Introduction to Geographical Information System

Geography to GIS

Dr Muhammad Ateeq Qureshi

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

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- What is Geography?
- History of Geography
- Emergence of Geography
- Modern Geography
- Concept of GIS
- Functions of GIS
- Components of GIS

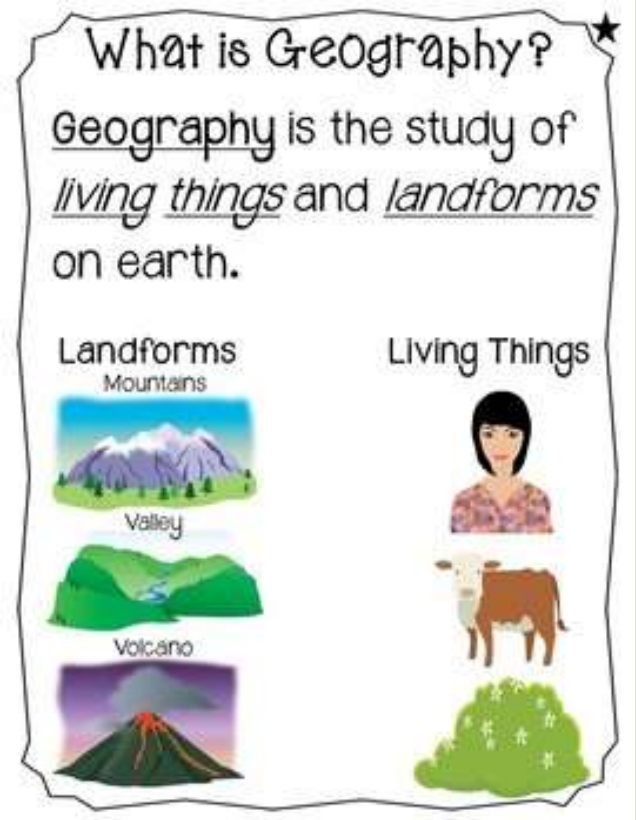
What is Geography?

What is Geography? 1/3

- The term "geography" comes to us from the ancient Greeks, who needed a word to describe the writings and maps that were helping them make sense of the world in which they lived.
- In Greek, *geo* means “earth” -*graphy* means “to write.”
- Using geography, Greeks developed an understanding of where their homeland was located in relation to other places, what their own and other places were like, and how people and environments were distributed.

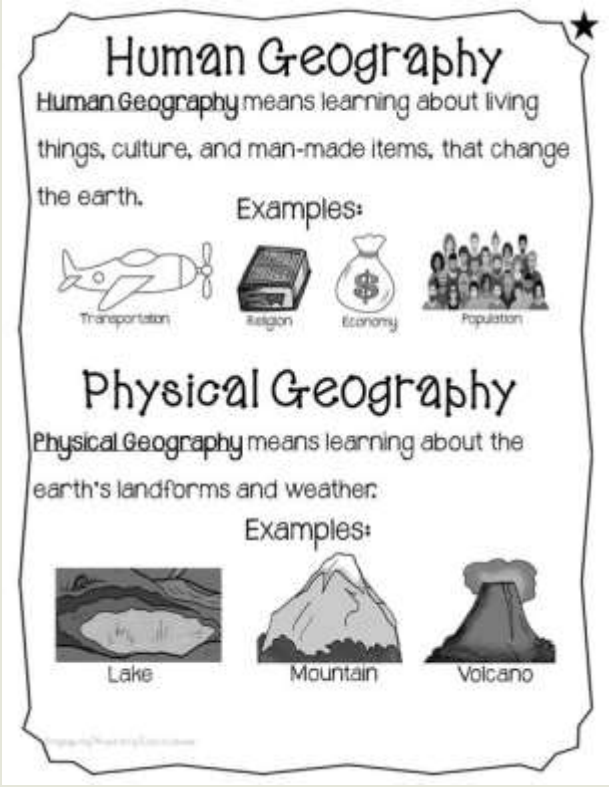
What is Geography? 2/3

- Geography is the study of places and the relationships between people and their environments.
- Geographers explore both the physical properties of Earth's surface and the human societies spread across it.
- They also examine how human cultural interacts with the natural environment, and the way that locations and places can have an impact on people.



What is Geography? 3/3

- Geography seeks to understand where things are found, **why** they are there, and **how** they develop and change over time.



History of Geography

History of Geography 1/12

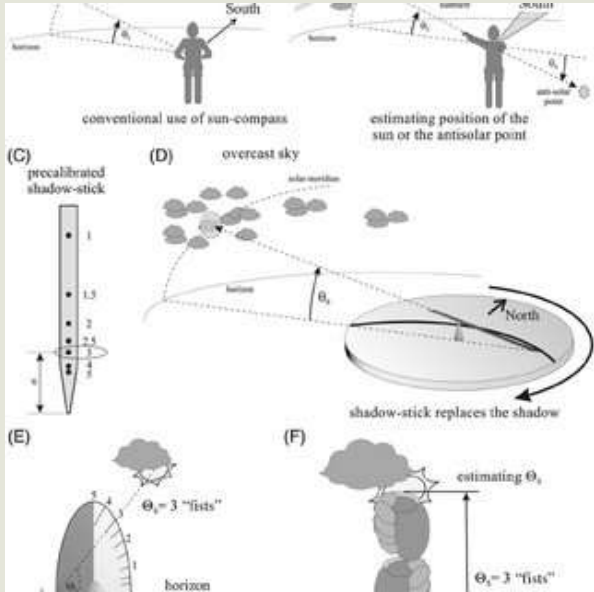
- The Greeks were not the only people interested in geography.
- Throughout human history, most societies have sought to understand something about their place in the world, and the people and environments around them.
- Indeed, mapmaking probably came even before writing in many places.

History of Geography 2/12

- Ancient Greek geographers were particularly influential.
- They developed very detailed maps of areas in and around Greece, including parts of Europe, Africa, and Asia.
- More importantly, they also raised questions about **how** and **why** different human and natural patterns came into being on Earth's surface, and **why** variations existed from place to place.

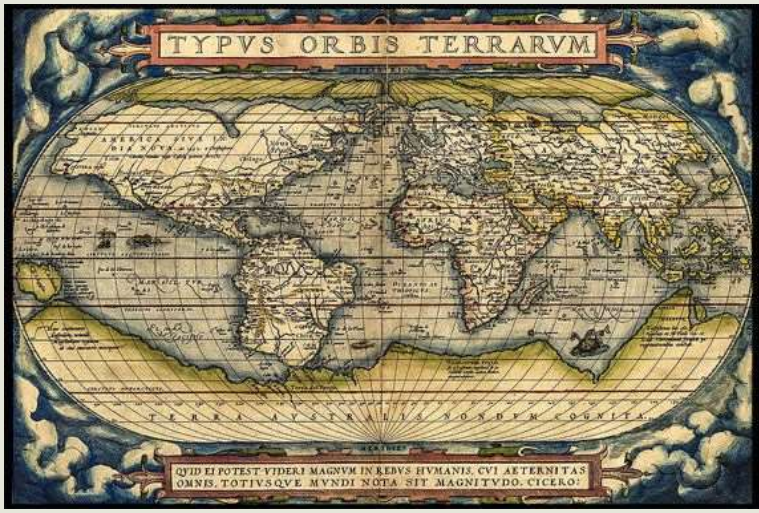
History of Geography 3/12

- The effort to answer these questions about patterns and distribution led them to figure out that the world was round, to calculate Earth's circumference, and to develop explanations of everything from the seasonal flooding of the Nile River to differences in population densities from place to place.



History of Geography 4/12

- During the **Middle Ages**, geography ceased to be a major academic pursuit in Europe.
- Advances in geography were chiefly made by scientists of the Muslim world, based around the Arabian Peninsula and North Africa.
- Geographers of this Islamic Golden Age created the world's first rectangular map based on a grid, a map system that is still familiar today.



History of Geography 5/12

- Islamic scholars also applied their study of people and places to agriculture, determining which crops and livestock were most suited to specific habitats or environments.
- In addition to the advances in the Middle East, the Chinese empire in Asia also contributed immensely to geography.

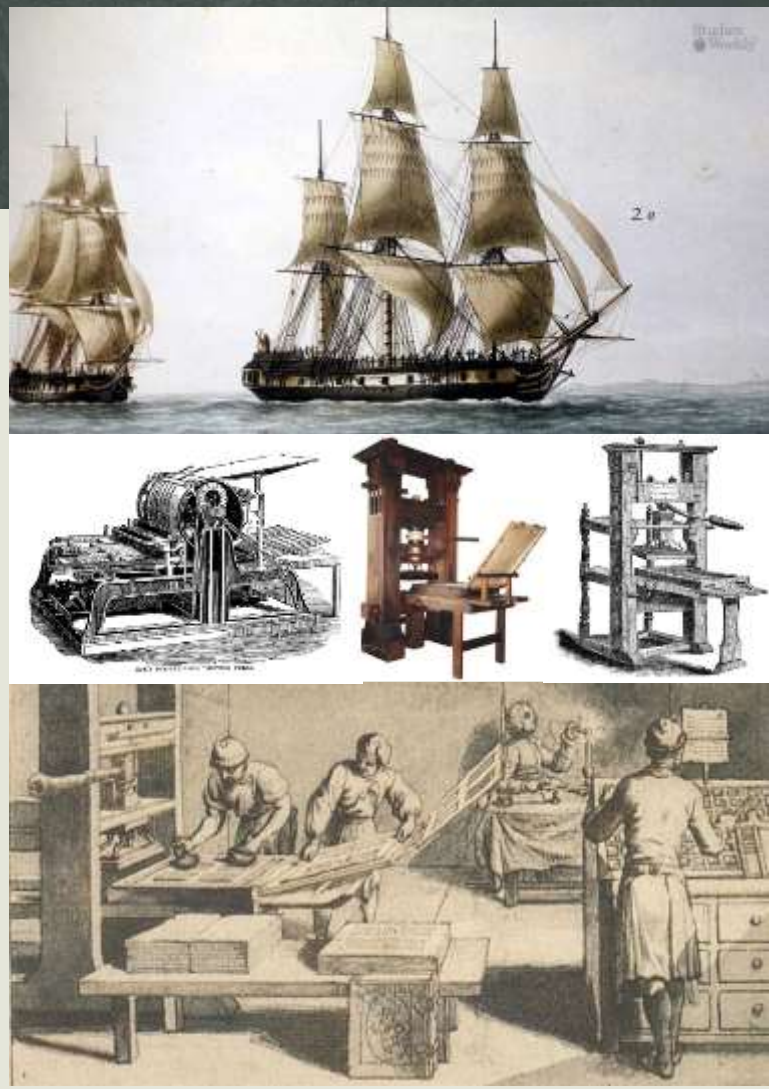
History of Geography 6/12

- Around 1000, they also achieved one of the most important developments in the history of geography.
- Until about 1500, China was the most prosperous civilization on Earth.
- The Chinese were scientifically advanced, especially in the field of astronomy.
- They were the first to use the compass for navigational purposes.

History of Geography 7/12

- In the early 1400s, the explorer Cheng Ho embarked on seven voyages to the lands bordering the China Sea and the Indian Ocean, establishing China's dominance throughout Southeast Asia.
- Through the 13th century travels of the Italian explorer Marco Polo.
- Europeans learned about the riches of China.

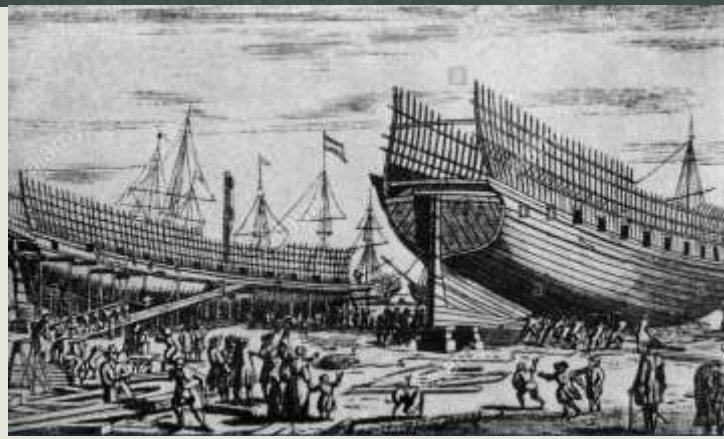
History of Geography 8/12



- The period of time between the 15th and 17th centuries is known in the West as the Age of Exploration or the Age of Discovery.
- With the dawn of the Age of Discovery, the study of geography regained popularity in Europe.
- The invention of the printing press in the mid-1400s helped spread geographic knowledge by making maps and charts widely available.

History of Geography 9/12

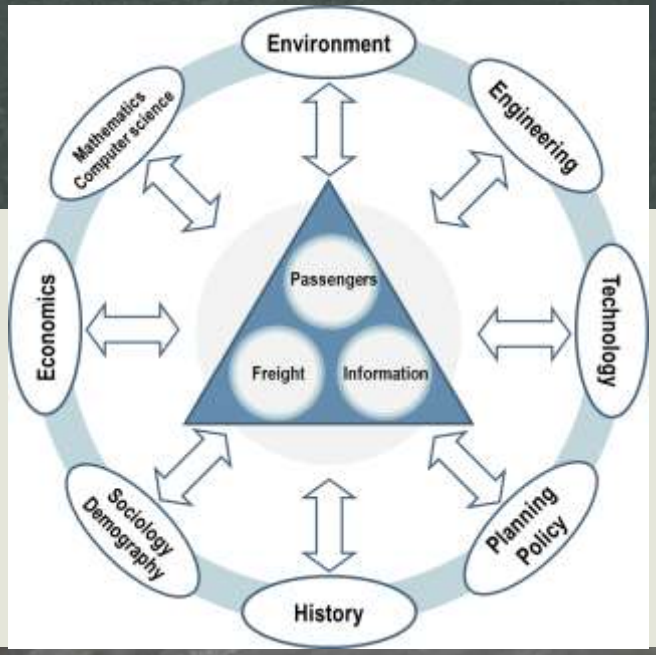
- Improvements in shipbuilding and navigation facilitated more exploring, greatly improving the accuracy of maps and geographic information.
- Greater geographic understanding allowed European powers to extend their global influence.
- During the Age of Discovery, European nations established colonies around the world.



History of Geography 10/12

- Improved transportation, communication, and navigational technology allowed countries such as the United Kingdom to successfully govern colonies as far away as the Americas, Asia, Australia, and Africa.
- Geography was not just a subject that made colonialism possible, however. It also helped people understand the planet on which they lived.

