GEE 4812: Principles of Geomatics

Remote Sensing & GIS

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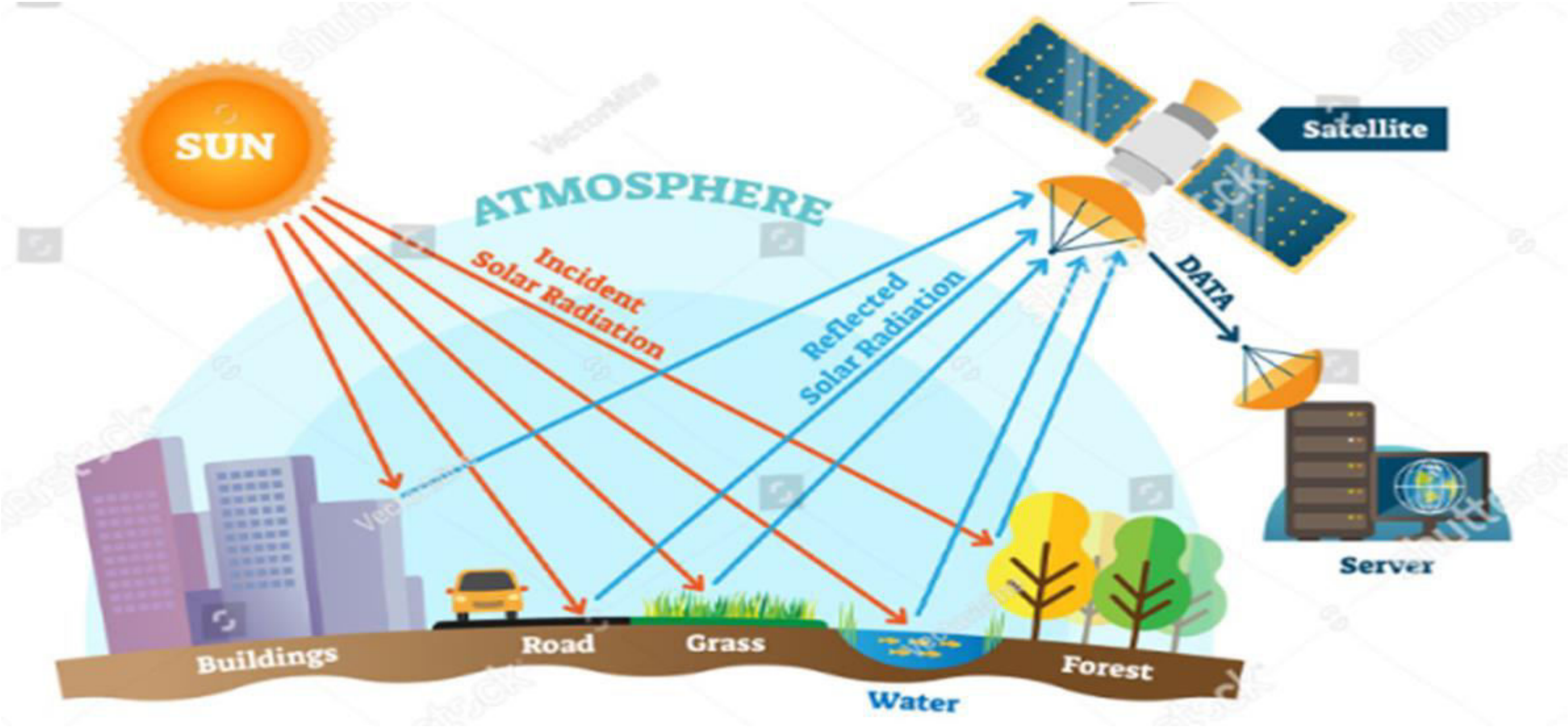
Remote Sensing: Definition

- is the science and art of obtaining information about a feature through the analysis of data acquired by a device that is not in contact with the feature under investigation. (F. F. Sabins, 1996)
- RS can broadly be defined as the technique of gathering information about a feature without being in direct contact.

Remote Sensing: Principle



Remote Sensing: Principle

- **Electromagnetic Radiation (EMR):** Remote sensing relies on the interaction of electromagnetic radiation with the Earth's surface and the objects on it. Electromagnetic radiation travels in waves and includes various forms, such as visible light, infrared, microwave, and radio waves.
- **Energy source:** Remote sensing begins with an energy source, such as sunlight or artificial radiation, which illuminates or interacts with the target on the Earth's surface.

Remote Sensing: Principle

- **Interaction with the Target:** The energy from the source interacts with the target object or surface. This interaction can be in the form of reflection, absorption, emission, or transmission of electromagnetic radiation.
- **Sensor:** Sensors detect the energy that is either emitted by the target or reflected from it. These sensors can be passive (detect natural energy, e.g., optical sensors for visible light) or active (emit energy and measure the return signal, e.g., radar).

Remote Sensing: Principle

- **Data Acquisition:** Remote sensing systems collect data in the form of digital images or other measurements. These data can be in the visible, infrared, microwave, or other parts of the electromagnetic spectrum.
- **Data Transmission:** The acquired data is transmitted to the ground station or receiving station, typically via radio signals or other communication methods.

Remote Sensing: Principle

- **Data Processing:** Once the data is received on the ground, it undergoes various processing steps, including calibration, correction for atmospheric effects, and georeferencing to ensure accuracy.
- **Image Analysis:** Analysts interpret and analyze the processed data to extract valuable information. This can include identifying land cover types, monitoring changes over time, detecting anomalies, and more.

