

Emerging Areas of Water Resources Engineering

Remote Sensing and GIS in Water Resources Management: An Overview

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What I will talk about...

- What is Remote Sensing?
- Why Remote Sensing?
- What is GIS?
- Where do we use GIS?
- Where I used Remote Sensing /GIS?

What you can ask me?

- Anything and Everything...!!
(Related to the topic, of course!)

What I will ask you?

- We will have two interactive sessions in between.

You can stop and ask me questions anytime!

What is Remote Sensing?

- Getting information from a distance.
- Obtaining data without touching an object, area etc.
- **Best Example : Looking with our eyes!!**

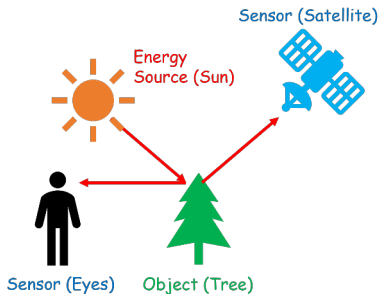


- **One more Example :Bats use Ultrasound!!**



Components of Remote Sensing

- We need a source of energy.
- The energy should fall on an object.
- The reflected energy is captured by a sensor.

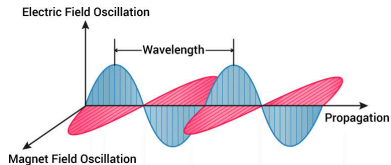
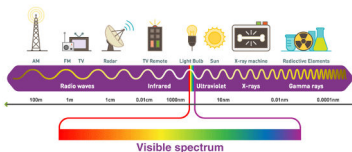


Light is a form of energy

Sun is a natural source of energy in the form of light. We can see objects only under light, be it natural or artificial. A satellite may not require visible light to sense an object.

Energy

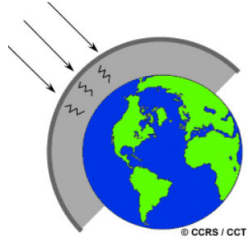
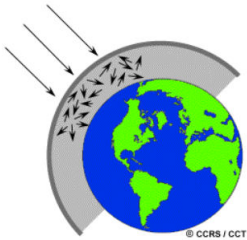
- Energy source is in the form of **Electromagnetic Radiation**.
- The light which our eyes can detect is part of the **Visible Spectrum**
- Satellite sensors can work in Microwave and visible spectrum.



Blue, **Green**, and **Red** are the primary colours or wavelengths of the visible spectrum.

Interactions with the Atmosphere

- Radiation used for remote sensing has to travel through the Earth's atmosphere
- Particles and gases in the atmosphere can affect the incoming radiation.
- Effects are caused by the mechanisms of **Scattering** and **Absorption**.

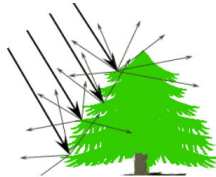
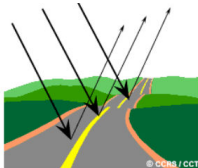


Carbon dioxide and Global Warming

Absorbs radiation strongly in the far infrared portion of the spectrum: associated with thermal heating, which traps heat inside the atmosphere.

Interactions with the target

- Radiation that is not absorbed or scattered in the atmosphere interacts with the Earth's surface.
- Energy is **Incident (I)** on the surface and experiences **Absorption (A)**, **Transmission (T)** and **Reflection (R)**.

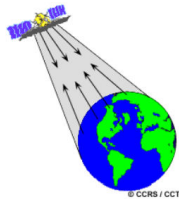
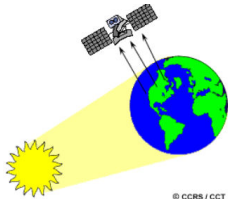


Specular and Diffuse Reflection

When a surface is smooth we get specular or mirror-like reflection. Diffuse reflection occurs when the surface is rough and the energy is reflected almost uniformly in all directions.

Sensors

- Sensor is a device which can record reflected energy.
- **Passive sensors** can only detect when there is energy naturally available, like the sun, for example.
- **Active sensors** provide their own energy source for illumination.
- **Digital Sensors** are commonly used which produce digital images.

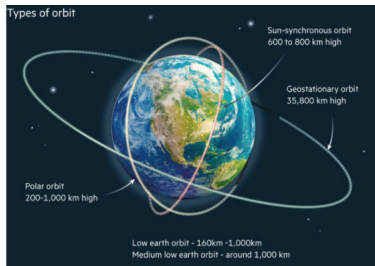


Which Sensor is Preferred?