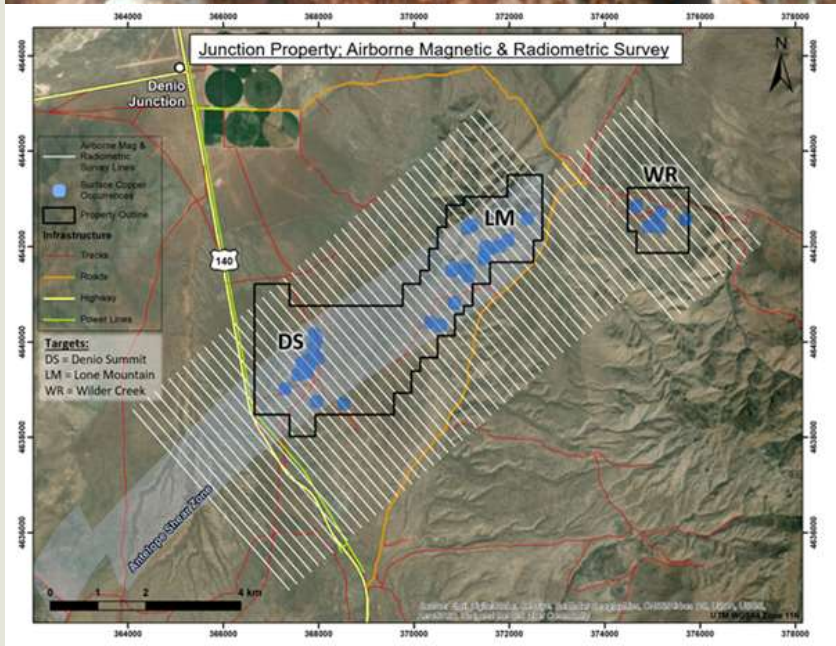
History of Geography 11/12



- Not surprisingly, geography became an important focus of study in schools and universities.
- Geography also became an important part of other academic disciplines, such as chemistry, economics, and philosophy.
- In fact, every academic subject has some geographic connection.

History of Geography 12/12

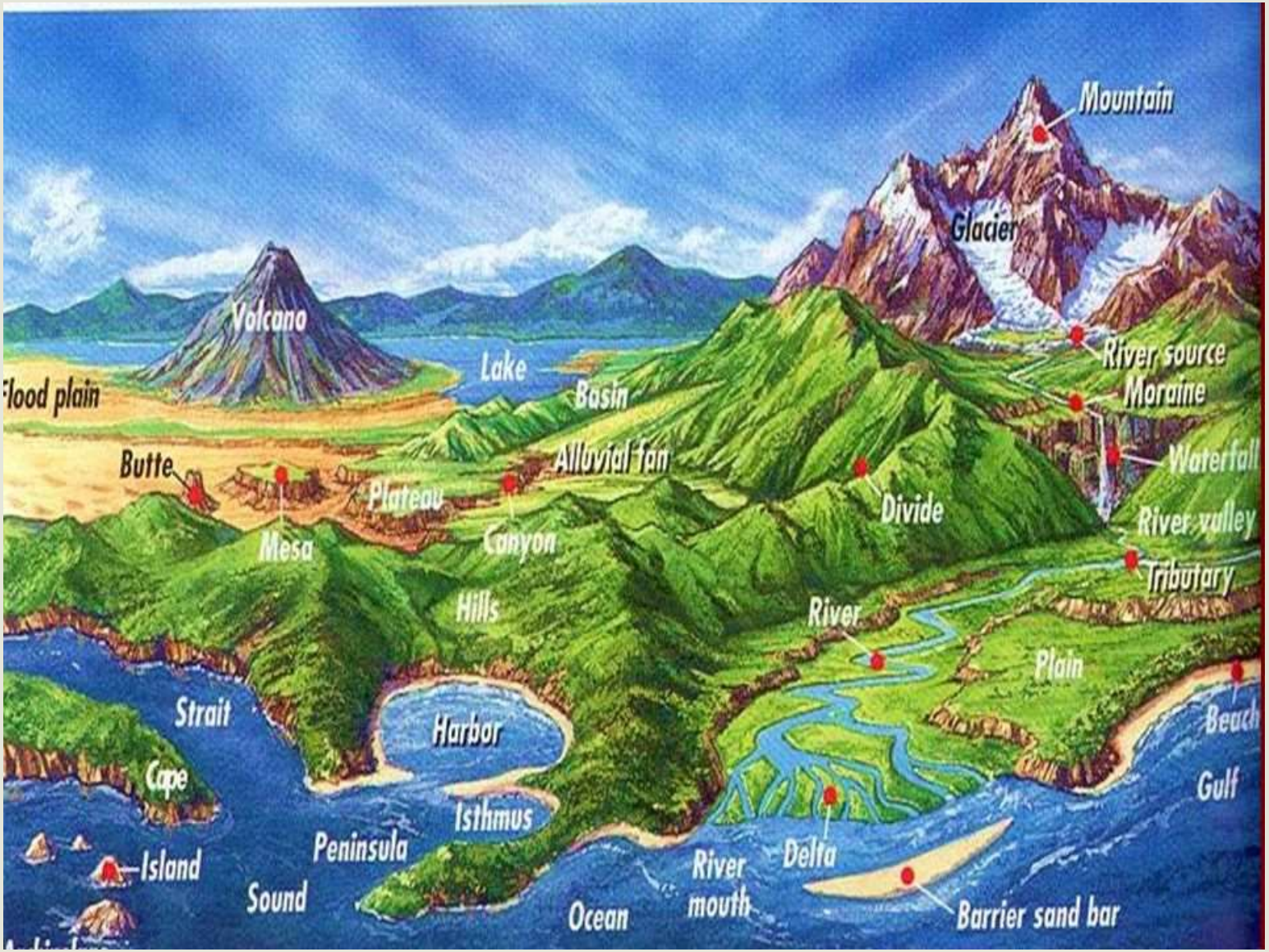
- Chemists study where certain chemical elements, such as gold or silver, can be found.
- Economists examine which nations trade with other nations, and what resources are exchanged.
- Philosophers analyze the responsibility people have to take care of the Earth.



Emergence of Modern Geography

Emergence of Modern Geography 1/6

- Some people have trouble understanding the complete scope of the discipline of geography because, unlike most other disciplines, geography is not defined by one particular topic.
- Instead, geography is concerned with many different topics—people, culture, politics, settlements, plants, landforms, and much more.


Mountain
Glacier
Volcano
Lake
Basin
Flood plain
River source
Moraine
Waterfall
Butte
Alluvial fan
Plateau
Divide
River valley
Mesa
Canyon
Tributary
Hills
River
Plain
Strait
Harbor
Beach
Cape
Gulf
Isthmus
Peninsula
Island
Delta
River mouth
Sound
Ocean
Barrier sand bar

Emergence of Modern Geography 2/6

- What distinguishes geography is that it approaches the study of diverse topics in a particular way (that is, from a particular perspective).
- Geography asks spatial questions—how and why things are distributed or arranged in particular ways on Earth's surface.
- It looks at these different distributions and arrangements at many different scales.
- It also asks questions about how the interaction of different human and natural activities on Earth's surface shape the characteristics of the world in which we live.

Emergence of Modern Geography 3/6

- Geography seeks to understand where things are found and why they are present in those places.
- How things that are located in the same or distant places influence one another over time and why places and the people who live in them develop and change in particular ways.
- Raising these questions is at the heart of the “geographic perspective.”
- ***Exploration*** has long been an important part of geography. But exploration no longer simply means going to places that have not been visited before.

Emergence of Modern Geography 4/6

- It means documenting and trying to explain the variations that exist across the surface of Earth, as well as figuring out what those variations mean for the future.
- The age-old practice of **mapping** still plays an important role in this type of exploration, but exploration can also be done by using images from satellites or **gathering information** from interviews.
- **Discoveries** can come by using computers to map and analyze the relationship among things in geographic space, or from piecing together the multiple forces, near and far, that shape the way individual places develop.

Emergence of Modern Geography 5/6

- Applying a geographic perspective demonstrates geography's concern not just with **where** things are, but with "the **why of where**"—a short, but useful definition of geography's central focus.
- Investigations of the geographic impact of human activities have advanced understanding of the role of humans in transforming the surface of Earth, exposing the spatial extent of threats such as water pollution by manmade waste.
- For example, geographic study has shown that a large mass of tiny pieces of plastic currently floating in the Pacific Ocean is approximately the size of Texas.

Emergence of Modern Geography 6/6

- Satellite images and other geographic technology identified the so-called "Great Pacific Garbage Patch."
- These examples of different uses of the geographic perspective help explain why geographic study and research is important as we confront many 21st century challenges.
- The study of geography is so broad, the discipline is typically divided into specialties.
- At the broadest level, geography is divided into **physical geography**, human geography, **geographic techniques**, and regional geography.

Physical Geography

Physical Geography

- The natural environment is the primary concern of physical geographers, although many physical geographers also look at how humans have altered natural systems.
- Physical geographers study Earth's seasons, climate, atmosphere, soil, streams, landforms, and oceans.
- Some disciplines within physical geography include geomorphology, glaciology, pedology, hydrology, climatology, biogeography, and oceanography.

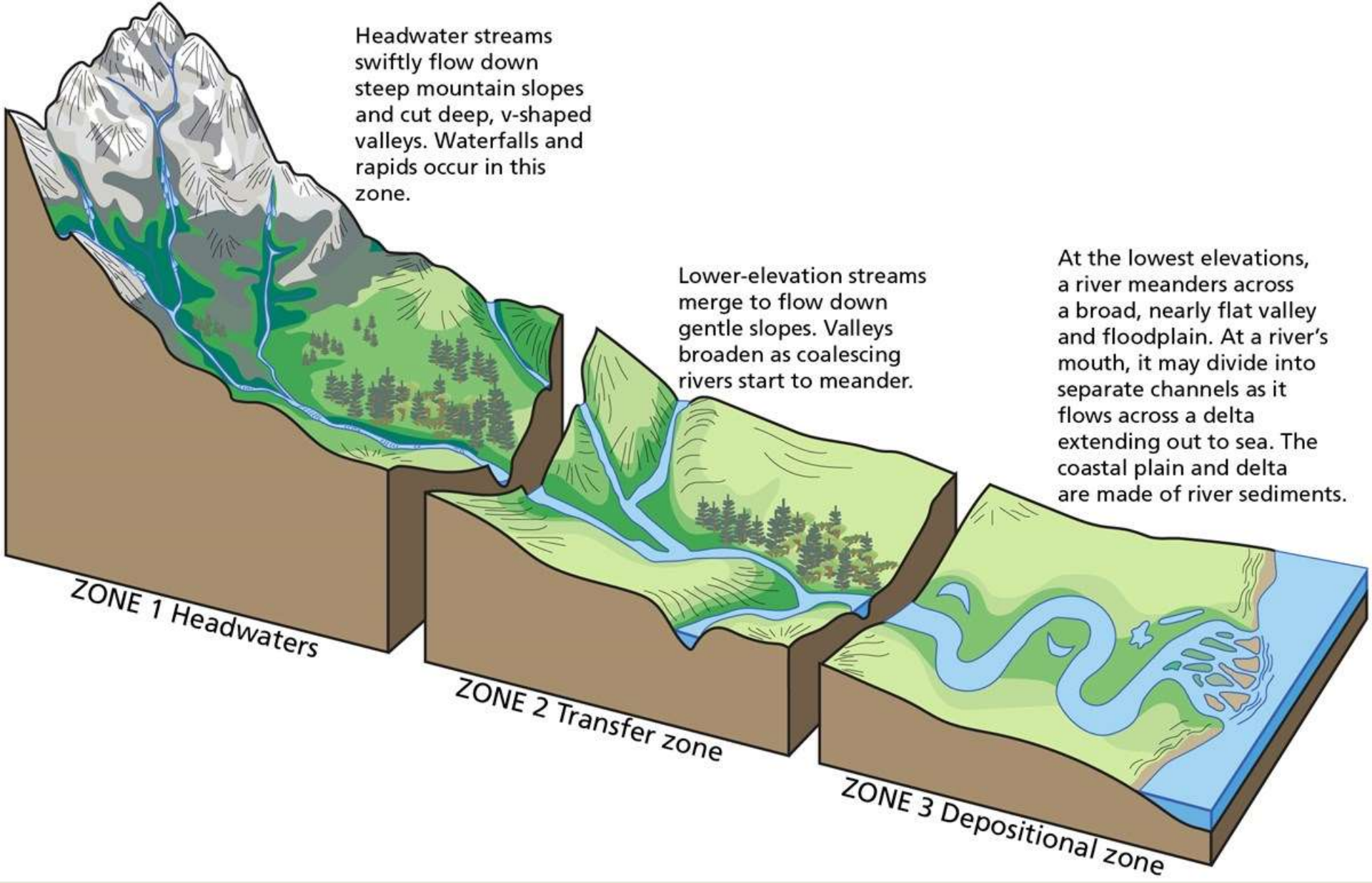
Geomorphology

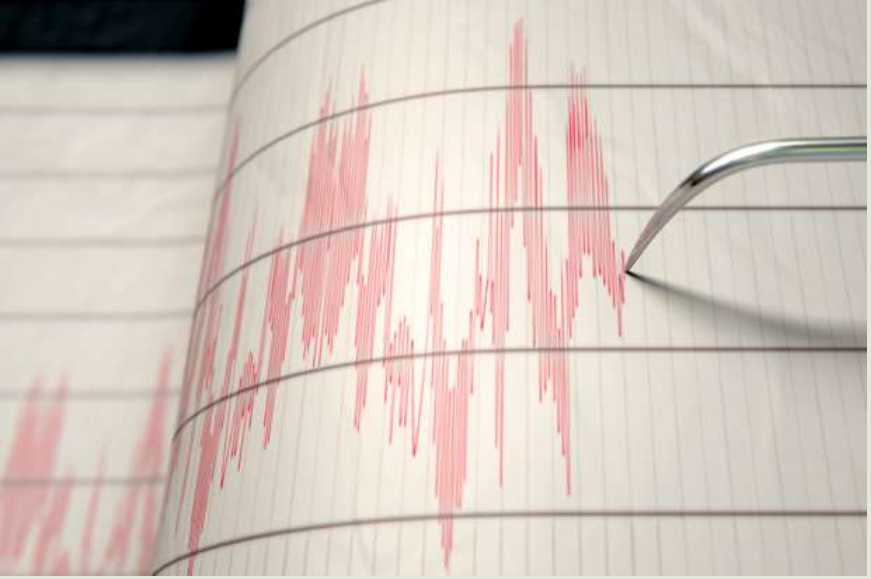
- Geomorphology is the study of landforms and the processes that shape them.
- Geomorphologists investigate the nature and impact of wind, ice, rivers, erosion, earthquakes, volcanoes, living things, and other forces that shape and change the surface of the Earth.