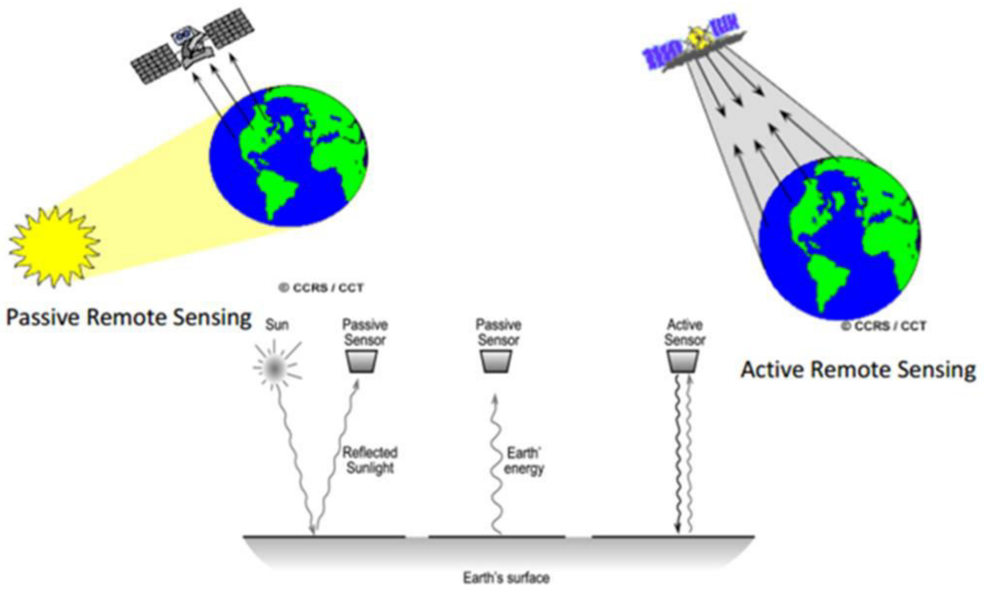
Remote Sensing: Principle

- **Applications:** The information obtained through remote sensing is used for a wide range of applications, including agriculture (crop monitoring), forestry (deforestation assessment), environmental monitoring (water quality assessment), urban planning (land use mapping), and disaster management (natural disaster assessment).
- **Decision Making:** The insights gained from remote sensing data help policymakers, scientists, and various stakeholders make informed decisions and take appropriate actions.

Remote Sensing: Passive vs Active Sensors

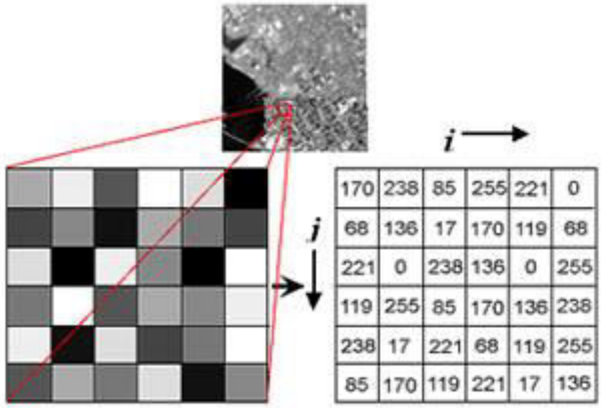
- **Passive sensors** measure the energy naturally emitted, and the sunlight is the primary source of energy used e.g Spectrometers, Radiometers and Cameras.

- **Active sensors** generate their electromagnetic energy source for illumination to the target and record the backscattered radiation from the target e.g radar, lidar, x-ray.



Remote Sensing: Digital Numbers

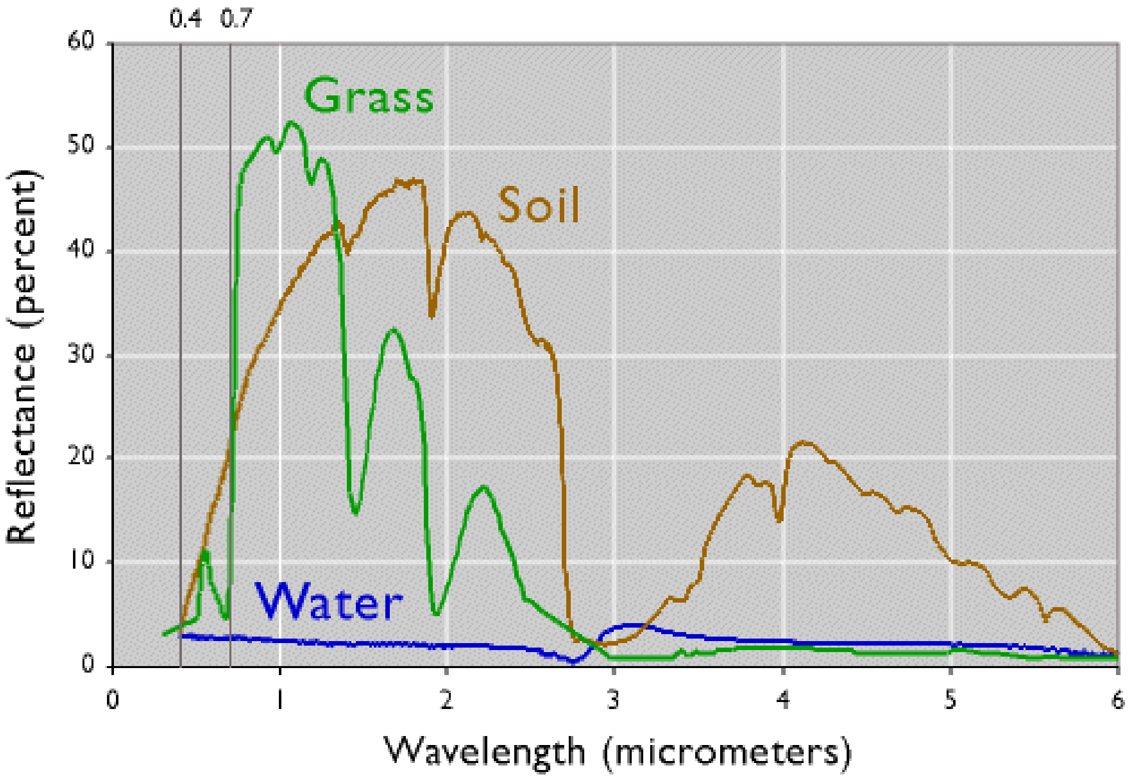
- Digital Numbers (DN) is value stored within a pixel of an image.
- DN represents amount of EMR reflected back to the sensor.
- DNs are sometimes called Brightness Values (BV).



