GEIDA FOUNDATION TRAINING — DAY 1

Earth Observation & Geoinformatics Fundamentals

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Batch 1 · 6 – 9 July 2026

Session 1 · 09:30–10:30

What is Earth Observation?

Earth Observation (EO) is the collection of information about the Earth’s surface, atmosphere and water systems using satellites, aircraft, drones or sensors. In this training, the focus is mainly on open satellite data.

– Satellites observe the same place repeatedly
– They measure reflected, emitted or transmitted energy
– This allows us to detect physical conditions — and change over time

CORE CONCEPT 1

What is Remote Sensing?

Remote sensing *is the science of obtaining and interpreting information from a distance, using sensors that are not in physical contact with the object being observed.*

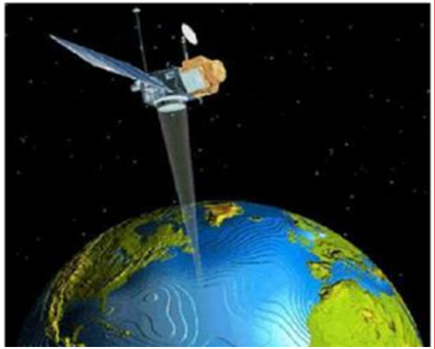
More specifically, “obtaining information from the land surface through sensors mounted on aerial or satellite platforms.”

Balloon Photography (1858)

Pigeon Camera (1903)

Aircraft

Space (1947)

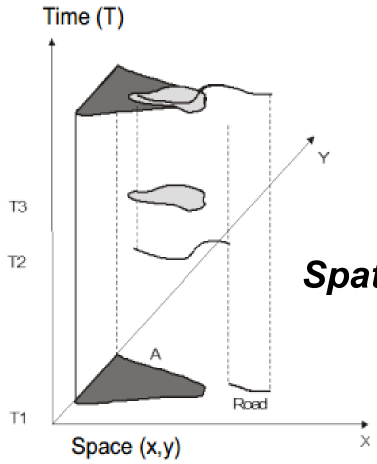


CORE CONCEPT 1

What does it offer?

State of the system at a particular point in time and 2D space.

A combination of such “observations” give valuable information on the resource under study.



Spatial-Temporal

CORE CONCEPT 2

What is geoinformatics?

Geoinformatics is the science and practice of collecting, managing, analysing, visualising and governing spatial data.