Wind Erosion

Wind Erosion

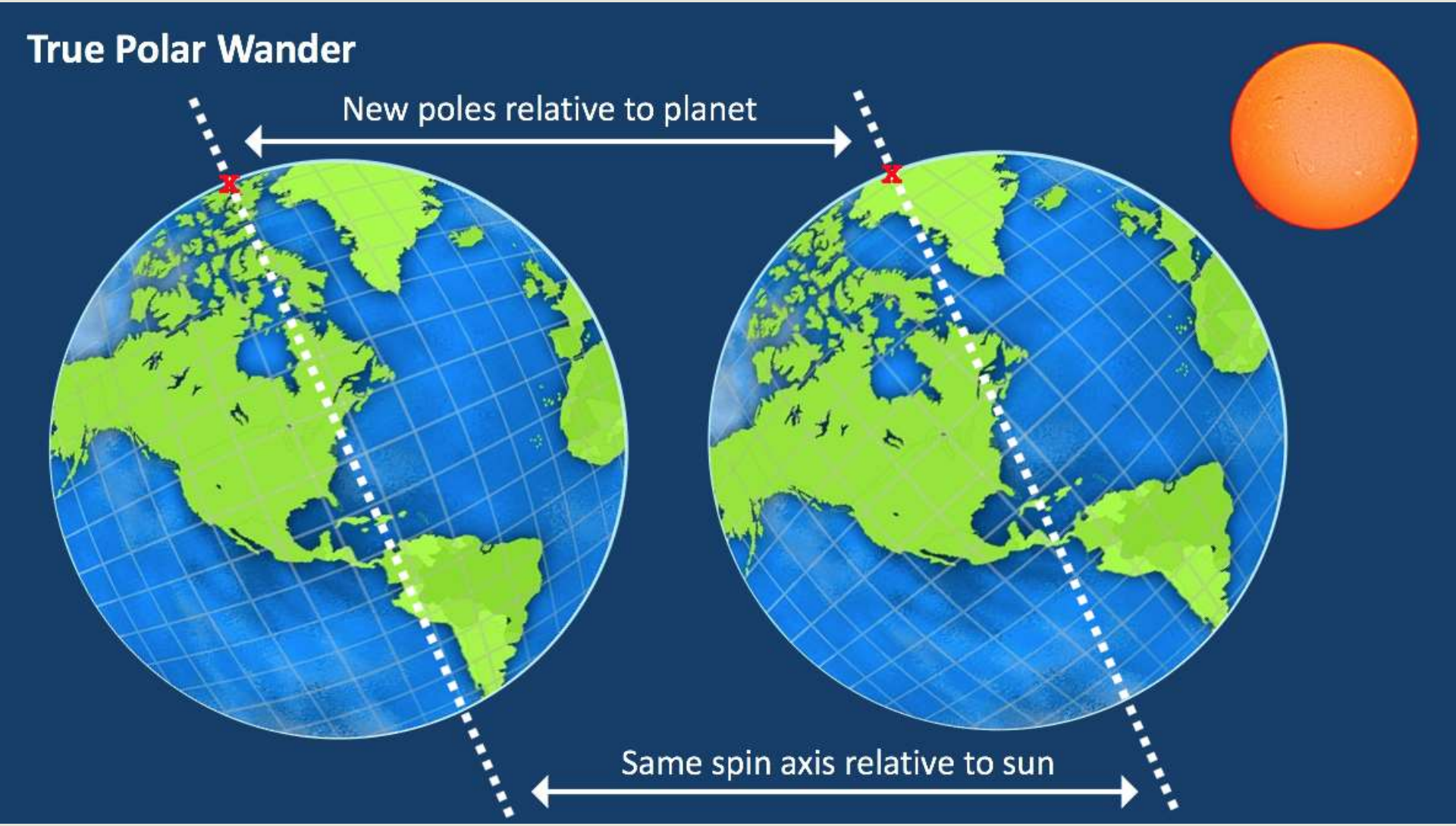
Wind Erosion

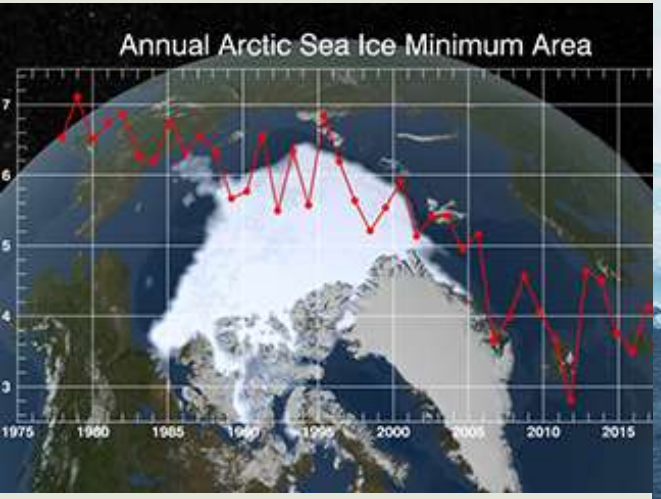

Headwater streams swiftly flow down steep mountain slopes and cut deep, v-shaped valleys. Waterfalls and rapids occur in this zone.
Lower-elevation streams merge to flow down gentle slopes. Valleys broaden as coalescing rivers start to meander.
At the lowest elevations, a river meanders across a broad, nearly flat valley and floodplain. At a river's mouth, it may divide into separate channels as it flows across a delta extending out to sea. The coastal plain and delta are made of river sediments.
ZONE 1 Headwaters
ZONE 2 Transfer zone
ZONE 3 Depositional zone



Glaciology

- Glaciologists focus on the Earth's ice fields and their impact on the planet's climate.
- Glaciologists document the properties and distribution of glaciers and icebergs.
- Data collected by glaciologists has demonstrated the retreat of Arctic and Antarctic ice in the past century.


True Polar Wander
New poles relative to planet
Same spin axis relative to sun


Annual Arctic Sea Ice Minimum Area
7
6
5
4
3
1975
1980
1985
2000
2010
2015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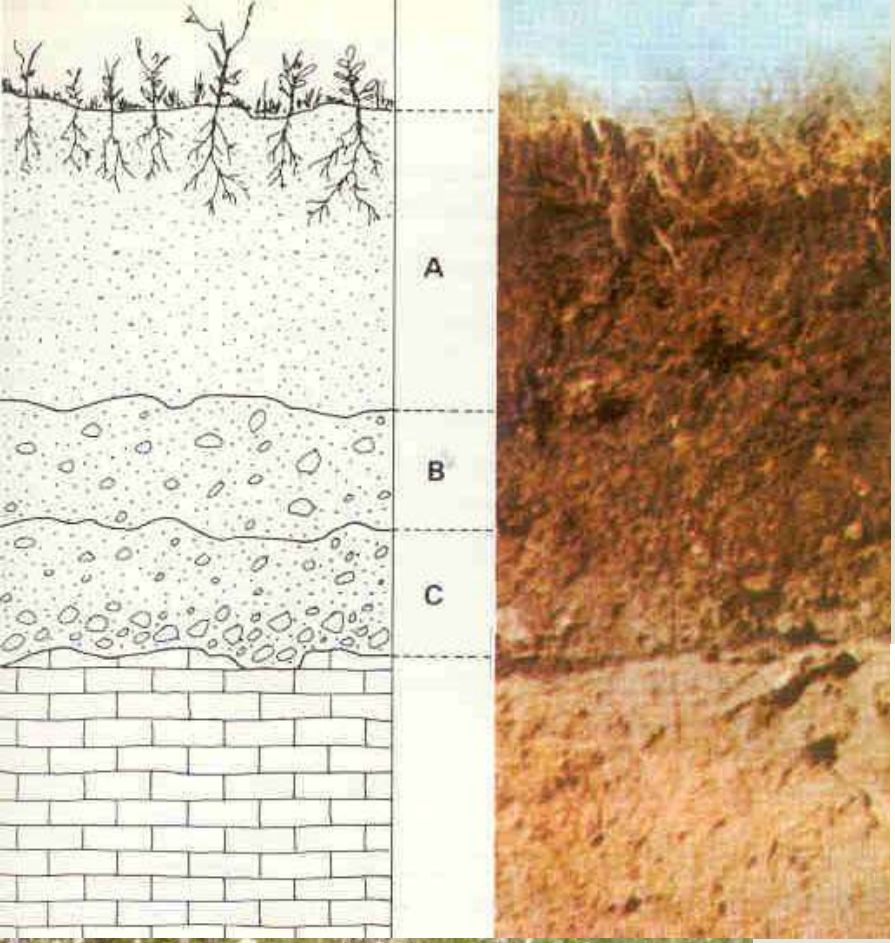
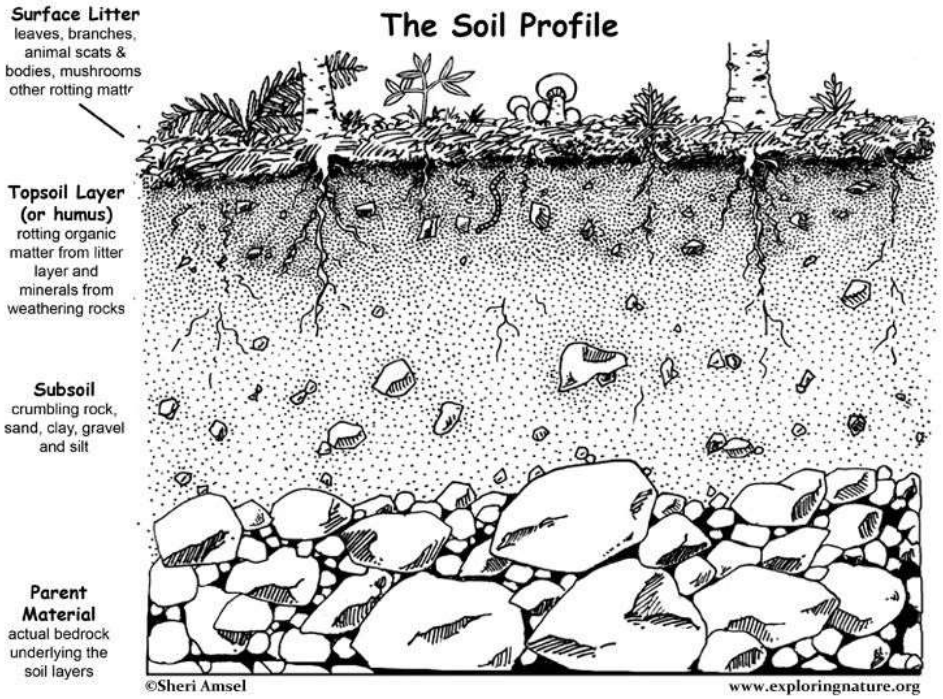
Pedology

- Pedologists study soil and how it is created, changed, and classified.
- Soil studies are used by a variety of professions, from farmers analyzing field fertility to engineers investigating the suitability of different areas for building heavy structures.

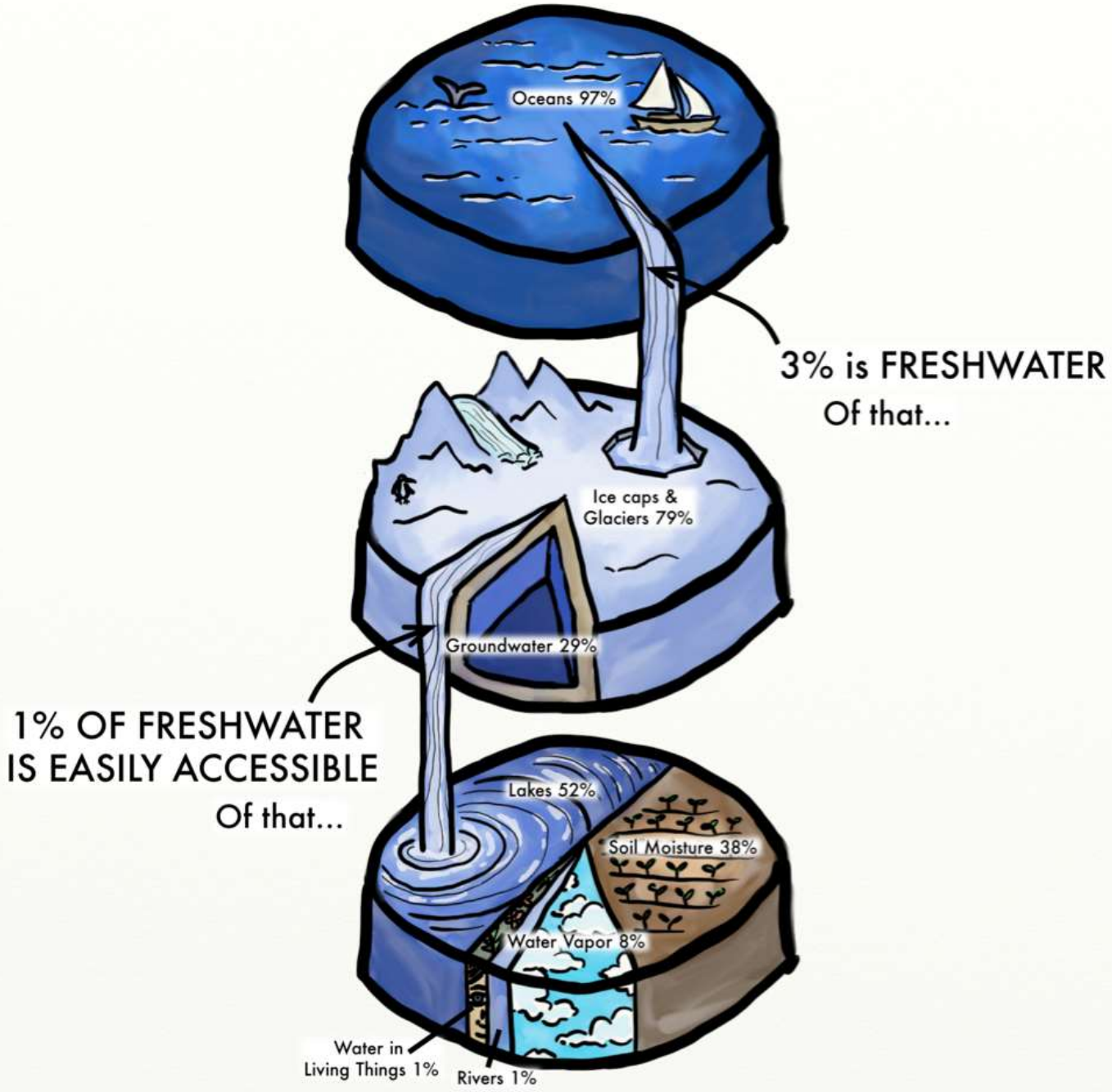

A
B
C


The Soil Profile
Surface Litter
leaves, branches, animal scats & bodies, mushrooms other rotting matt
Topsoil Layer (or humus)
rotting organic matter from litter layer and minerals from weathering rocks
Subsoil
crumbling rock, sand, clay, gravel and silt
Parent Material
actual bedrock underlying the soil layers
©Sheri Amsel
www.exploringnature.org