Pixel location (i,j)	BV_{ij}
1,1	170
1,2	238
1,3	85
....	....
1,6	0
2,1	68
....	....

Remote Sensing: Spectral Signature

- Different Earth's features display different spectral behaviour depending upon their interactions with EMR..
- Features such as water, rock, soils, and vegetation, interact with the varying wavelengths of EMR differently, which can uniquely identify the feature.

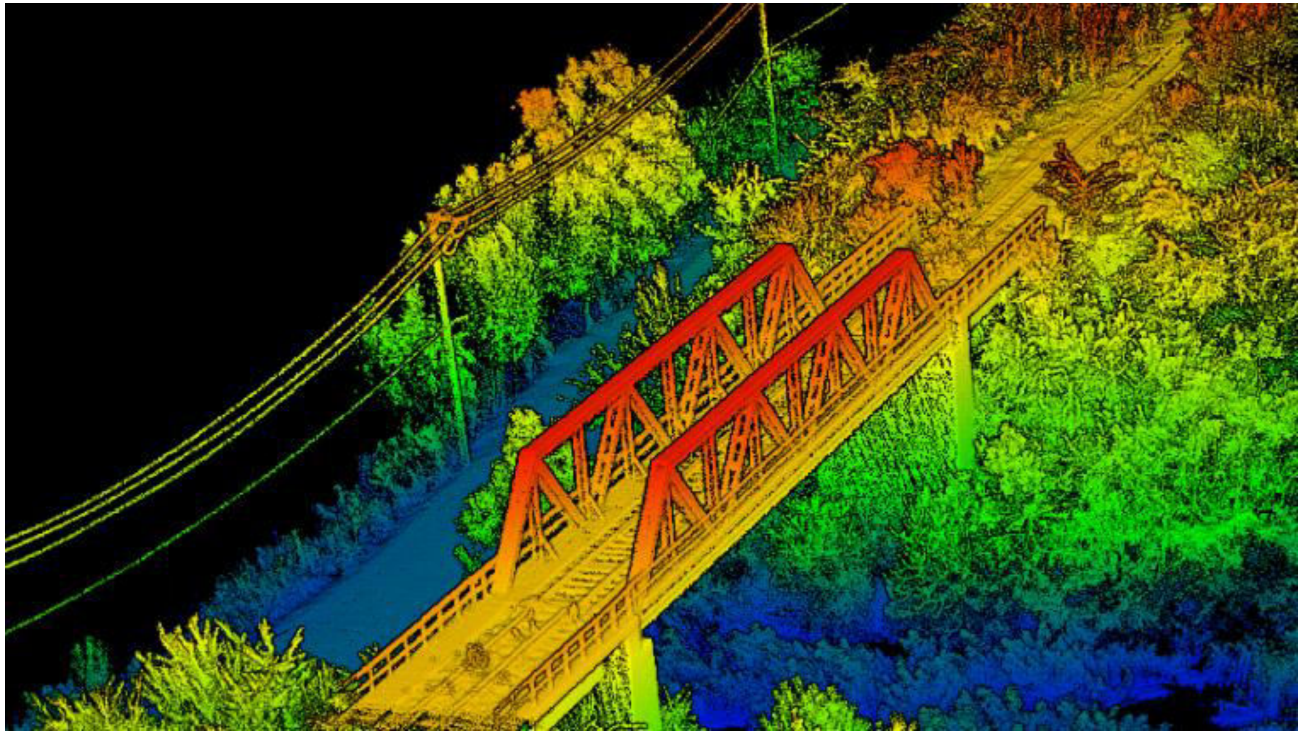


Remote Sensing: Application

- Mining
- Moisture Content measurement
- Monitoring Vegetation Health
- Crop Yield Estimation
- Deforestation Monitoring
- Meteorology, etc