Active sensors can measure anytime, even if it's dark or cloudy. We use passive sensors to measure naturally emitted energy (such as thermal infrared) during both day and night.

Orbits of Satellites

- The path followed by a satellite is called its orbit.
- **Geostationary orbit:** Satellites observe and collect information continuously over specific areas.
- **Polar/Sun-synchronous:** Designed to follow a north-south orbit.
- Most of the satellite platforms today are in near-polar orbits.

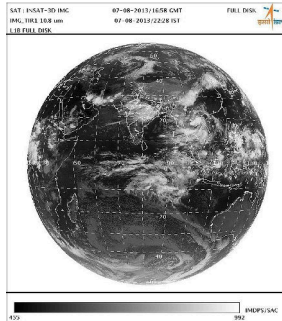
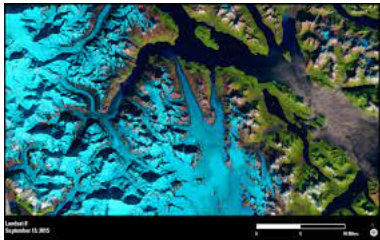


Which Orbit is Preferred?

Weather and communications satellites commonly have geostationary orbits. Earth observing satellites follow a polar orbit.

Types of Satellite Sensors

- Weather Satellites/Sensors
- Land Observation Satellites
- Marine Observation Satellites
- Terrain Mapping Satellites



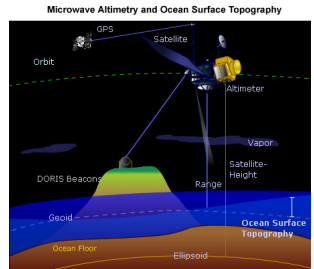
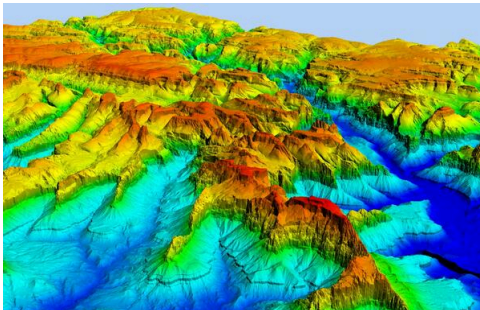
Google Maps uses images from **LANDSAT!**

India has 3 weather satellites

Kalpana-1, INSAT-3A and INSAT-3D

Microwave Sensors

- Longer wavelength microwave radiation can penetrate through cloud cover.
- Can measure soil moisture and rainfall.
- Altimeter can measure surface elevation.
- Microwave RADAR is used to map the terrain digitally.

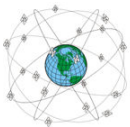
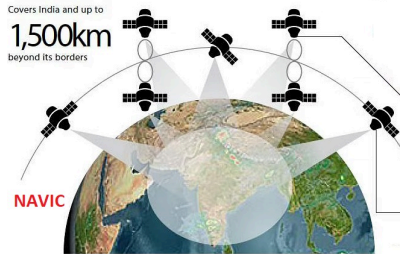


Many Applications

Microwave Remote Sensing is used in Agriculture, Forestry, Geology, Hydrology and Oceanography.

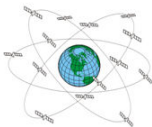
Navigation Systems

- **Global Positioning System** is controlled by USA.
- Four satellites are required to compute the four dimensions of X, Y, Z (position) and Time.
- **NavIC (Navigation with Indian Constellation)** is navigation satellite system of India.



GPS

- 6 Orbital planes
- 24 Satellites + Spare
- 55° Inclination Angle
- Altitude 20,200km



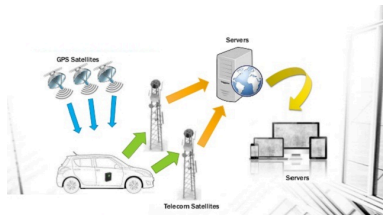
Galileo

- 3 Orbital planes
- 27 Satellites + 3 Spares
- 56° Inclination Angle
- Altitude 23,616km



GLONASS

- 3 Orbital planes
- 21 Satellites + 3 Spares
- 64.8° Inclination Angle
- Altitude 19,100km



Remote Sensing Applications in Agriculture

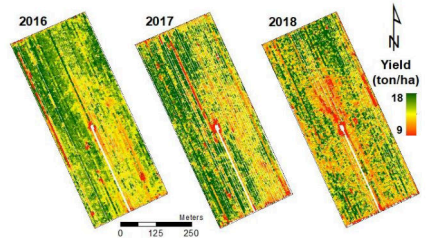
- Crop type classification
- Crop condition assessment
- Crop yield estimation
- Mapping of soil

Object-based crop classification



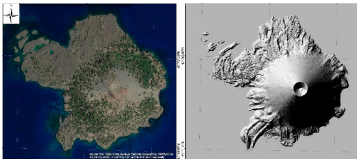
- | | | |
|---|--|---|
|  Corn |  Winter wheat |  WSG |
|  Soybean |  WWsoybean |  CSG |

Satellite and airborne images are used as mapping tools to classify crops, examine their health and viability, and monitor farming practices.