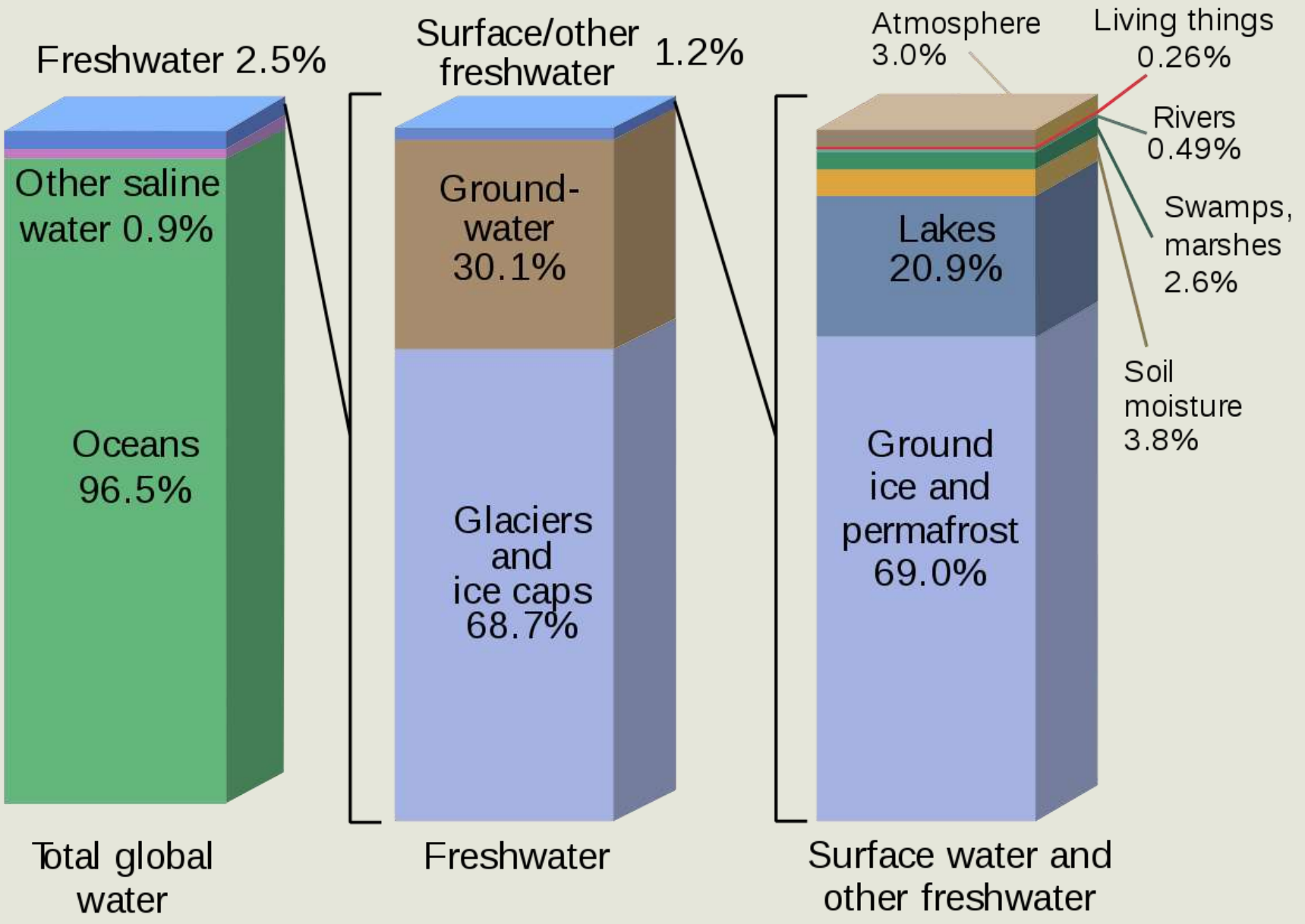
Hydrology

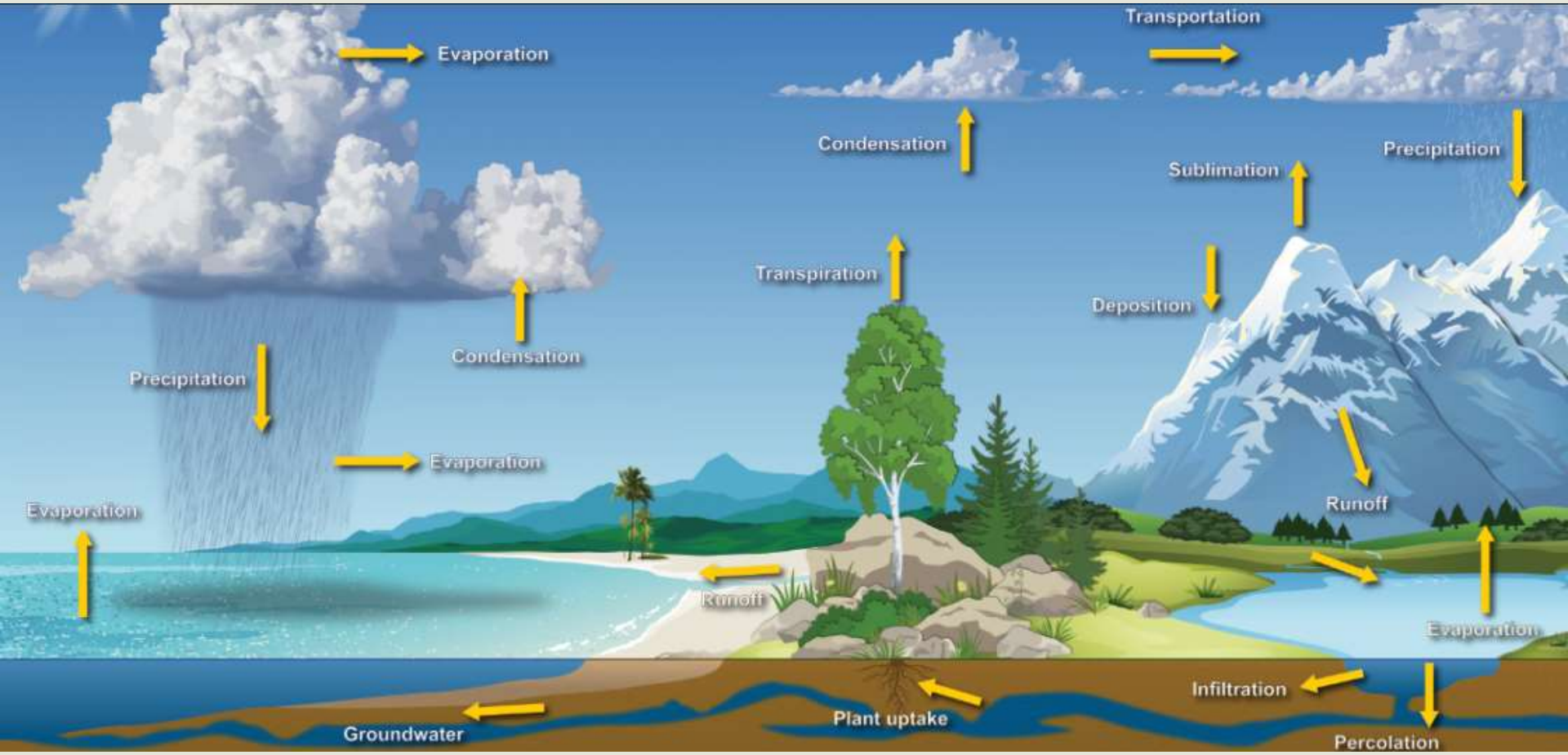
- Hydrology is the study of Earth's water, its properties, distribution and effects.
- Hydrologists are especially concerned with the movement of water as it cycles from the ocean to the atmosphere, then back to Earth's surface.
- Hydrologists provide insights that are critical to building dams, designing irrigation systems, monitoring water quality, tracking drought conditions, and predicting flood.

EARTH'S WATER



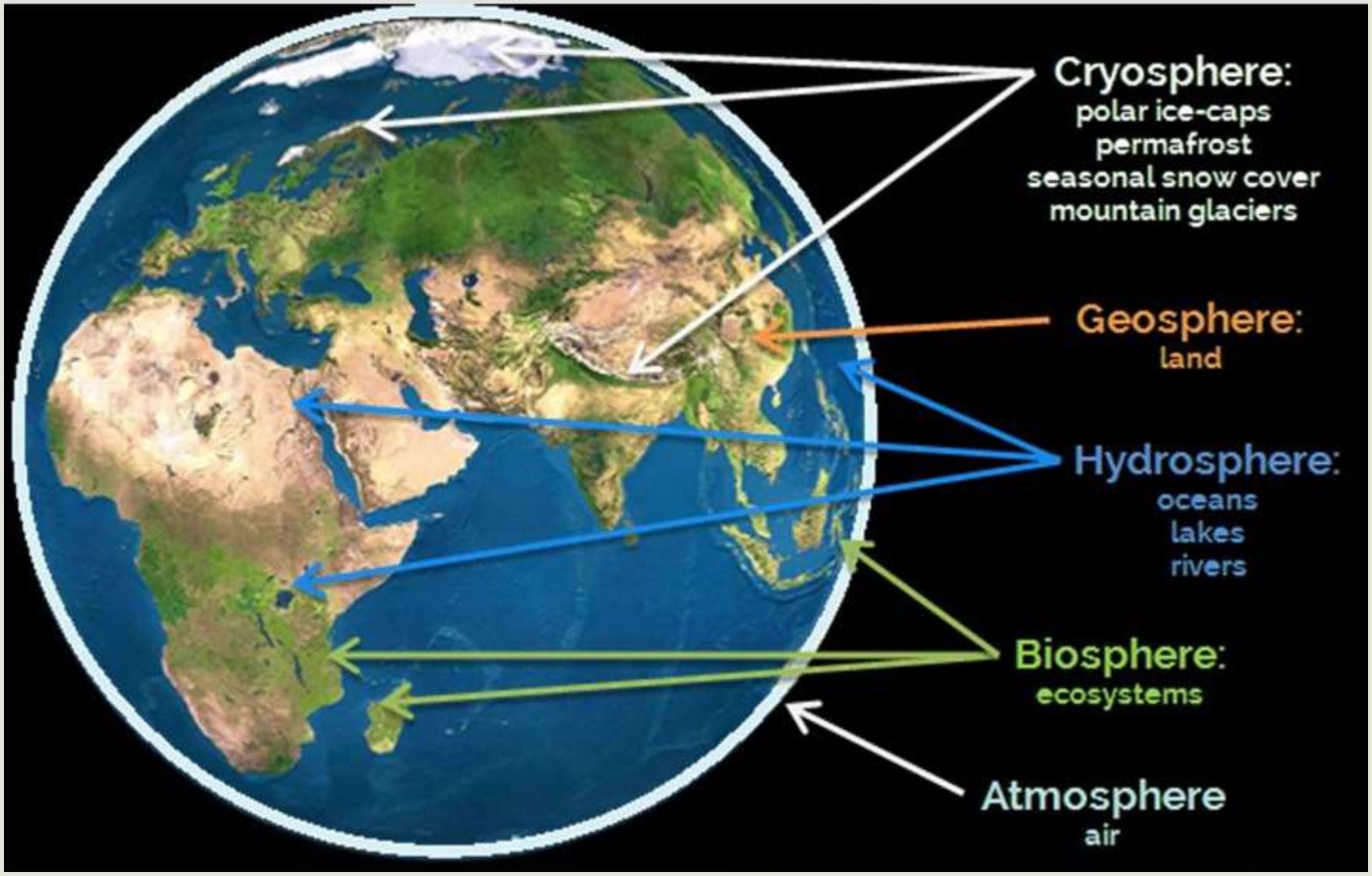
Where is Earth's Water?

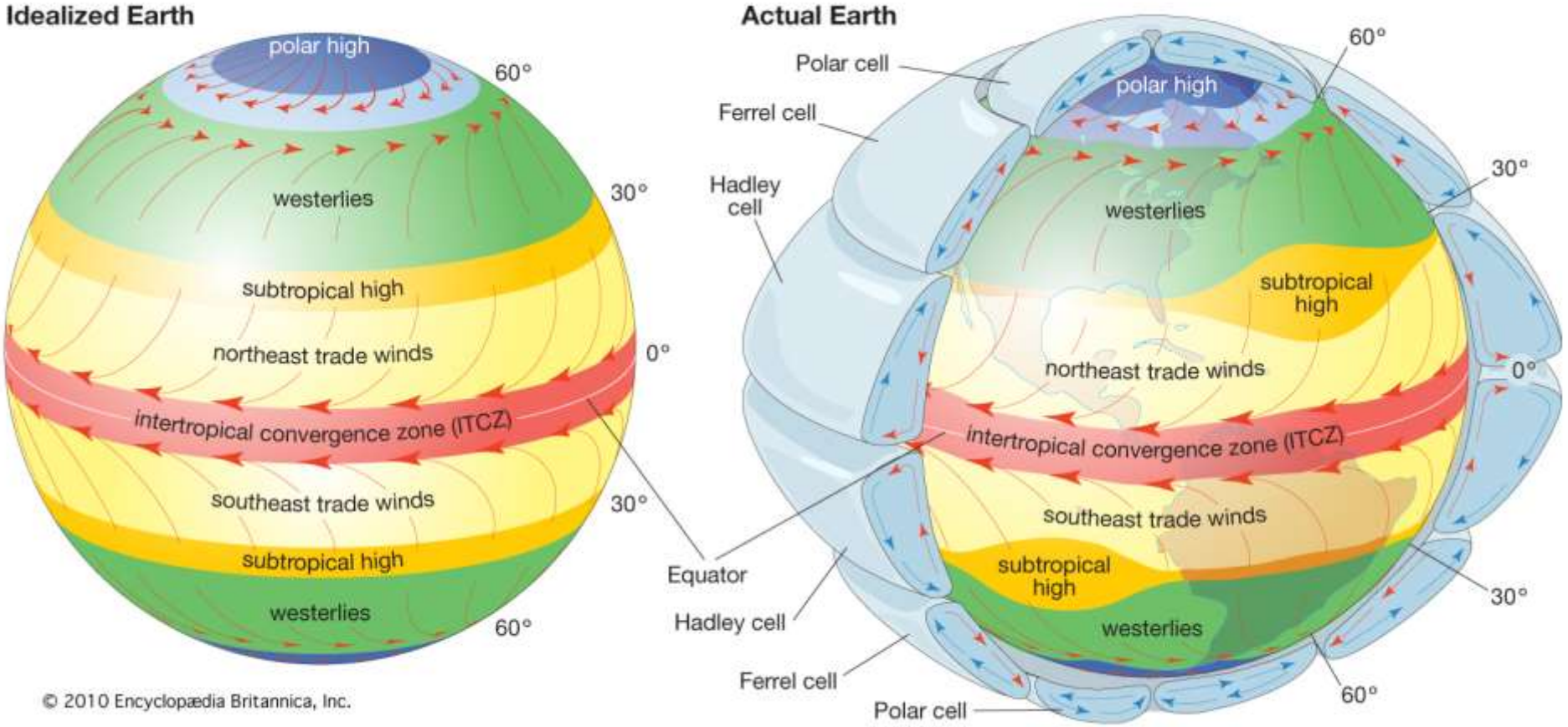



Evaporation
Transportation
Condensation
Precipitation
Sublimation
Transpiration
Deposition
Condensation
Precipitation
Evaporation
Runoff
Evaporation
Runoff
Evaporation
Infiltration
Plant uptake
Groundwater
Percolation