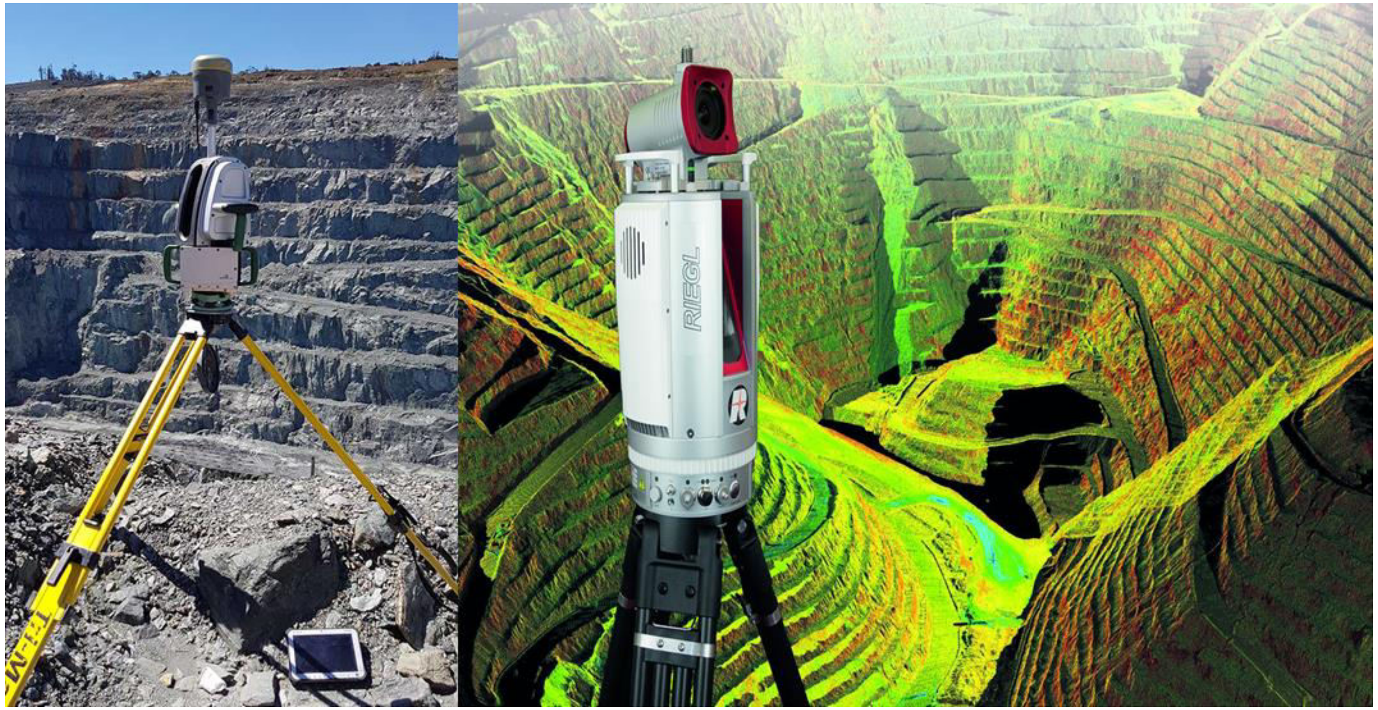
Remote Sensing: Lidar Surveying

- Creation a precise 3D map of the environment.
- 3D model of Bridges, Power lines, trees e.t.c.



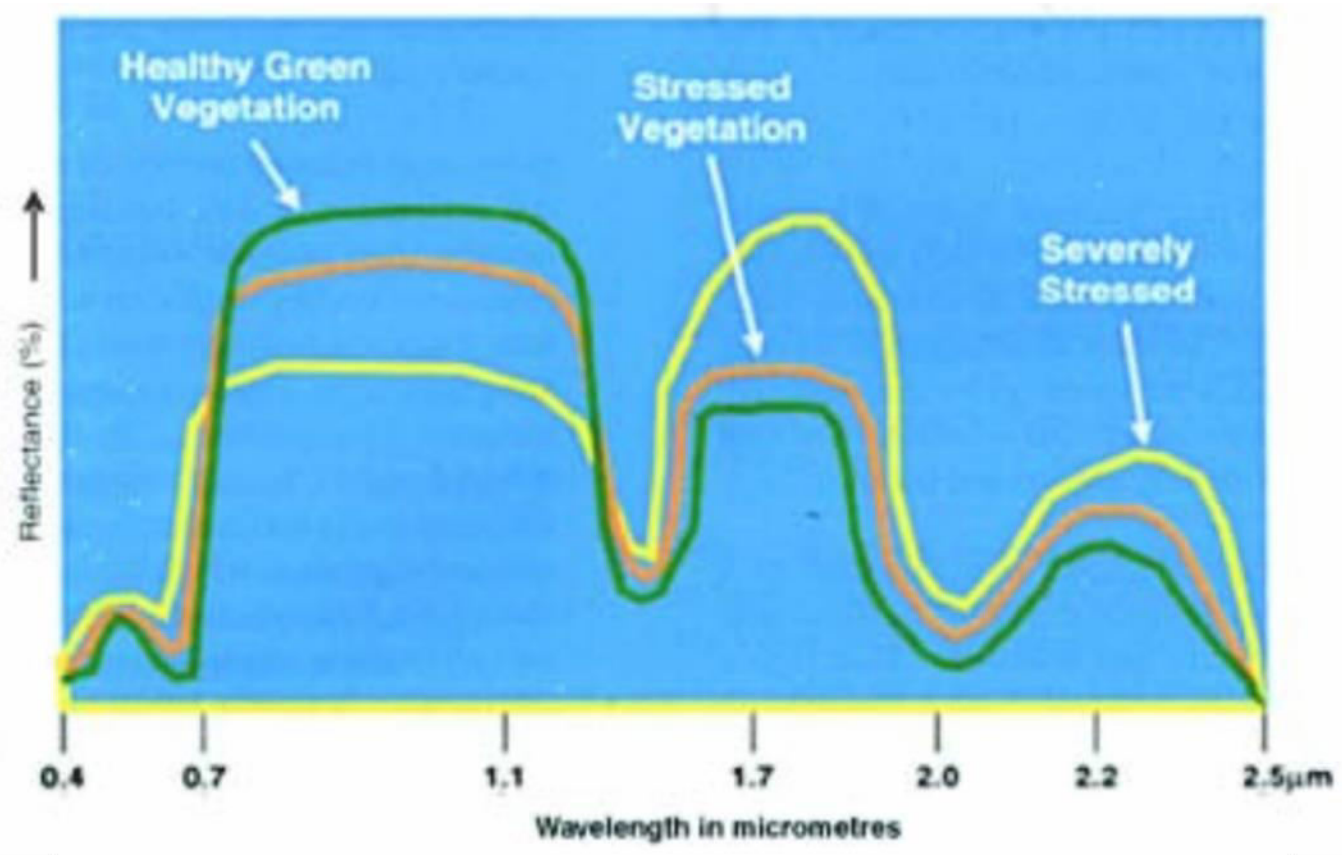
Remote Sensing: Lidar Surveying

- 3D modelling of an open pit mine using Lidar Surveying.
- Elevation data can be generated from the model.



