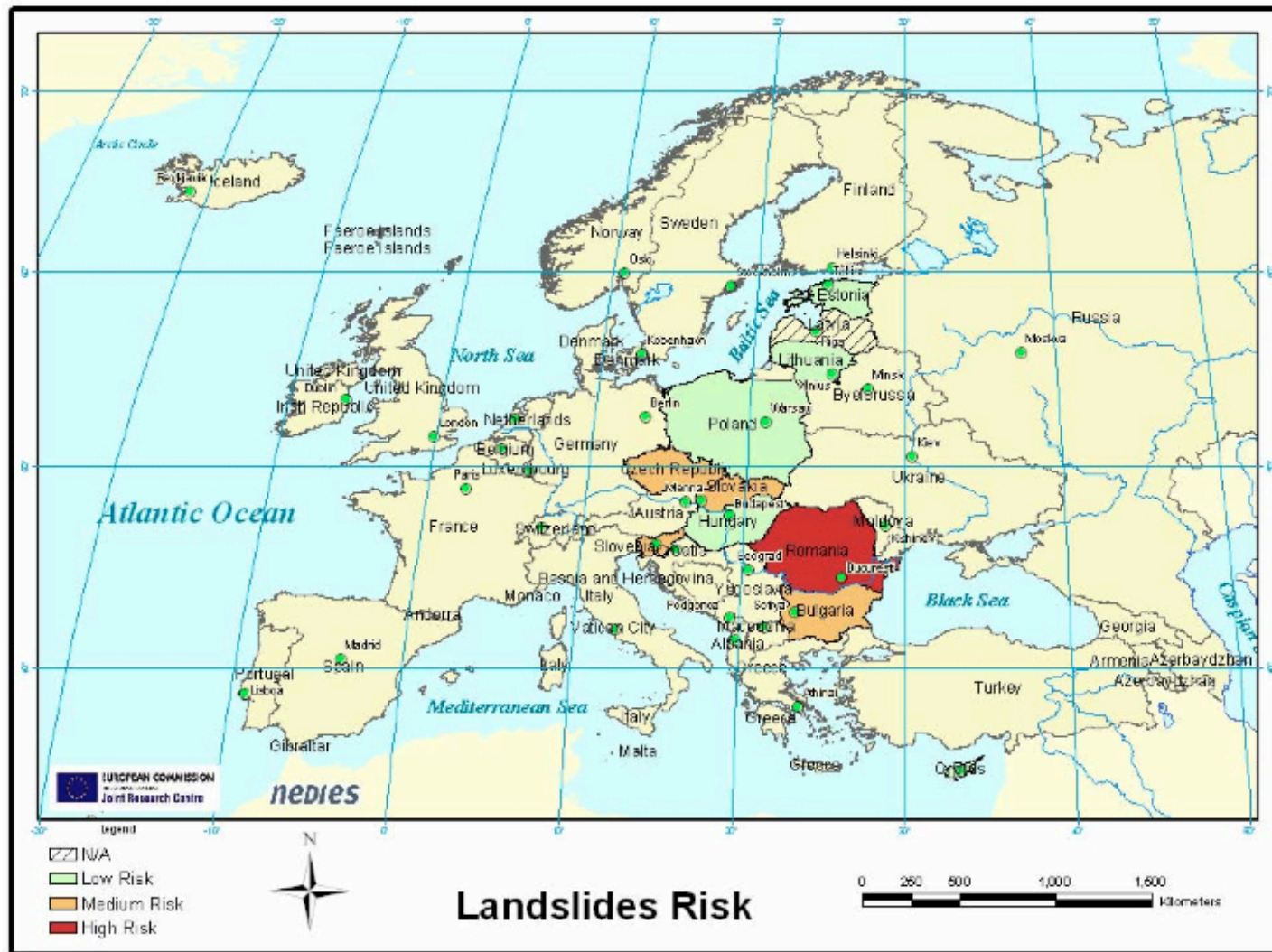


Source: <http://soils.usda.gov/use/worldsoils/mapindex/erosh2o.html>

Washington D.C. 2002

EXAMPLES OF GIS APPLICATIONS 6/6

○ Landslide Risk Mapping



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- <http://www.asdi.com/remote-sensing/applications/ground-truthing>
- http://www.sfu.ca/rdl/GIS/tour/comp_gis.html
- <http://www.mapsofindia.com/gis/gis-components.html>
- <http://www.picsearch.com/pictures/fashion/jewelry/watch%20brands/garmin.html>
- http://bgis.sanbi.org/gis-primer/page_12.htm