Climatology

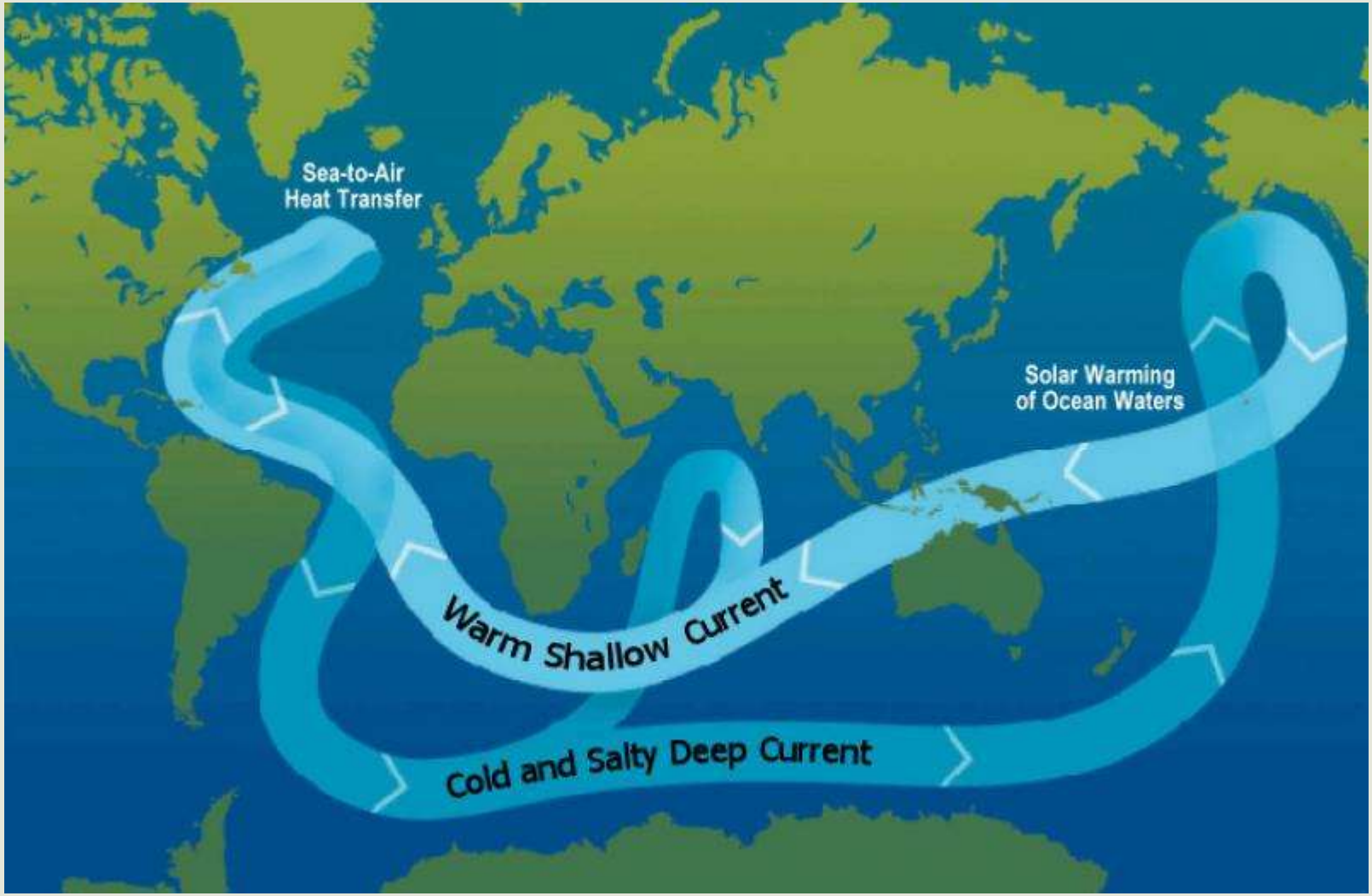
- Climatologists study Earth's climate system and its impact on Earth's surface.
- Climatologists make predictions about El Nino, a cyclical weather phenomenon of warm surface temperatures in the Pacific Ocean.
- They analyze the dramatic worldwide climate changes caused by El Nino, such as flooding, drought, heavy rains or an unseasonably warm winter.


Cryosphere:
polar ice-caps
permafrost
seasonal snow cover
mountain glaciers
Geosphere:
land
Hydrosphere:
oceans
lakes
rivers
Biosphere:
ecosystems
Atmosphere
air


Idealized Earth
polar high
60°
westerlies
30°
subtropical high
northeast trade winds
0°
intertropical convergence zone (ITCZ)
southeast trade winds
30°
subtropical high
westerlies
60°
© 2010 Encyclopædia Britannica, Inc.
Actual Earth
Polar cell
Ferrel cell
Hadley cell
60°
polar high
30°
westerlies
subtropical high
northeast trade winds
0°
intertropical convergence zone (ITCZ)
southeast trade winds
subtropical high
westerlies
Equator
Hadley cell
Ferrel cell
Polar cell
30°
60°

Oceanography

- Oceanography, a related discipline of physical geography, focuses on the creatures and environments of the world's oceans.
- Observation of ocean tides and currents constituted some of the first oceanographic investigations.
- Today, oceanographers conduct research on the impacts of water pollution, track tsunamis, design offshore oil rigs, investigate underwater eruptions of lava, etc.


Sea-to-Air
Heat Transfer
Solar Warming
of Ocean Waters
Warm Shallow Current
Cold and Salty Deep Current

Geographic Techniques

Geographic Techniques 1/7

- Specialists in geographic techniques study the ways in which geographic processes can be analyzed and represented using different methods and technologies.
- Mapmaking, or cartography, is perhaps the most basic of these.
- Cartography has been instrumental to geography throughout the ages.


THE WORLD,

Geographic Techniques 2/7

- As early as 1500 BCE, Polynesian navigators in the Pacific Ocean used complex maps made of tiny sticks and shells that represented islands and ocean currents they would encounter on their voyages.
- Satellites placed into orbit by the U.S. Department of Defense communicate with receivers on the ground called global positioning system (GPS) units to instantly identify exact locations on Earth.

GLOBAL POSITIONING SYSTEM (GPS)

Geographic Techniques 3/7

- Today, almost the entire surface of Earth has been mapped with remarkable accuracy, and much of this information is available instantly on the internet.
- One of the most remarkable of these websites is Google Earth, which “lets you fly anywhere on Earth to view satellite imagery, maps, terrain, 3D buildings, from galaxies in outer space to the canyons of the ocean.”

Geographic Techniques 4/7

- Technological developments during the past 100 years have given rise to a number of other specialties for scientists studying geographic techniques.
- The airplane made it possible to photograph land from above.
- Now, there are many satellites and other above-Earth vehicles that help geographers figure out what the surface of the planet looks like and how it is changing.

Geographic Techniques 5/7

- Geographers looking at what above-Earth cameras and sensors reveal are specialists in remote sensing.
- Pictures taken from space can be used to make maps, monitor ice melt, assess flood damage, track oil spills, predict weather, or perform endless other functions.

Geographic Techniques 6/7

- Computerized systems that allow for precise calculations of how things are distributed and relate to one another have made the study of geographic information systems (GIS) an increasingly important specialty within geography.
- GIS are powerful databases that collect all types of information (maps, reports, statistics, satellite images, surveys, etc.) and link each piece of data to a geographic reference point, such as geographic coordinates.

Geographic Techniques 7/7

- This data, called geospatial information, can be stored, analyzed, modeled, and manipulated in ways not possible before GIS computer technology existed.
- The popularity and importance of GIS has given rise to a new science known as geographic information science (GISci).
- Geographic information scientists study patterns in nature as well as human development.

Basic Concept of GIS

What does GIS stand for?

- ***Geographic*** relates to the surface of the Earth
- ***Information*** is a knowledge derived from study, experience, or interaction.
- ***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

GISystem and GIScience

- **Geographic information System** is the analysis, storage, visualization and management of geographic data.
- **Geographic information System** focuses on the processes and methods that are used to sample, represent, manipulate and present information about the world *(Goodchild, 1992).*
- **Geographic information** science (GIScience) is the scientific discipline that studies data structures and computational techniques to capture, represent, process, and analyze GI.
- A framework for using information theory, spatial analysis and statistics, cognitive understanding, and cartography *(Longley et al., 2005).*

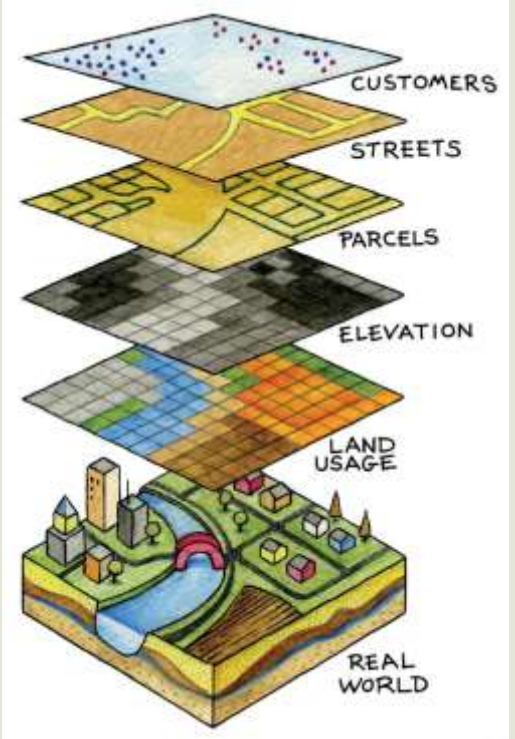
Functional Definition

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

GIScience Different From Geographic Information Systems?

We know all know that **Geographic Information Systems** looks at the "***what***" and "***where***".

GISystem store its information as points, lines and polygons. The "where" is their physical geography on a map.



- ***Points*** may be Towers/Poles as XY locations.
- ***Lines*** may be wires that are connected to each customer.
- ***Polygons*** may be the areas each line services.

GIScience Different From Geographic Information Systems?

All of these have attributes tied to them. The "***what***" is information about their feature.

- Towers can be made of steel, wood and other material.
- Wires can be overhead or underground.
- Service areas can have population and demographics they service.

The focal point of Geographic Information Science is the technical implementation of Geographic Information Systems.

In other words, it involves the conceptual ideas for ***how*** to implement GIS.

GIScience Builds Better Geographic Information Systems

- While GISystems answers the "***what***" and "***where***".
- GIScience is concerned with the "***how***".
- *For example*, GIScience conceptualizes ***how*** to store spatial information, collect data and analyze it.
- It covers all aspects of GISystems such as remote sensing, surveying, mathematics, programming and geography.
- GISystems relies on the developments in GIScience for future developments.

GIScience Builds Better Geographic Information Systems

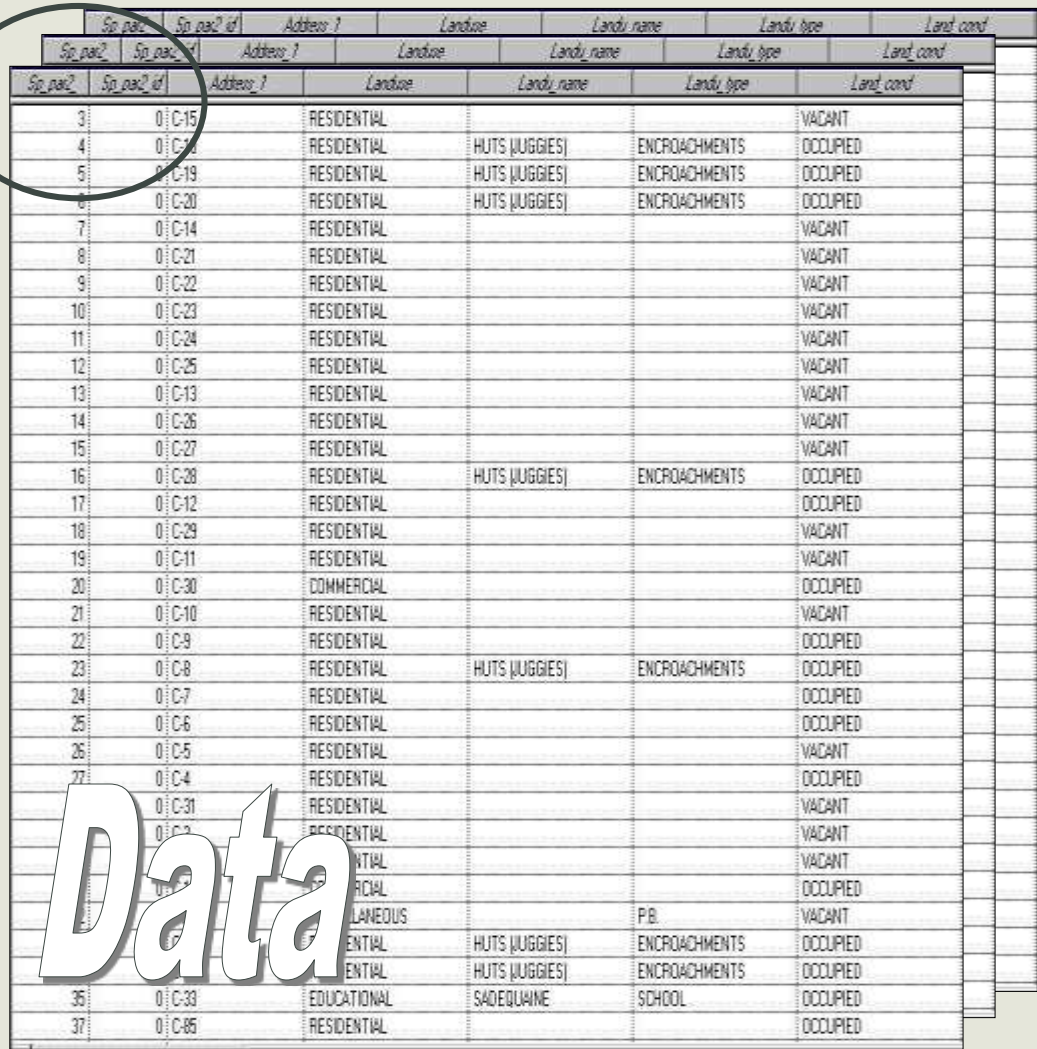
- GIS users use Geographic Information Systems as a **software tool** in every day work.
- But how did these tools become available?
- It came from GIScience which studies the data structures and computational techniques.
- As you know, this is the backbone of GIS systems which we use every day.