Remote Sensing: Vegetation Health

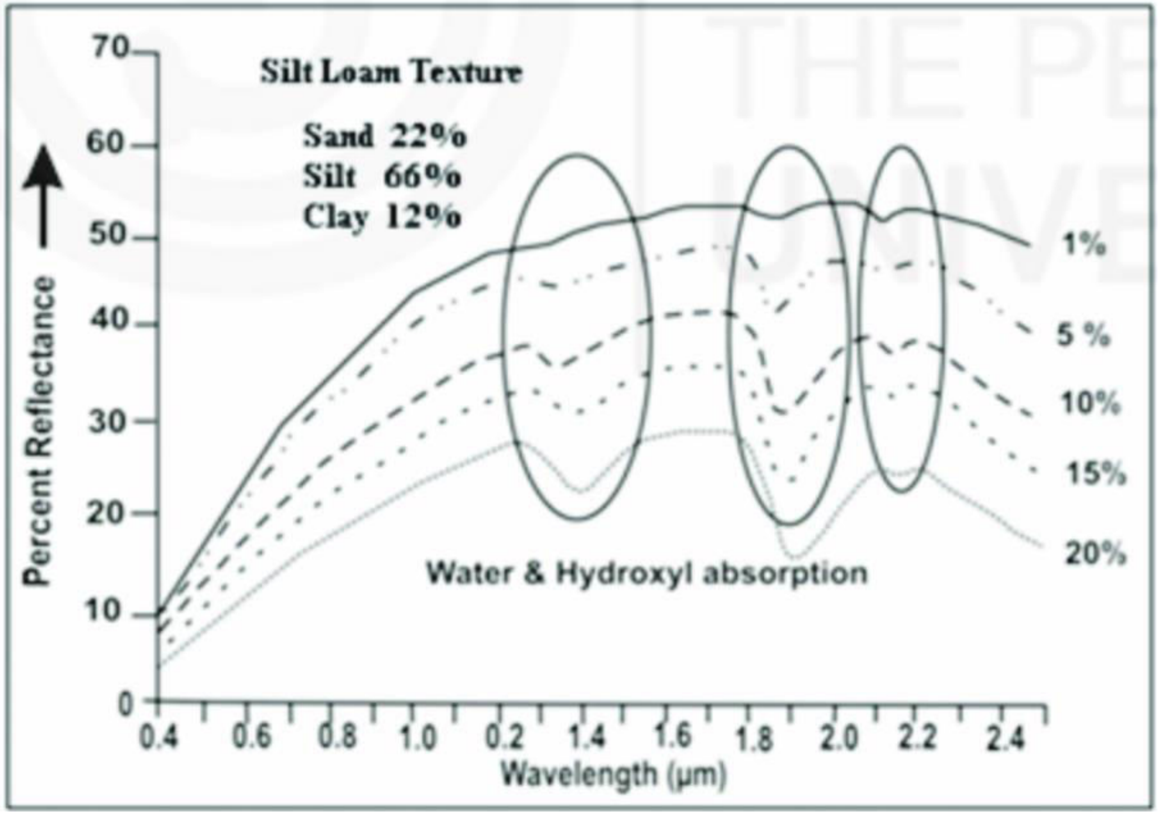
- The internal structure of healthy leaves acts as excellent diffuse reflectors of near-infrared wavelengths.
- Monitoring vegetation health.



Example of spectral signatures of healthy, stressed and severely stressed vegetations (source: http://rst.gsfc.nasa.gov/Sect3/Sect3_1.html)

Remote Sensing: Soil Moisture Content

- The presence of soil moisture reduces the surface reflectance of soil at all visible wavelengths (Jensen, 1983).
- This occurs until the soil is saturated, at which point further additions of moisture have no effect on reflectance.

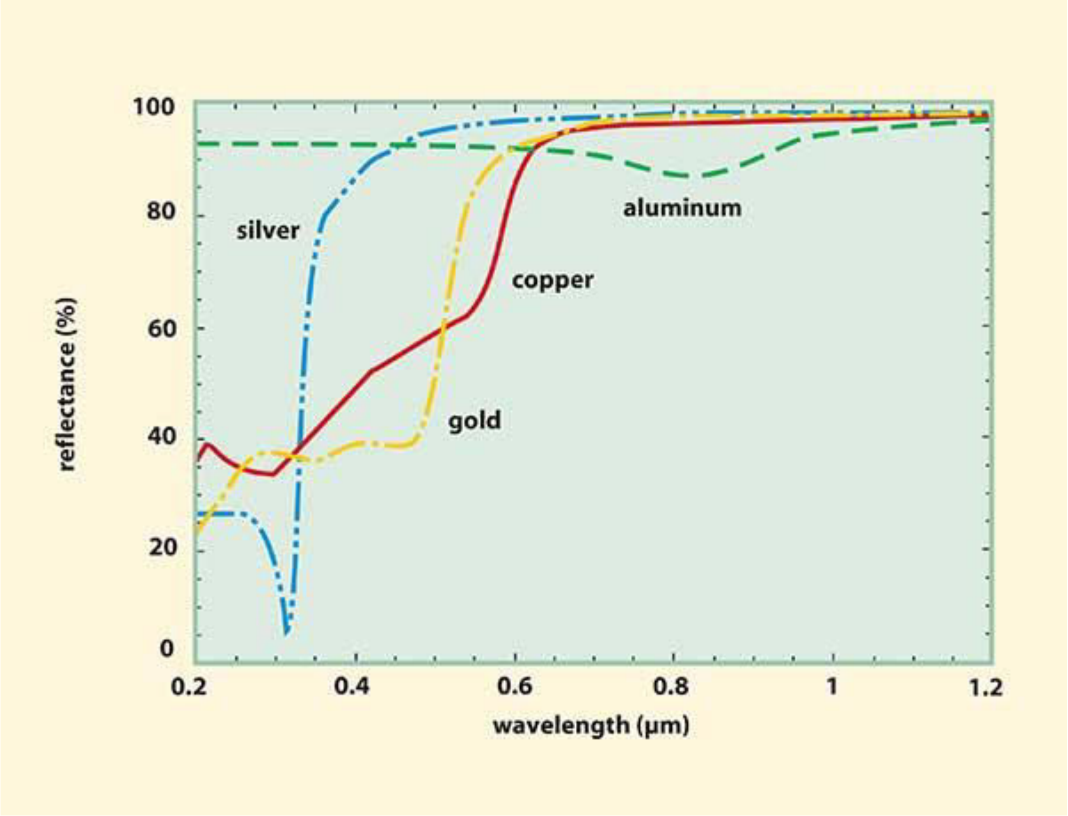


Variation in the spectral reflectance characteristics of soil according to moisture content (modified after www.cps-amu.org/sf/notes/m1r-1-8.htm)