EO

Observations from satellites

+

GIS

Manages and analyses spatial data

+

Governance

Standards, metadata, access control

+

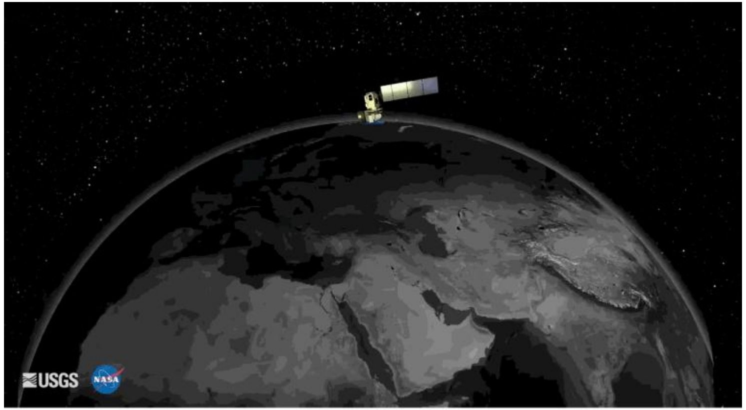
Decisions

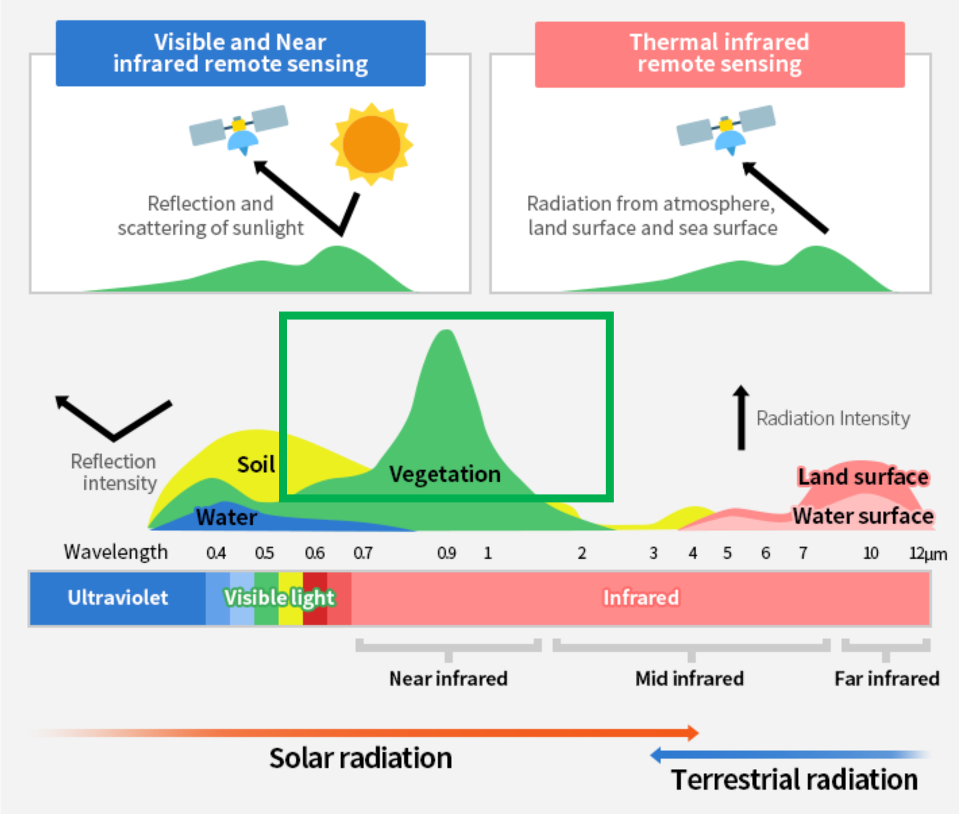
Analytics linked to project documents

EO + GIS + data governance + analytics + project documents = geoinformatics for development finance