Basic Functions of GIS

Conventional Ways to Store Data

DATABASES

- **A Database comprises of tables having fields with specific data structure.**
- **The tables are linked with each other through various common fields.**



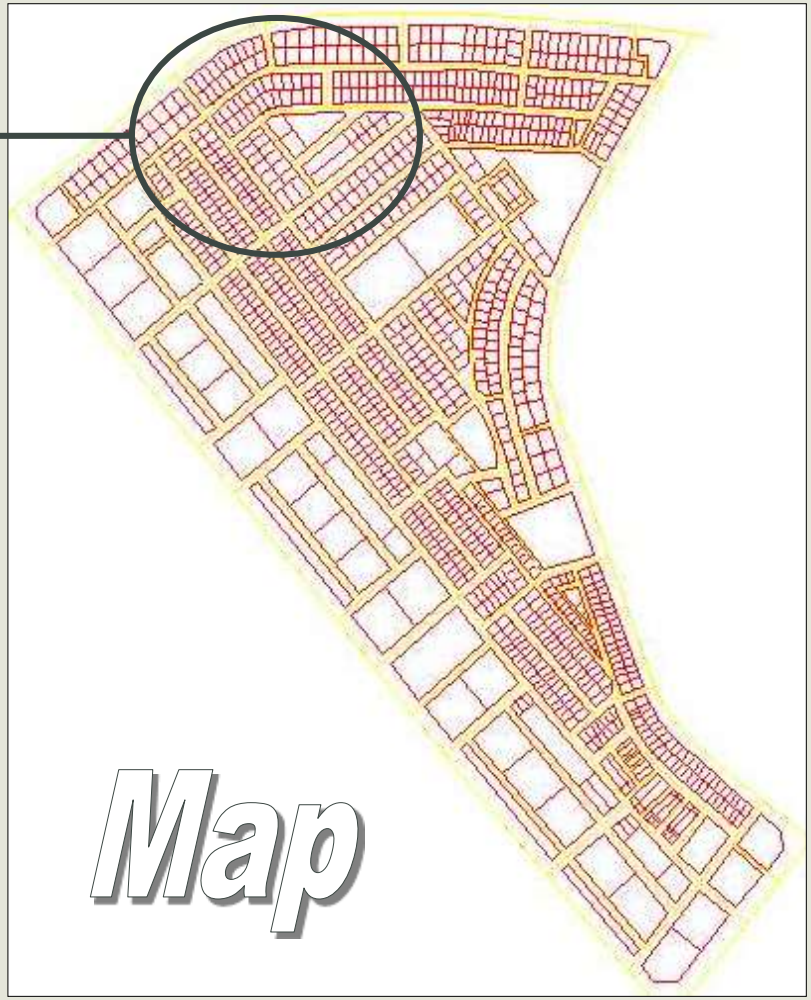
Sp_pac2_	Sp_pac2_id	Address_1	Landuse	Landu_name	Landu_type	Land_cond
3	0	C-15	RESIDENTIAL			VACANT
4	0	C-16	RESIDENTIAL	HUTS (JUGGIES)	ENCROACHMENTS	OCCUPIED
5	0	C-19	RESIDENTIAL	HUTS (JUGGIES)	ENCROACHMENTS	OCCUPIED
6	0	C-20	RESIDENTIAL	HUTS (JUGGIES)	ENCROACHMENTS	OCCUPIED
7	0	C-14	RESIDENTIAL			VACANT
8	0	C-21	RESIDENTIAL			VACANT
9	0	C-22	RESIDENTIAL			VACANT
10	0	C-23	RESIDENTIAL			VACANT
11	0	C-24	RESIDENTIAL			VACANT
12	0	C-25	RESIDENTIAL			VACANT
13	0	C-13	RESIDENTIAL			VACANT
14	0	C-26	RESIDENTIAL			VACANT
15	0	C-27	RESIDENTIAL			VACANT
16	0	C-28	RESIDENTIAL	HUTS (JUGGIES)	ENCROACHMENTS	OCCUPIED
17	0	C-12	RESIDENTIAL			OCCUPIED
18	0	C-29	RESIDENTIAL			VACANT
19	0	C-11	RESIDENTIAL			VACANT
20	0	C-30	COMMERCIAL			OCCUPIED
21	0	C-10	RESIDENTIAL			VACANT
22	0	C-9	RESIDENTIAL			OCCUPIED
23	0	C-8	RESIDENTIAL	HUTS (JUGGIES)	ENCROACHMENTS	OCCUPIED
24	0	C-7	RESIDENTIAL			OCCUPIED
25	0	C-6	RESIDENTIAL			OCCUPIED
26	0	C-5	RESIDENTIAL			VACANT
27	0	C-4	RESIDENTIAL			OCCUPIED
	0	C-31	RESIDENTIAL			VACANT
	0	C-3	RESIDENTIAL			VACANT
			NTIAL			VACANT
			RCIAL			OCCUPIED
			LANEOUS		P.B.	VACANT
			ENTIAL	HUTS (JUGGIES)	ENCROACHMENTS	OCCUPIED
			ENTIAL	HUTS (JUGGIES)	ENCROACHMENTS	OCCUPIED
35	0	C-33	EDUCATIONAL	SADEQUAINE	SCHOOL	OCCUPIED
37	0	C-85	RESIDENTIAL			OCCUPIED

Data

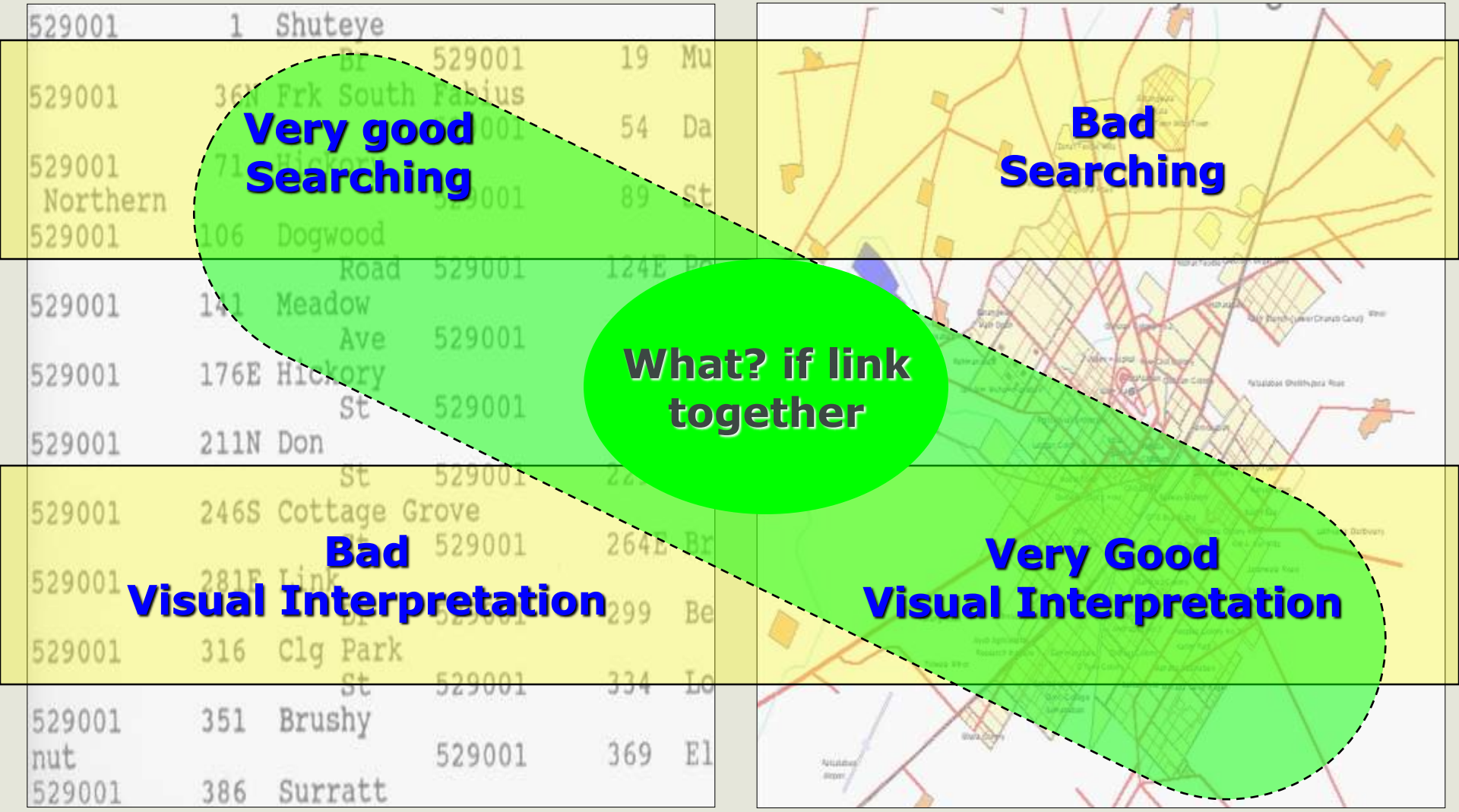
Conventional Ways to Store Data

MAPS

- Map can be defined as ***"A Facility for displaying interpretation of geographic information on a flat surface."***
- Location information describes the position of a particular geographic feature on earth's surface & provides the basis for representing spatial relationships between these features.



Databases Vs Maps



GIS Functions

capture*, *storage*, *analysis*, *query*, *display*, and *output

Basic GIS Functions

Capture

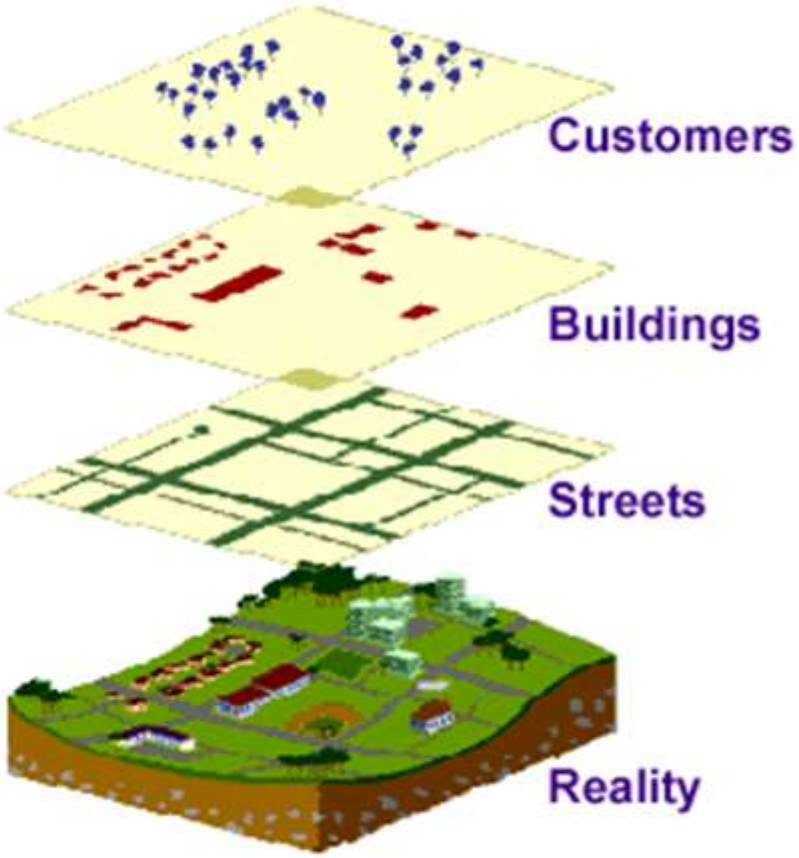
Store

Query

Analyze

Display

Output



Basic GIS Functions

Capture Collecting data using different data structures and technologies – GPS, RS, Digitizing, etc.

Store Data stored in the form of databases, spatial files, drawings, images, etc.

Query A GIS must provide utilities for finding specific features based on their location or attribute values

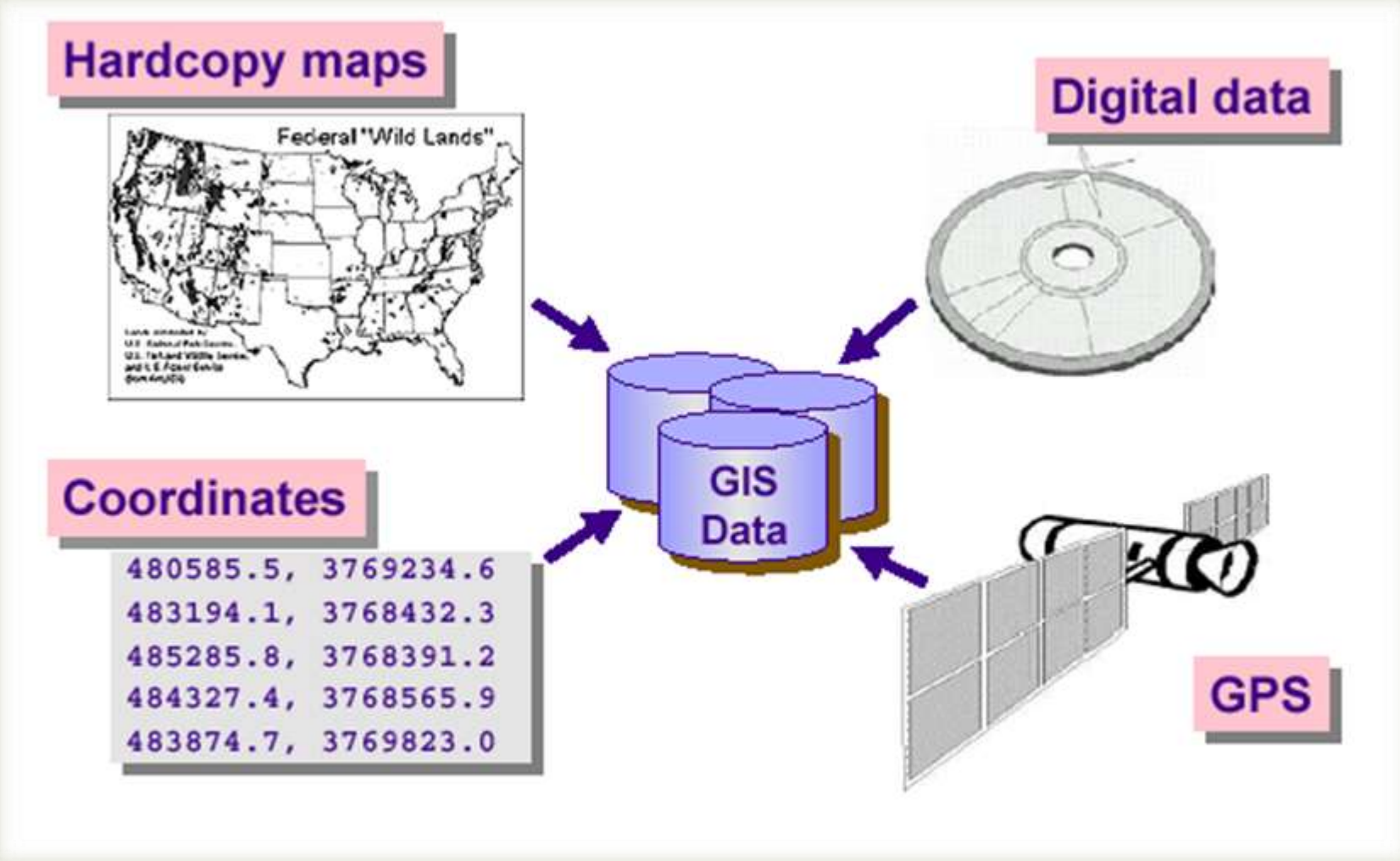
Analyze A GIS must have the ability to answer questions regarding the interaction of spatial relationships between multiple datasets