https://egyankosh.ac.in/bitstream/123456789/39531/1/Unit-3.pdf

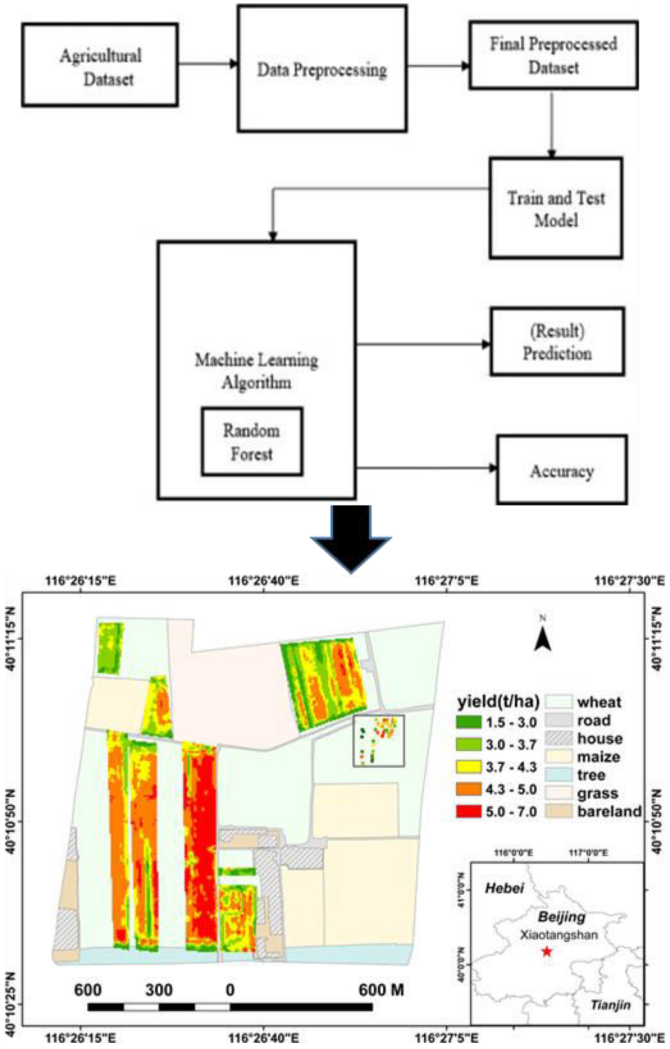
Remote Sensing: Mineral Exploration

- Rocks, like soils, are single scatterer and exhibit relatively simple spectral properties.
- Rock spectral reflectance primarily depends on their mineral composition.



Remote Sensing: Crop Yield Estimation

- A very common approach is the usage of Normalized Difference Vegetation Index (NDVI) or other satellite data bands. These bands are then combined with previous yields to build models of future yields. NDVI is obtained by the composition of near- infrared and red spectral channels.



https://isprs-annals.copernicus.org/articles/IV-3-W2-2020/59/2020/isprs-annals-IV-3-W2-2020-59-2020.pdf

GIS (Geographic Information Science)

What is GIS?

GIS is an acronym for:

- Geographic Information Systems (US)
- Geographical Information Systems (UK, Aust., Canada)
- Geographic Information Science (Academia)

Ernest Munsanje (Notes: 2015)

GIS: Definition

- A geographic information system (GIS) is a system that creates, manages, analyzes, and maps all types of data.
- GIS connects data to a map, integrating location data (where things are) with all types of descriptive information (what things are like there).
- GIS can be broadly be defined as a tool for working with geographic information.

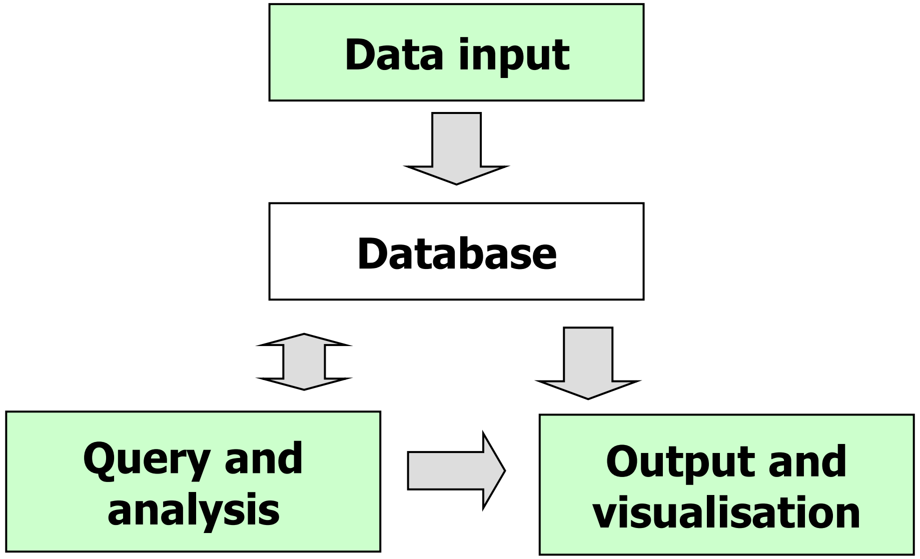
GIS

- This provides a foundation for mapping and analysis that is used in science and almost every industry.
- GIS helps users understand patterns, relationships, and geographic context.
- The benefits include improved communication and efficiency as well as better management and decision making

https://www.esri.com/en-us/what-is-gis/overview

GIS

- **Data entry : early stage in** which data about the studied phenomena is entered into the GIS, and representations are built
- **Data analysis : middle stage** in which representations are manipulated and studied to gain (new) insight
- **Data presentation : final** stage in which the results of analyses are presented (in maps or otherwise).