Remote Sensing Applications in Water Resources

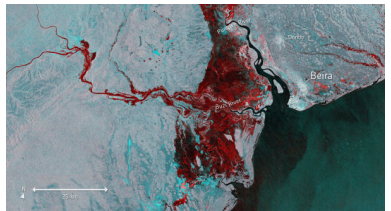
- Wetlands mapping
- Soil moisture estimation
- Flood mapping and monitoring
- Drainage basin modelling
- Catchment Land Use/ Land cover



Synthetic Aperture Radar (SAR) is used mainly for water related measurements. Here a sensor produces its own energy and then records the amount of that energy reflected back.

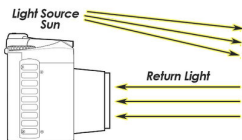
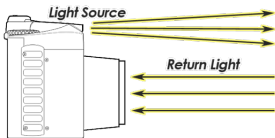


A recording of the Great Flood of the Mississippi River, 1993 (St. Louis, Missouri). The images were acquired by the Thematic Mapper instrument onboard the Landsat-5 satellite. © NASA Earth Observatory

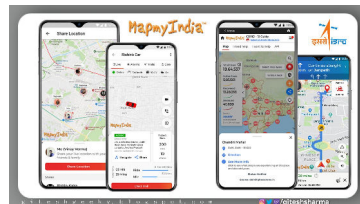


Interactive Session

- Our body has 3 organs which act as remote sensors! What are they?
- Eyes, Nose and Ears!
- What type of a sensor is a camera?
- Both active and passive.!!



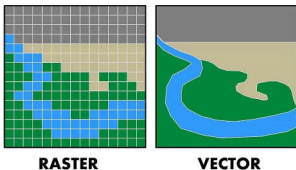
- Which data does Google maps use for navigation?
- It uses both GPS and GLONASS.
- Have you used Indian navigation system?
- You can use the MapmyIndia app.



What is GIS?

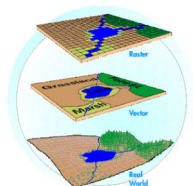
- **Geographical Information System**
- GIS consists of a database, maps, and a computer-based link between them.
- Two types of map data : Raster and Vector

THE WORLD can be represented in two ways:



Raster vs. Vector

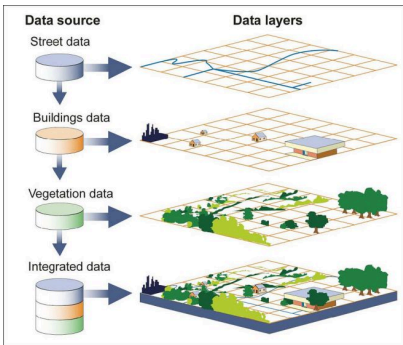
Stored as cell values	Stored as coordinates (x,y,z)
Continuous Data	Discrete Data
Used for storing rainfall, temperature etc.	Representing rivers, roads, buildings etc.



Users understand patterns in a geographic context.

GIS Components

- Data
- Hardware
- Software
- GIS is combination of Remote Sensing and Analytics.

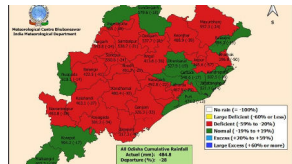
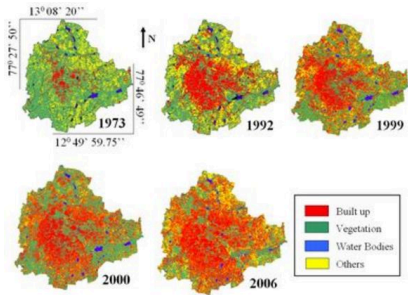
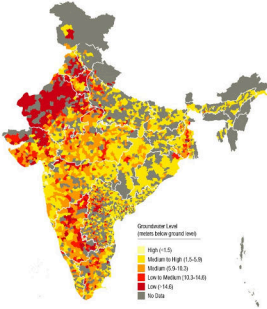


Source: GAO.