Display There must be tools for visualizing the spatial information in the form of maps

Output Results of display should be able to be output in a variety of formats

GIS Functions

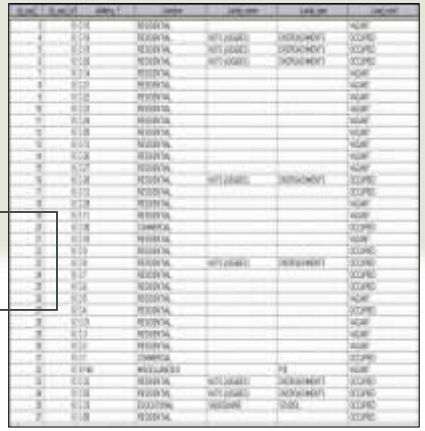
Data Capturing



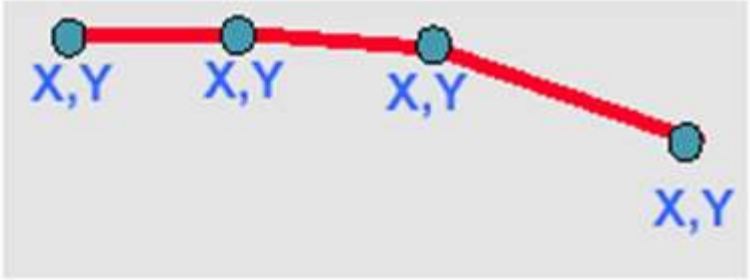
GIS Functions

Storing Data

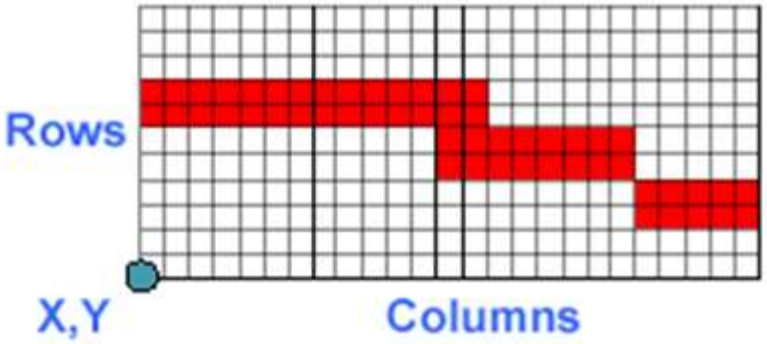
❖ Tables



- Vector formats
  - Discrete representations of reality



- Raster formats
  - Use square cells to model reality



Reality
(A highway)

GIS Functions

Spatial Query

- Identifying specific features

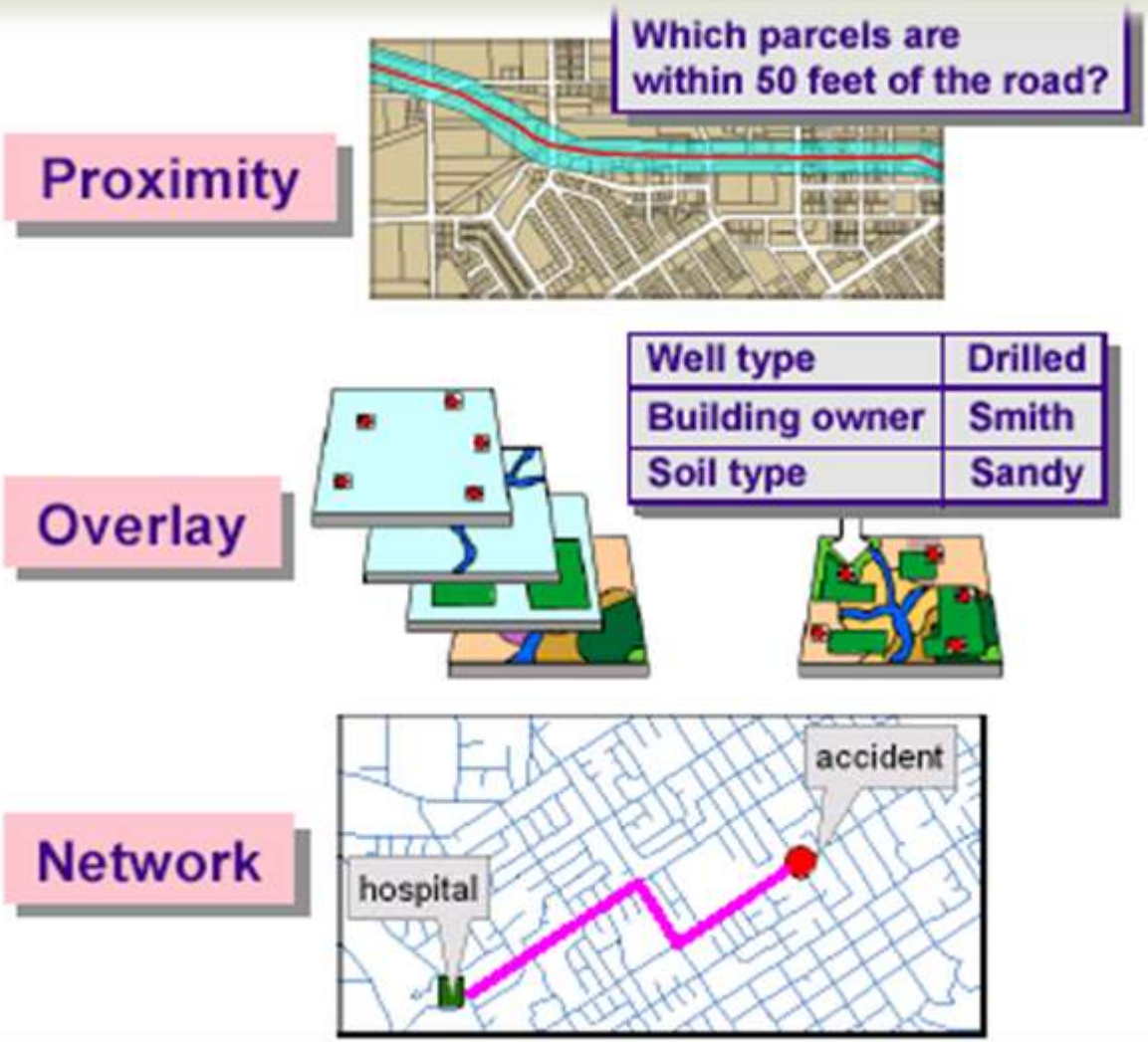
➢ **Query: Select Florida county Taylor on map**

- Identifying features based on conditions

Florida counties with a population greater than 300,000

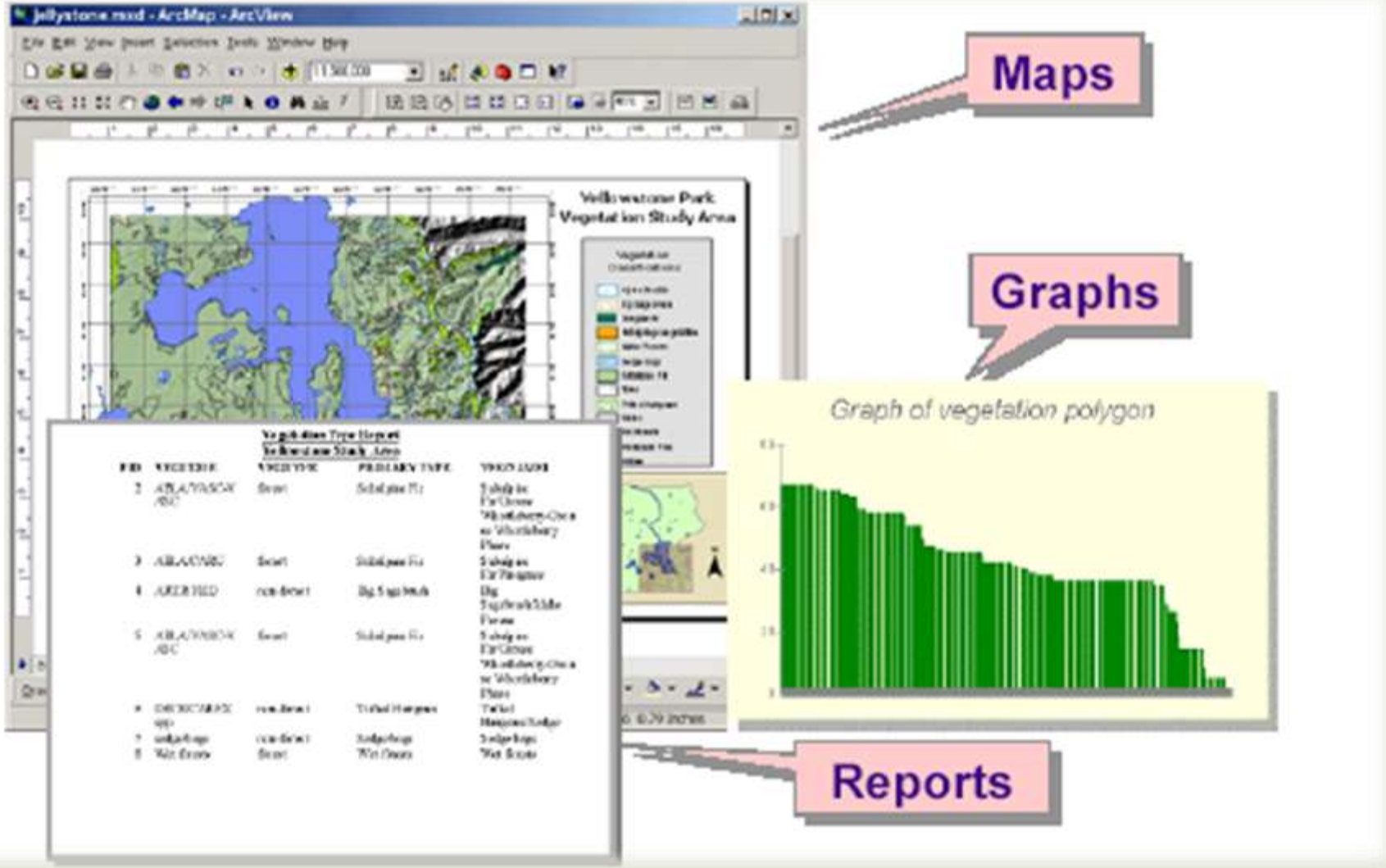
GIS Functions

Spatial Analysis



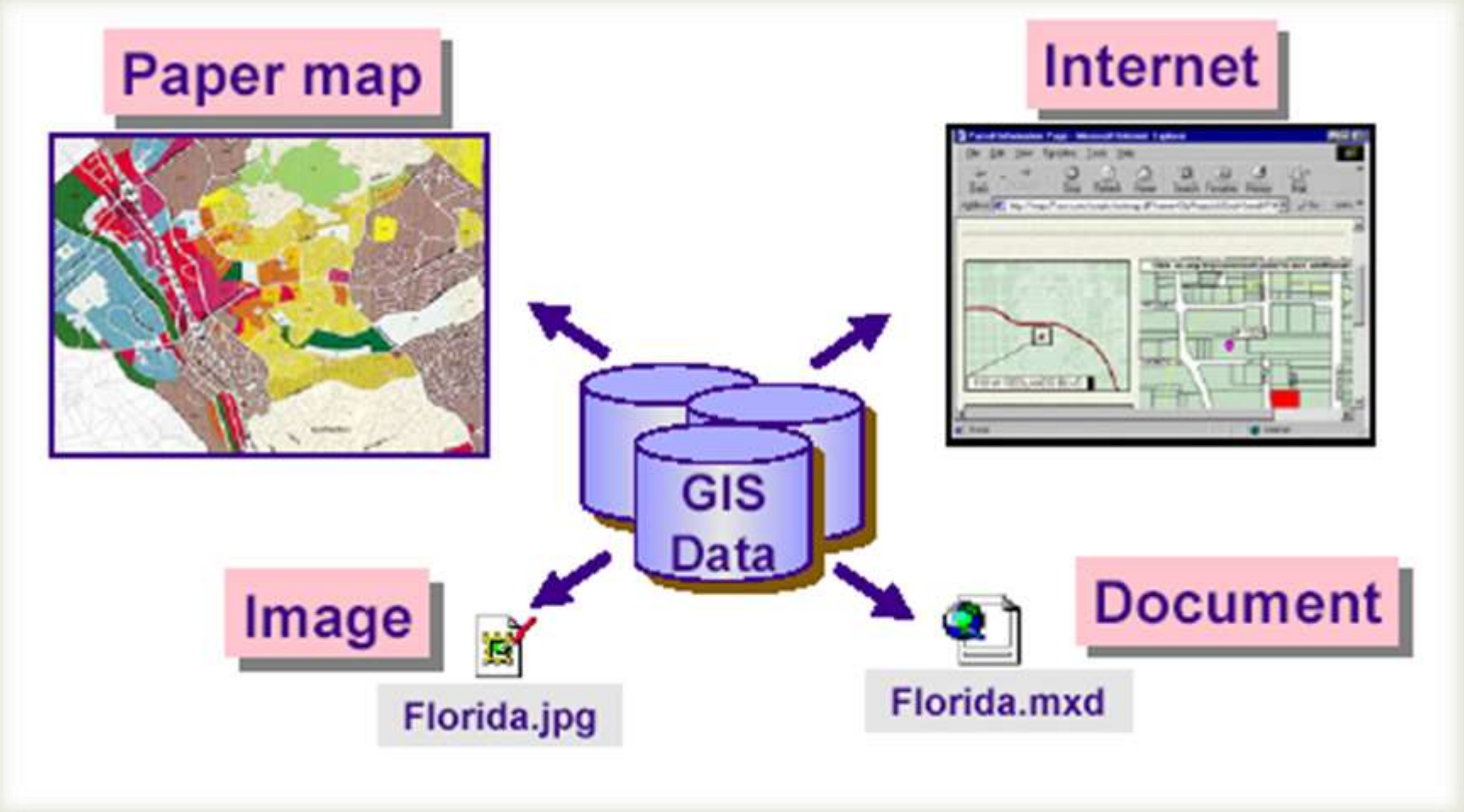
GIS Functions

Display



GIS Functions

Output



GIS Functions

Output

Soft Copy

- Electronic map (visual digital map + multimedia)
- Digital Atlas
- Digital Layouts
- Web Based Maps (Interactive Web Mapping)