HOW SENSORS SEE

A satellite image is not just a photograph





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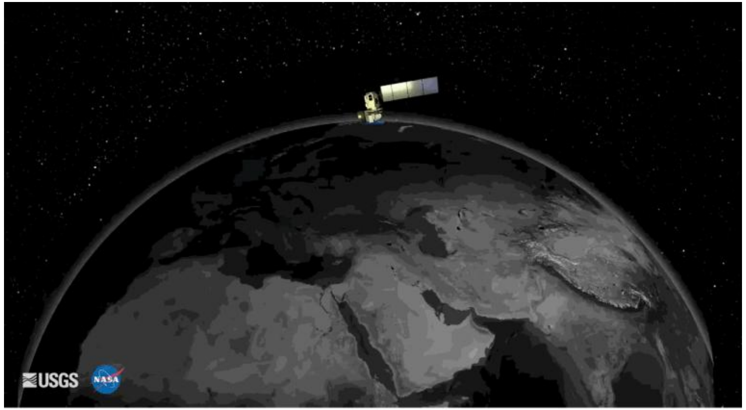
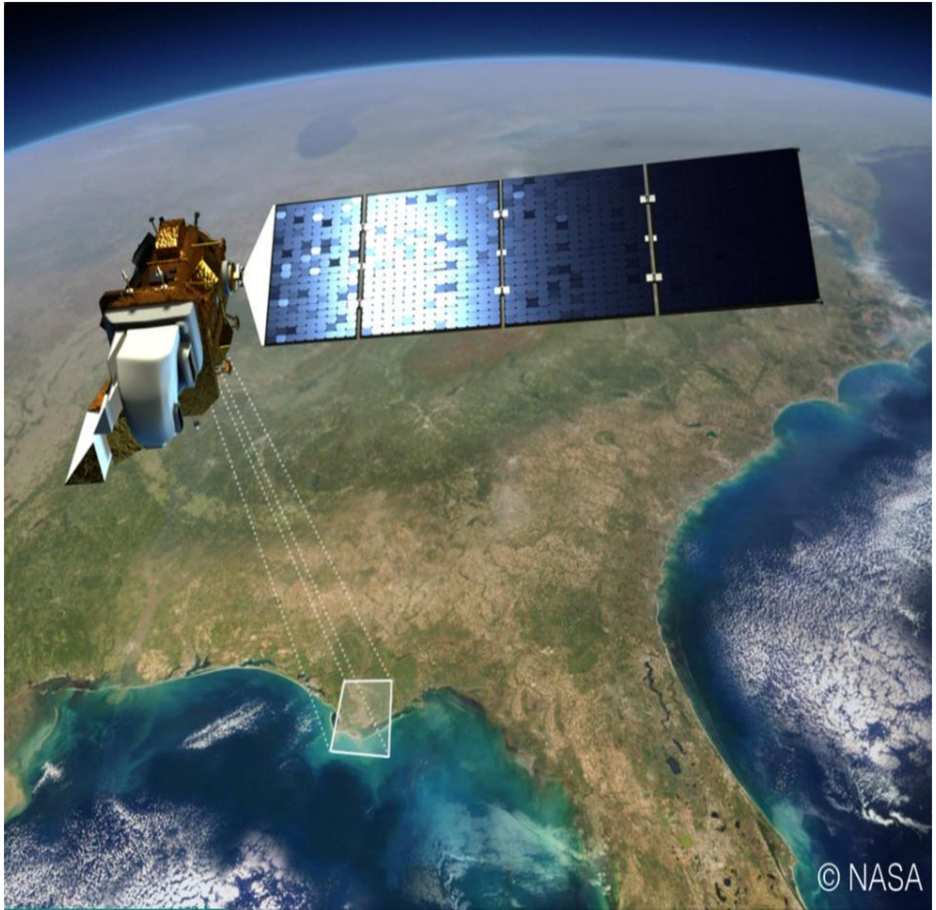
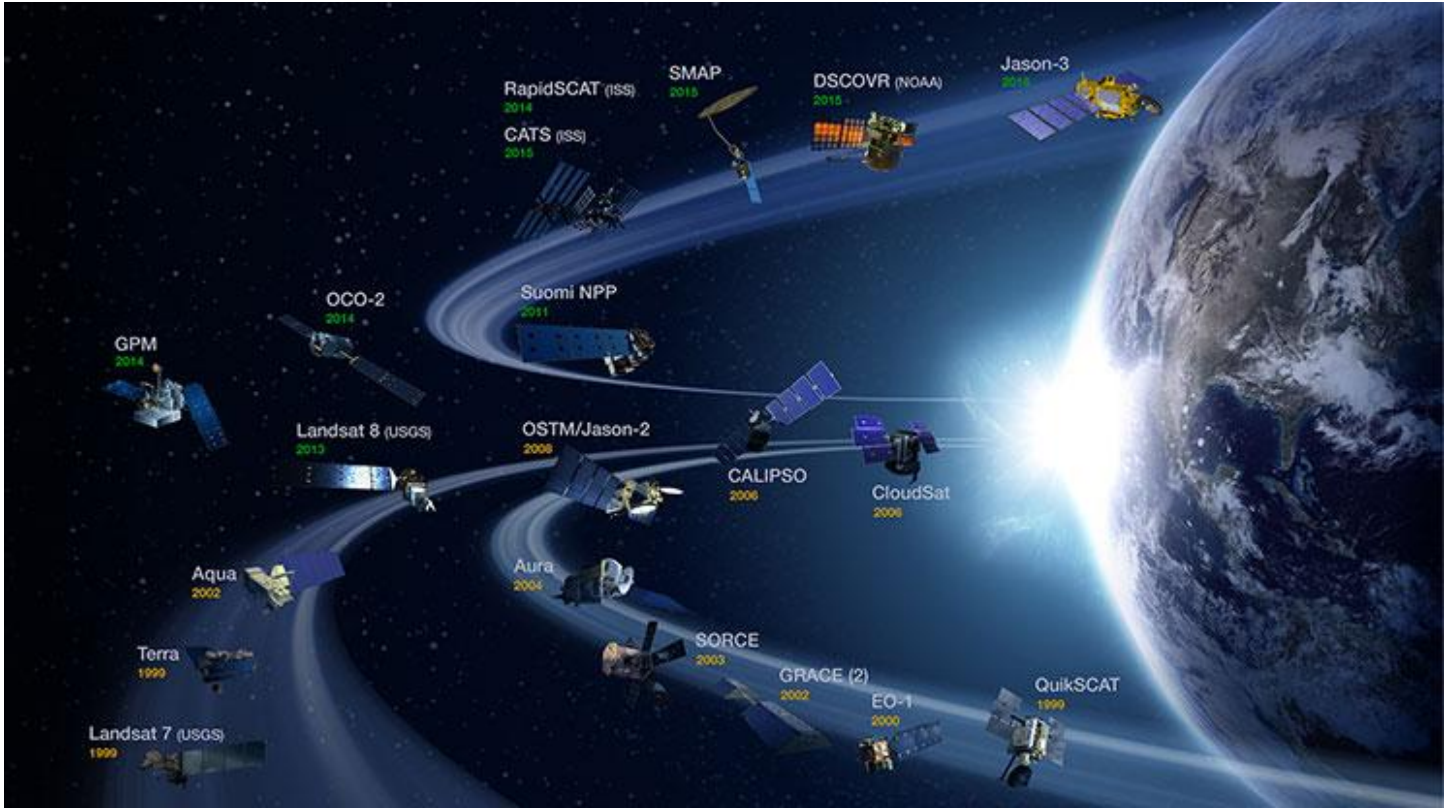