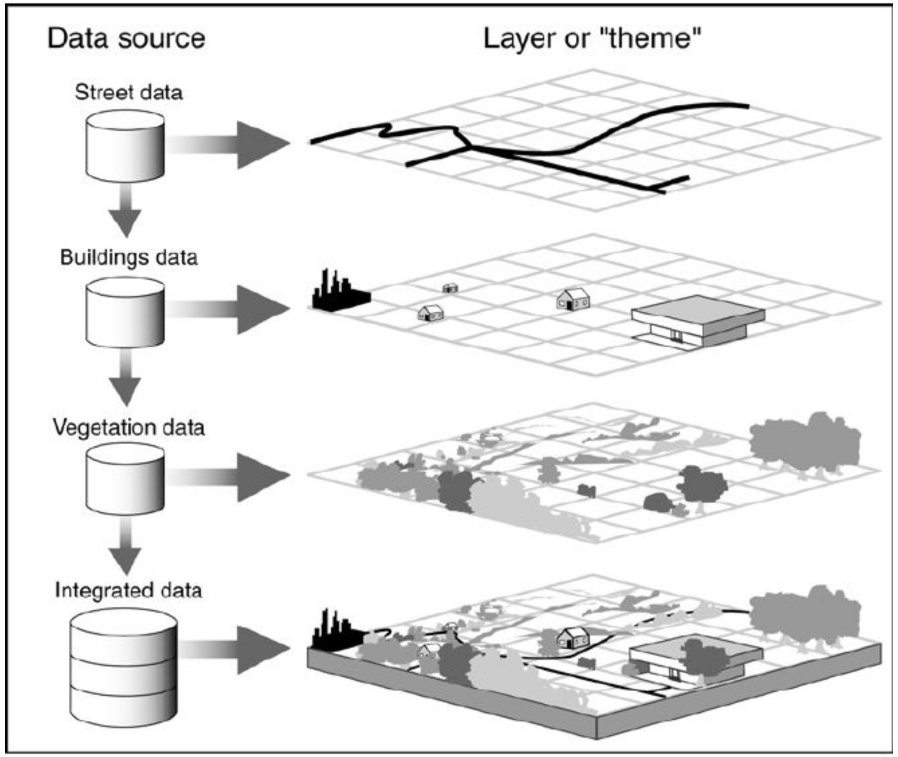


GIS: Principle

- **Spatial Data:** GIS revolves around spatial data, which refers to information tied to specific locations on the Earth's surface.
- Spatial data can include various types of information such as points, lines, polygons, and raster images.
- These data elements are used to represent real-world features like buildings, roads, rivers, and more.

GIS: Principle

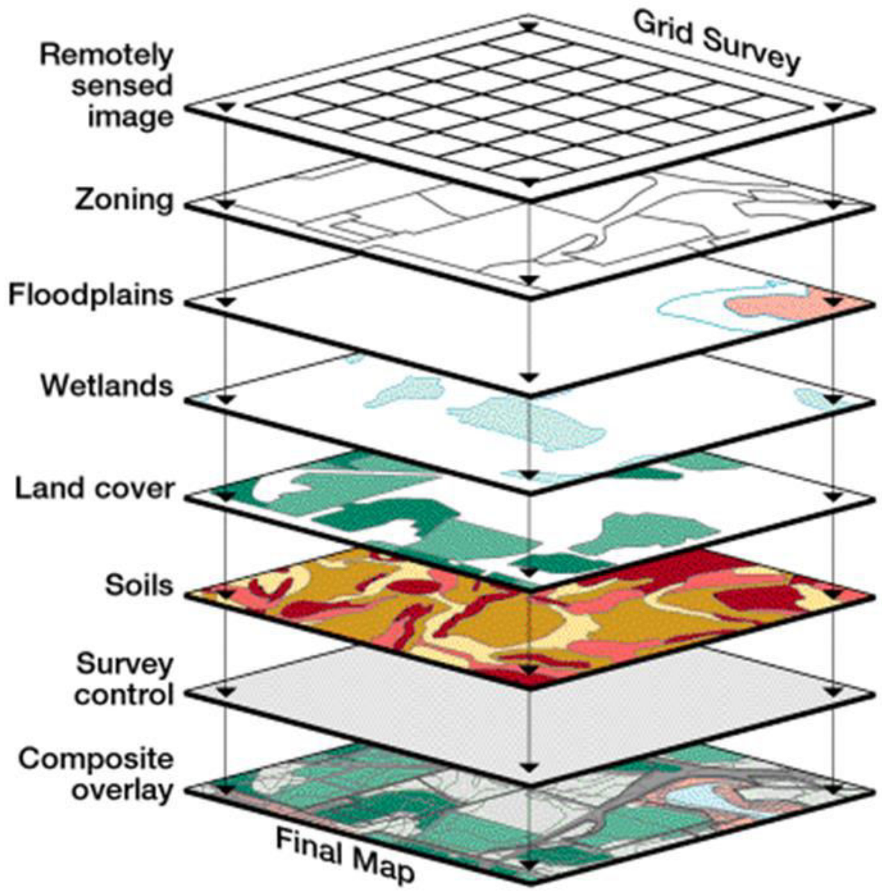
- **Data Integration:** GIS integrates data from multiple sources and formats.
- This data can come from surveys, satellite imagery, GNSS devices, paper maps, and various databases.
- The ability to combine different datasets is a key strength of GIS, as it allows for the creation of comprehensive and meaningful maps and analyses



Source: GAO.