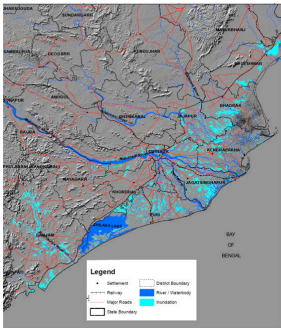
GIS Applications

- Water Resources Management
- Urban and Town Planning
- Disaster Management
- Vegetation Management
- Business and Sales



GIS Applications in Flood Modelling

- Whenever a flood event occurs in India, NRSC provides flood maps.
- During the last one and half decades, major flood events in Odisha were mapped.



Cumulative Cyclone Inundated areas in Part of Odisha State

Cyclone Titli hit Odisha coast near Gopalpur early on 11-Oct-2018 which triggered heavy rains during Second week of October, in low lying areas of Ganjam, Puri, Jagatsingpur, Khordha, Kendrapara and Jajapur districts

Analysis of Radarsat-2, Sentinel-1 SAR & Resourcesat-2 AWiFS Images of 12,13 & 14-Oct-2018

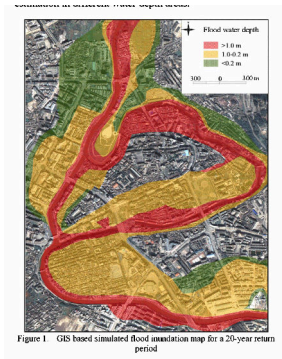
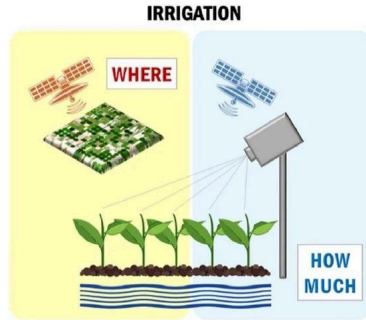
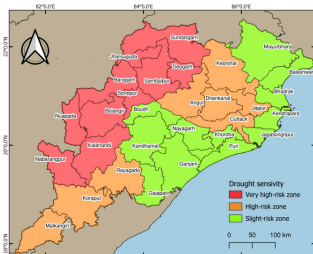


Figure 1 GIS based simulated flood inundation map for a 20-year return period

GIS analysis is performed on the DEMs to obtain the specific catchment area maps and slope maps. This will give us flood risk and inundation maps.

GIS Applications in Irrigation Management

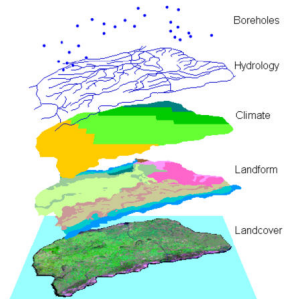
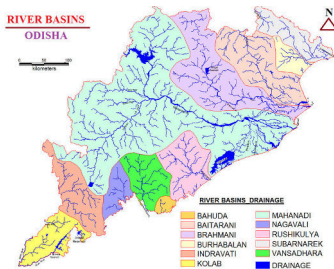
- Assessment of water availability in reservoirs for optimal management.
- Determination of irrigation water demand over space and time.
- Water logging and salinity problems in irrigated lands.
- Agricultural drought risk management.



NDVI (Normalized Difference Vegetation Index) is an important parameter for vegetated land in GIS applications.

GIS Applications in Hydrology

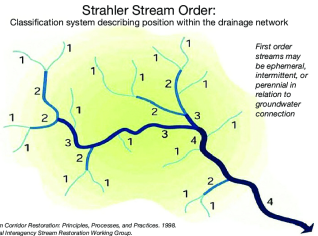
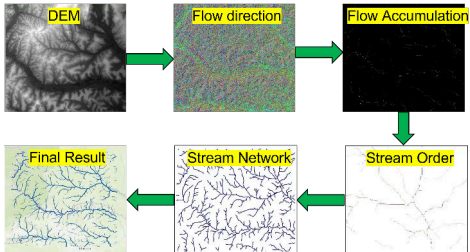
- Remote Sensing provides essential inputs for hydrologic models.
- GIS provides a Platform for Simulation of Hydrological Model.
- Estimating runoff from rainfall.
- River network mapping



RS, GIS & DEM combined with mathematical models provide a convenient platform for hydrology applications.