Subset of satellites by NASA

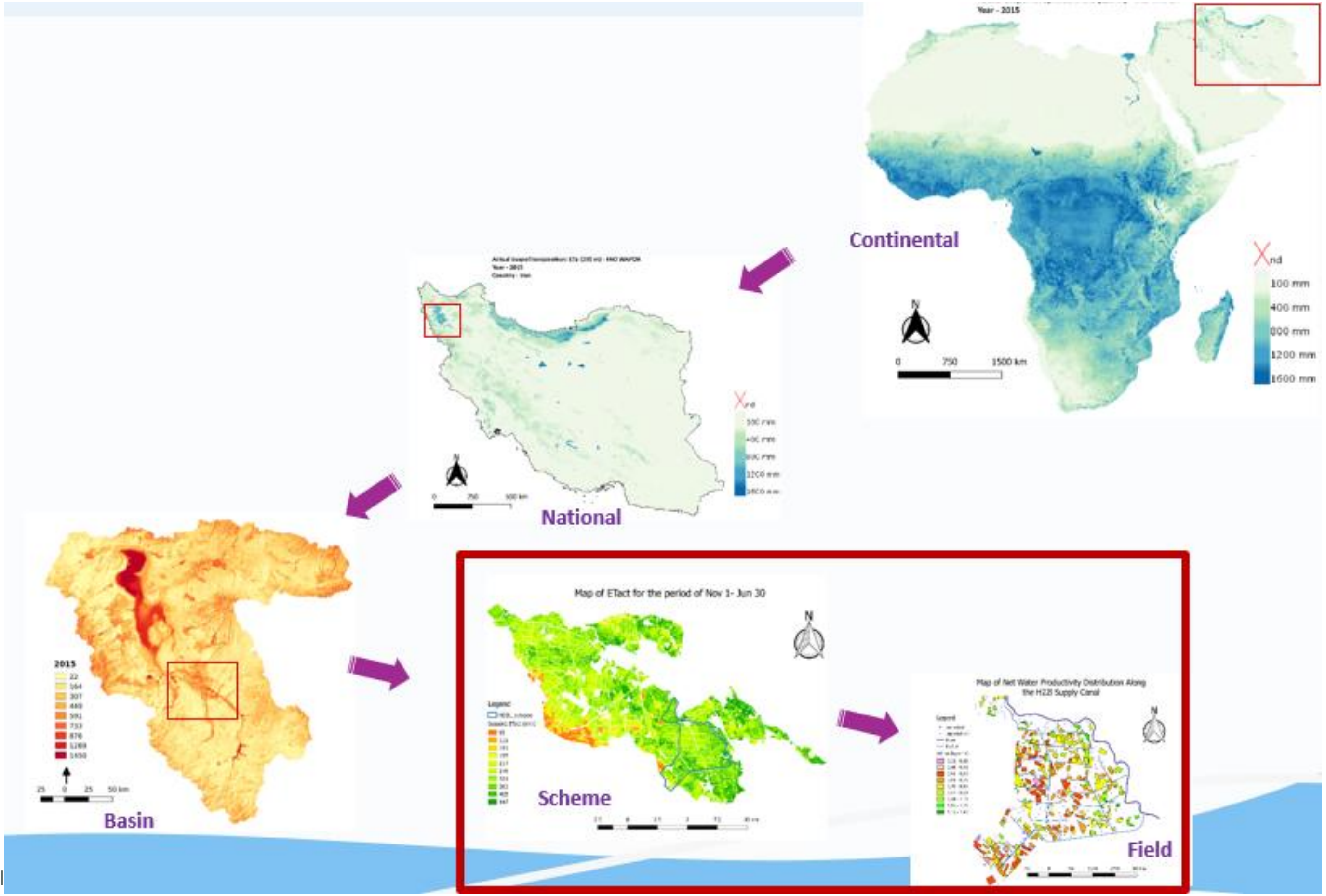


How many satellites are there in orbit?

- **More than 8000!!!!**
- Around 4852 active ones
- 1030 of them are monitoring Earth – Geo/Physical and Weather
- What would be other satellites used for ??

- First image of earth in the year 1960
  - **Around 60 years back !!!!!!!**

ADVANTAGES OF SATELLITE DATA



A satellite image is not just a photograph

A normal photo records visible red, green and blue light. Satellite sensors also record invisible signals — and those are what reveal vegetation health, water, soil moisture, temperature and built-up areas.

Red / Green / Blue

Natural colour — what the eye sees

Near-infrared

Vegetation vigour and health

Shortwave infrared

Moisture, burn scars, wet vs dry surfaces

Thermal

Land-surface temperature

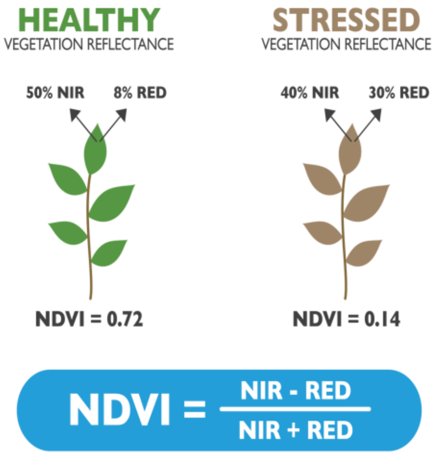
Radar (microwave)