GIS: Principle

- **Data Layers:** GIS organizes spatial data into layers.
- Each layer contains a specific type of information, such as roads, land use, or population density.
- These layers can be overlaid and analyzed together to gain insights and make informed decisions

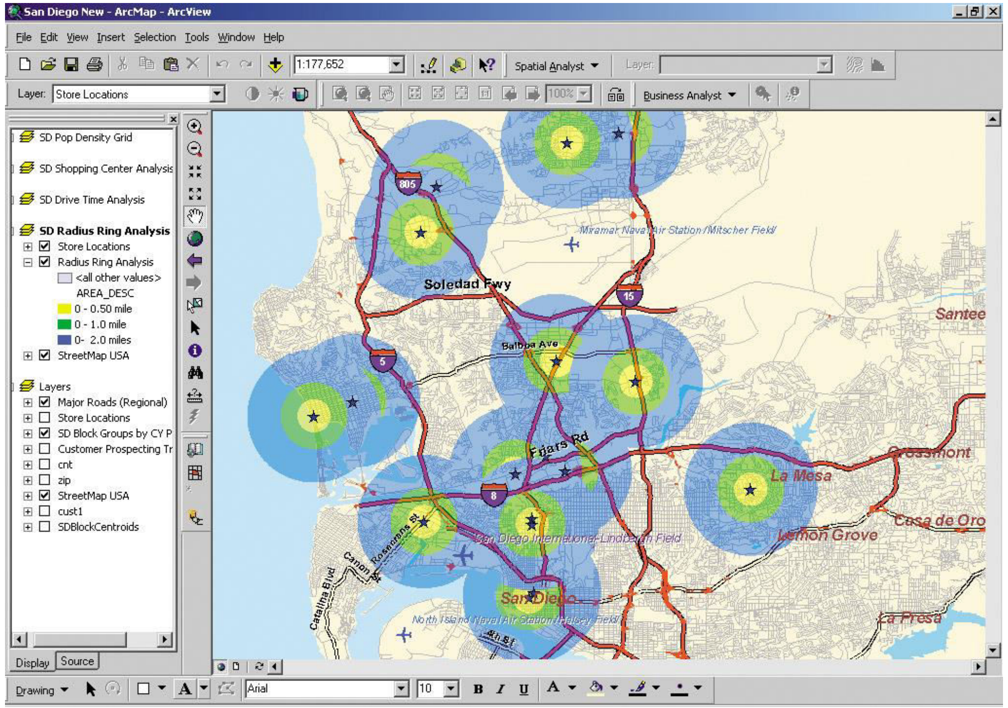


GIS: Principle

- **Spatial Analysis:** One of the primary purposes of GIS is to perform spatial analysis.

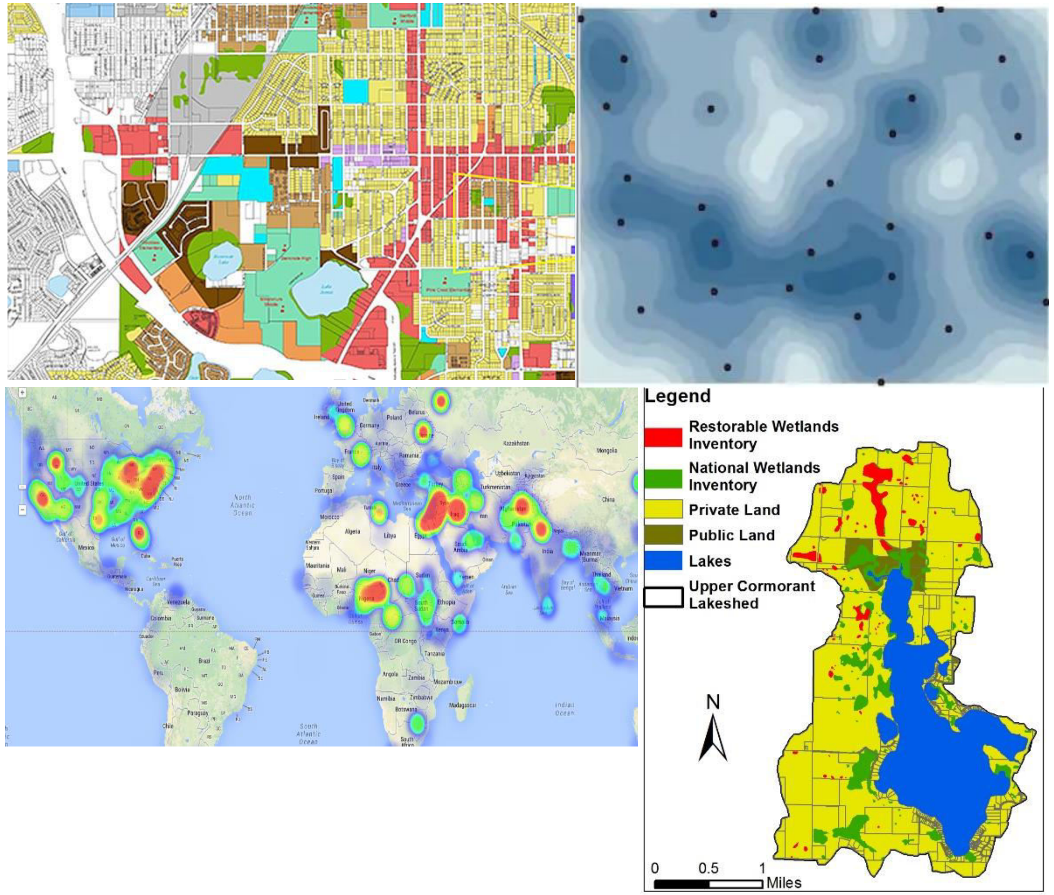
- This involves using various tools and techniques to answer questions or solve problems related to geography.

- Spatial analysis can include tasks like proximity analysis, spatial modeling, and geoprocessing.



GIS: Principle

- **Visualization:** GIS enables the creation of visual representations of spatial data through maps and charts.
- Visualization is a powerful tool for understanding complex geographic patterns and conveying information to a wide audience.



GIS: Application

- Land Surveying
- Urban Planning
- Map making
- Health Industry
- Mining
- Health Industry
- Agriculture
- Site Suitability Analysis
- Change Detection
- Impact Assessment
- Disaster Management
- Water and Sewer Utilities etc

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