Hard Copy

- Maps (Topographic, Statistical, 3D, Contour etc)
- Atlases
- Reports (Write-ups etc)
- Charts, Graphs

Basic Component of GIS

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 Components of GIS

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

GIS Hardware

- *The type of hardware determines, to an extent, the speed at which a GIS will operate.*
- *The choice of hardware system ranges from Personal Computers to multi user Super Computers.*
- *Additionally, it may influence the type of software used.*


Activity Preview
Follow a Route
Go
Start

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.*


BLUE MARBLE
GEOGRAPHICS
MIND THE GAP BETWEEN WORLD AND MAP


INTERGRAPH
erdas
an Intergraph brand


ENVI

ArcGIS


AUTOCAD
MAP 3D

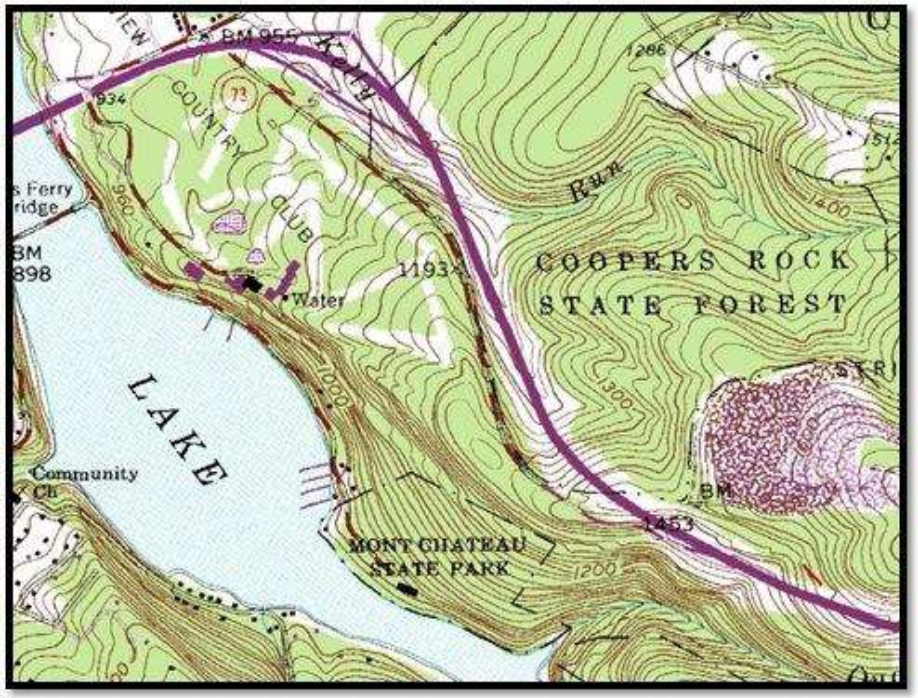

ILWIS

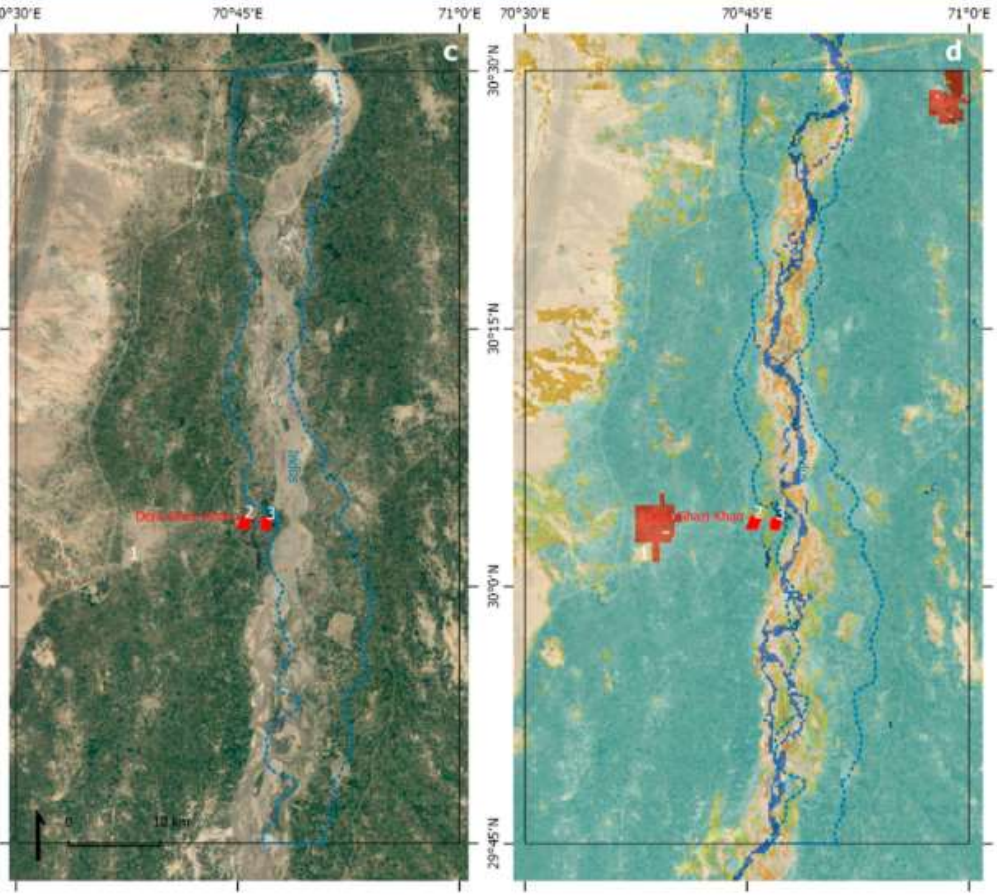

MapInfo
THE INFORMATION DISCOVERY COMPANY

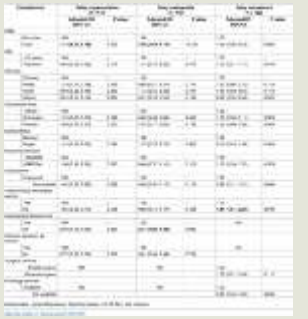
Data

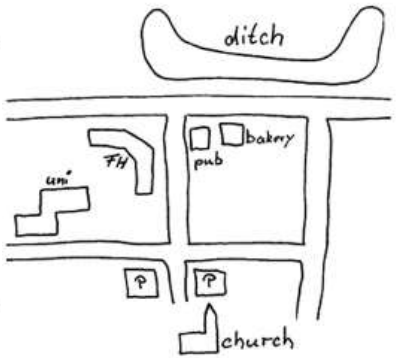
- *Data is the information used within a GIS.*
- *Since a GIS often incorporates data from multiple sources, its accuracy defines the quality of the GIS.*
- *GIS quality determines the types of questions and problems that may be asked of the GIS.*
- *Geographic data and related tabular data are the backbone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

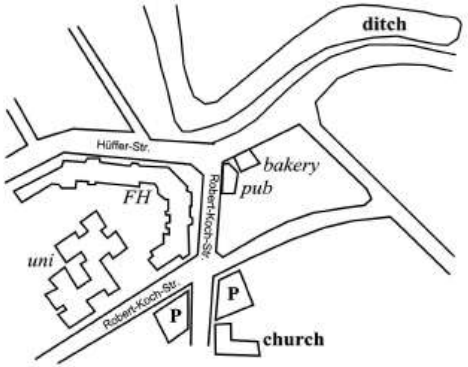

a
b
Islamabad
Jammu
Chenab
Jhelum
Dera Ismail Khan
Amritsar
Beas
Beas
Lahore
Indus
Sutlej
Ludhiana
Ravi
Dera Ghazi Khan
Multan
Yamuna
Bahawalpur
Hisar
New Delhi
Ganges
0
5000 km


BM 955
934
COUNTRY
CLUB
Water
BM
898
1193
COOPERS ROCK
STATE FOREST
LAKE
Community
Ch
MONT CHATEAU
STATE PARK
1453
1200
1300
1400
960


70°30'E
70°45'E
71°0'E
c
d
30°30'N
30°15'N
30°0'N
29°45'N
Indus
0
12 km

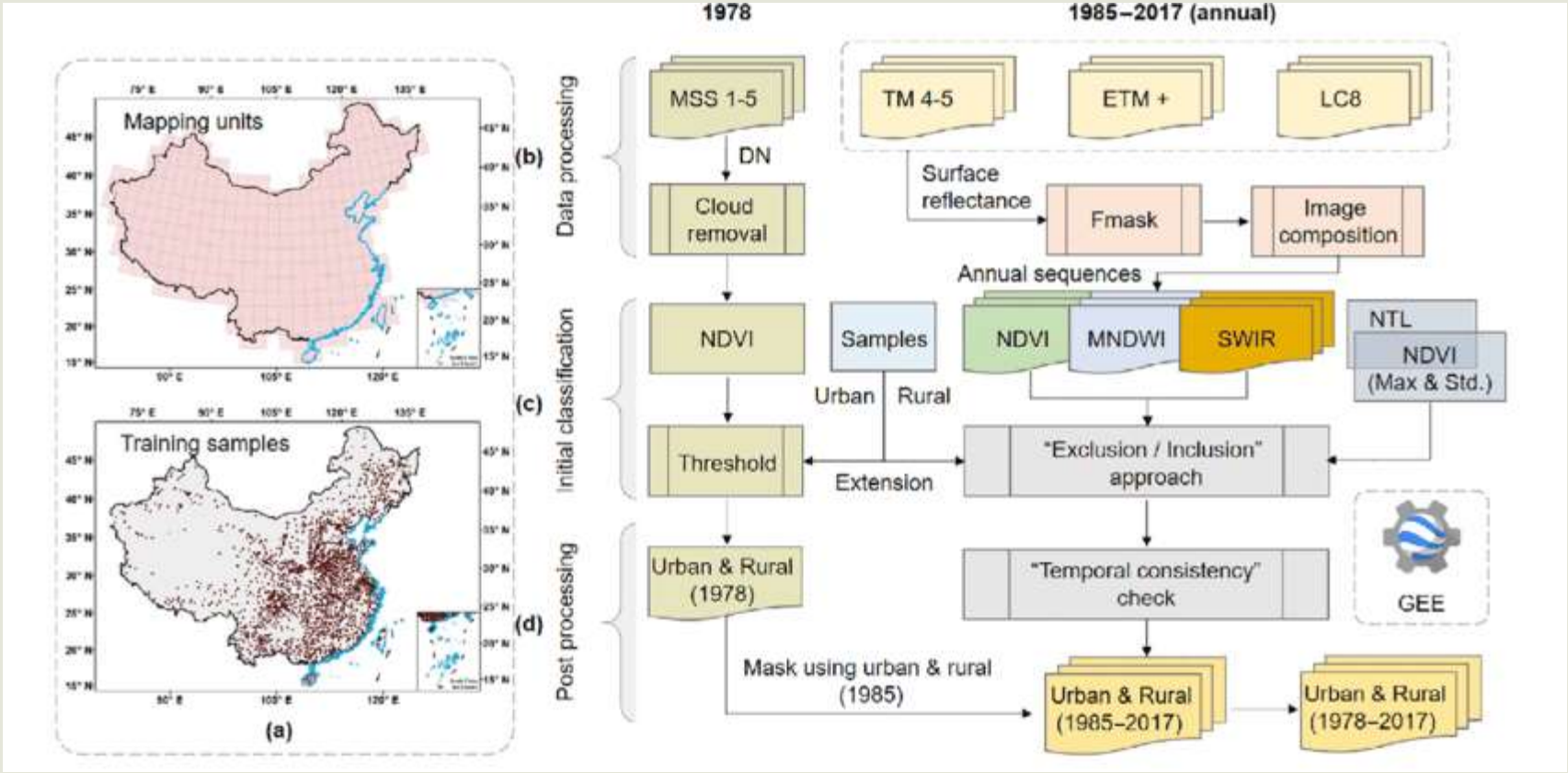


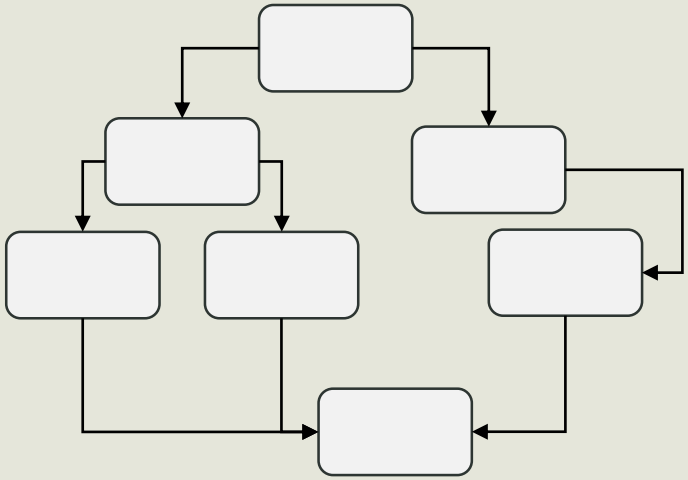

ditch
FH
bakery
pub
uni
P
P
church


ditch
Hüffer-Str.
bakery
pub
FH
Robert-Koch-Str.
uni
Robert-Koch-Str.
P
P
church

Procedures / Methods

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


1978
1985–2017 (annual)
Mapping units
(b)
Training samples
(c)
(d)
(a)
Data processing
Initial classification
Post processing
MSS 1-5
TM 4-5
ETM +
LC8
DN
Surface reflectance
Cloud removal
Fmask
Image composition
Annual sequences
NDVI
Samples
NDVI
MNDWI
SWIR
NTL
NDVI (Max & Std.)
Urban
Rural
Threshold
Extension
"Exclusion / Inclusion" approach
GEE
Urban & Rural (1978)
"Temporal consistency" check
Mask using urban & rural (1985)
Urban & Rural (1985–2017)
Urban & Rural (1978–2017)



People

- *The most important part of a GIS.*
- *Define and develop the procedures used by a GIS.*
- *Solve real time spatial problems.*
- *Can overcome shortcoming of the other 4 elements (data, software, hardware, procedure) but not vice-versa.*
- *They plan, implement and operate to draw conclusions for decision making.*