Works through cloud and at night

Nighttime lights

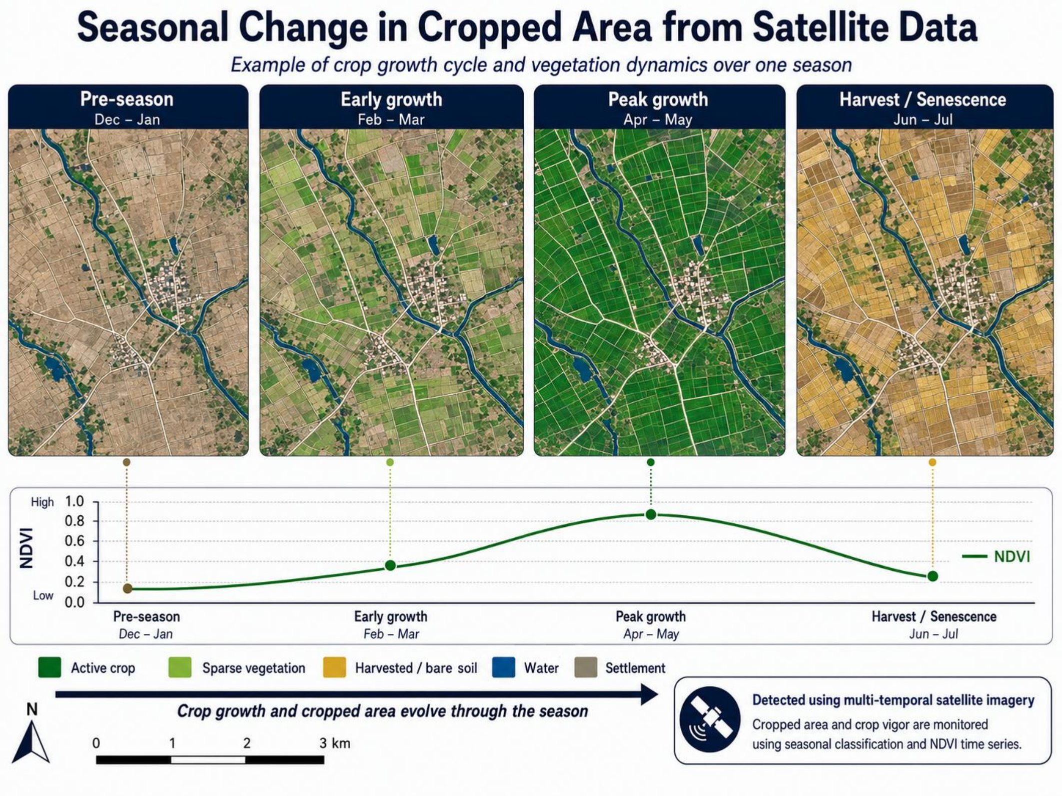
Proxy for human activity

Vegetation health & land use characteristics

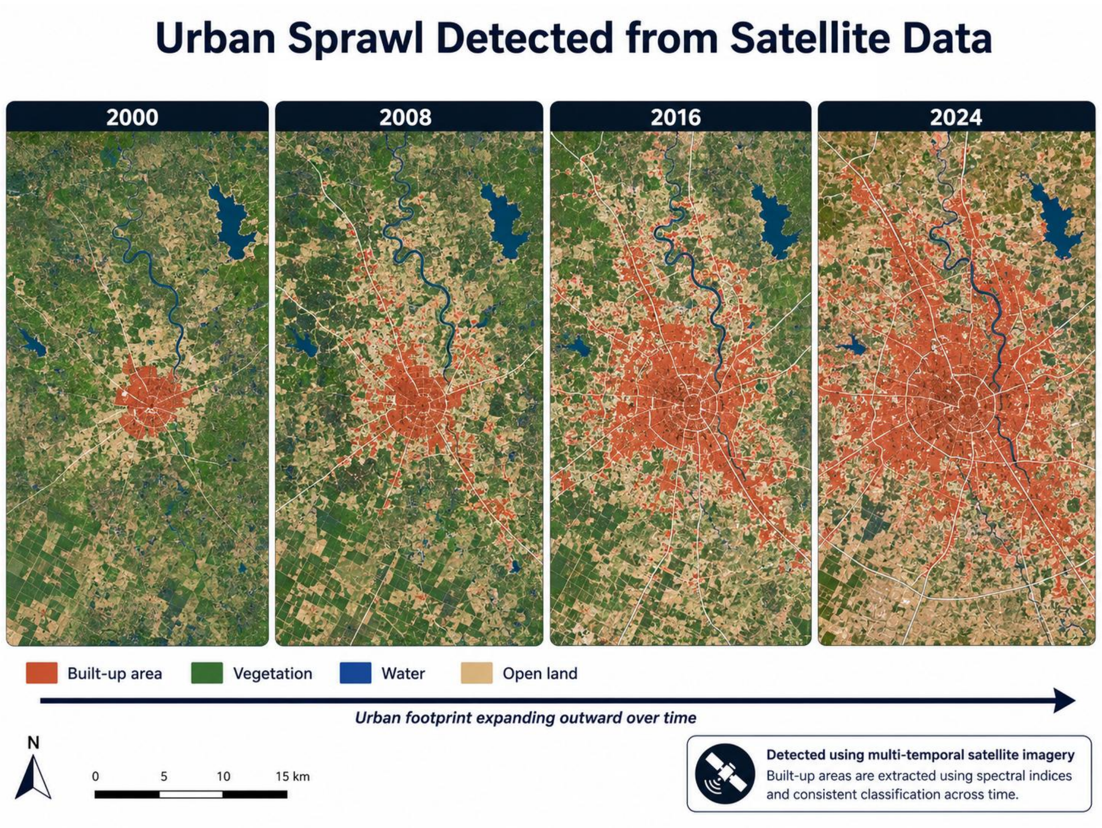


NDVI – Normalized Difference Vegetation Index