River Network Mapping using GIS

- Select a Digital Elevation Model (DEM)
- Get the flow direction and accumulation based on slope.
- Order the stream according to Strahler method.
- Add a basemap to get the final result.



$$1 + 1 \implies 2$$

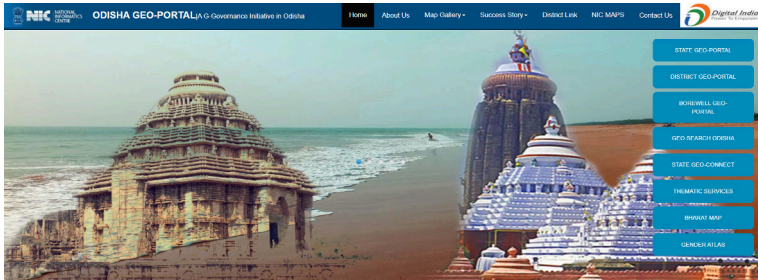
$$1 + 2 \implies 2$$

$$2 + 2 \implies 3$$

The stream order is used in geomorphology and hydrology to indicate the level of branching in a river system.

Interactive Session

- Does Odisha state government implement GIS?
- Yes!! In fact, they have a GIS portal at <https://gisodisha.nic.in/>



- How does Google maps tell you the best hotels and restaurants?

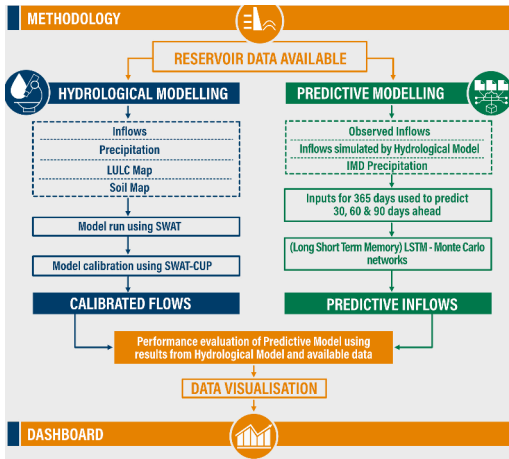
They use GIS and GPS together. When you simply search for a hotel, GPS locates you. Then, based on GIS data, it sends you the best hotel recommendations. This is an example of GIS used for business.

Where I used GIS?



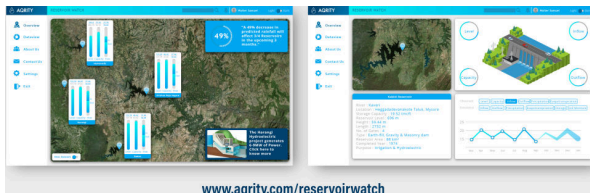
- Forecast real-time water availability in reservoirs.
- Make use use of GIS/RS data.
- Implement Artificial intelligence/ machine-learning.
- Create a dashboard website.
- Bengaluru city as the study area
- Satellite LU/LC & soil data, Rainfall-Runoff modelling using ArcSWAT/GIS.
- LSTM machine learning model for time-series prediction.
- HTML/JavaScript for dashboard.

Methodology



Machine Learning Solutions for Reservoir Modelling, AGU 2021, New Orleans, December 2021.

Results

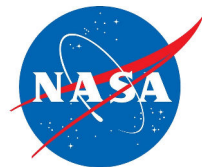


<https://reservoir-watch.aqrity.com/>



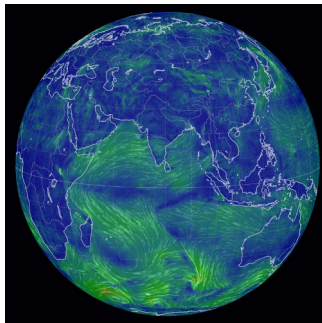
Where can you learn GIS and RS for free?

- **Coursera** : <https://www.coursera.org/learn/gis>
- **ArcGIS Learn** : <https://learn-arcgis-learnngis.hub.arcgis.com/>
- **Prof. Nagesh Kumar, IISc Website** :
http://civil.iisc.ernet.in/~nagesh/rs_gis.htm
- **NASA Earth Science portal**:
<https://appliedsciences.nasa.gov/join-mission/training>



Some cool websites!

- To look at satellite pictures from LANDSAT : <https://landsat.visibleearth.nasa.gov/>
- Live weather from satellites: <https://zoom.earth/>
- To look at Climate models: <https://earth.nullschool.net/>
- Geo-guesser game!! <https://www.geoguessr.com/>



Thank You !

Ref: REMOTE SENSING AND IMAGE INTERPRETATION by TM. Lillesand; Canada center for Remote Sensing; NASA; ISRO; ESA.