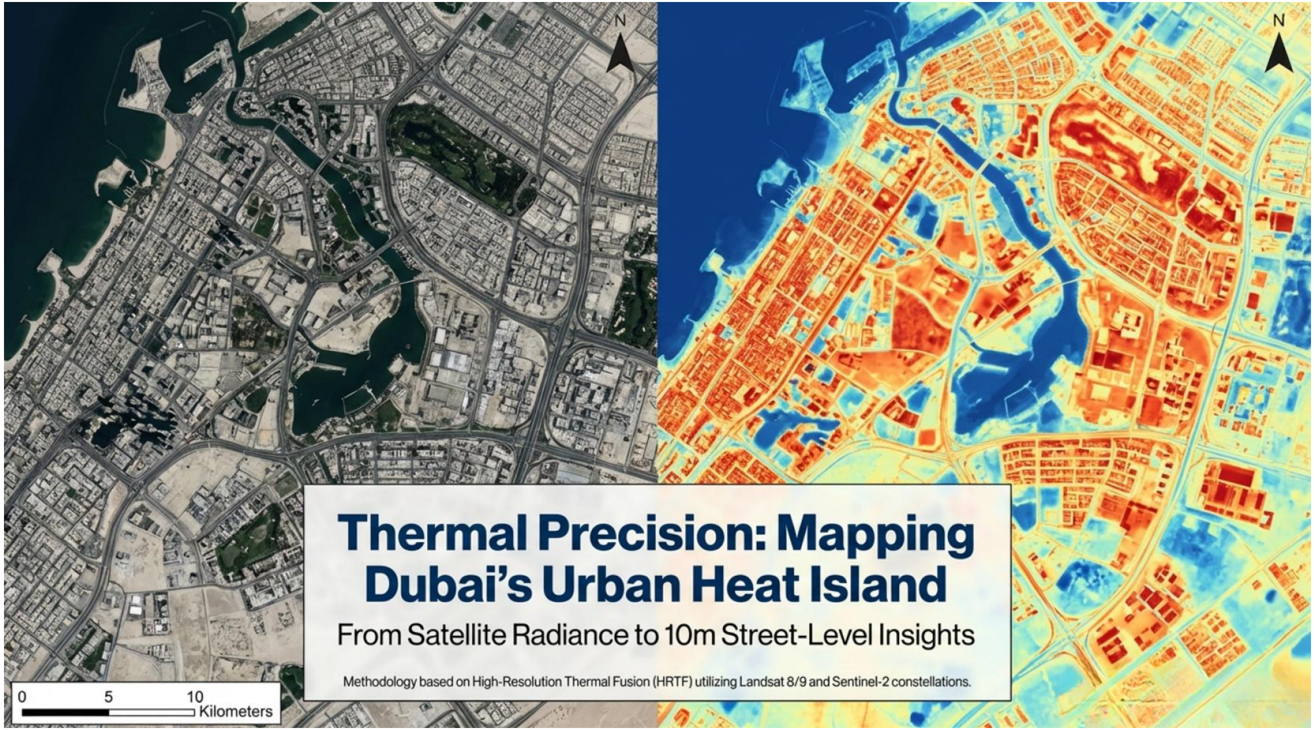
Vegetation health & land use characteristics



Urban sprawl



Urban heat island



WHY IT MATTERS

Satellites create repeatable evidence

1 **Baseline**

What was there before the project?

2 **Monitoring**

What is changing during implementation?

3 **Comparison**

What changed after completion?

4 **Scale**

Can we compare projects, countries and portfolios using the same method?

Two Major Types

1 Vector

Multiple formats
Always first requirement
Location & boundaries

- Shapefile
- Geopackage
- Geodatabase
- GeoJSON
- Keyhole Markup Language (KML)
- Etc.

https://gdal.org/en/stable/drivers/vector/index.html

2 Raster

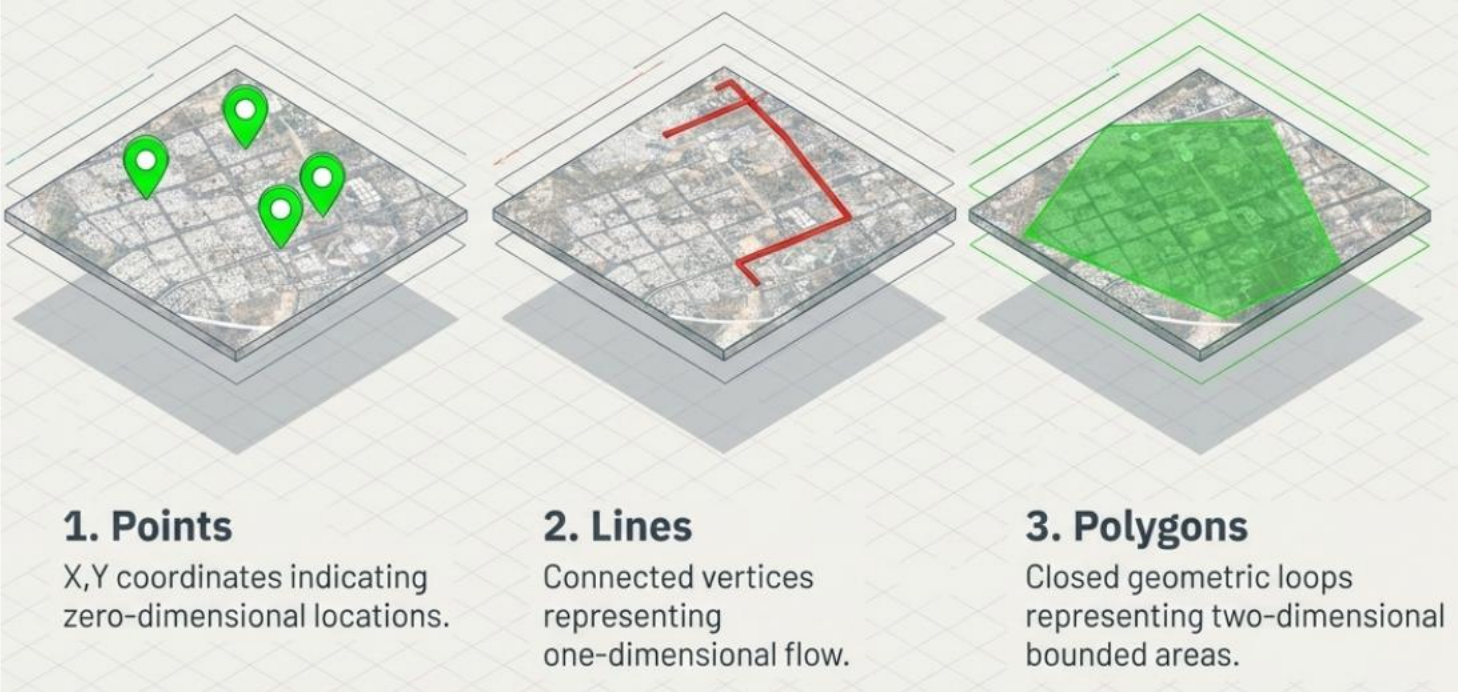
Multiple Formats
Images
Grids/Pixels/Cells

- GeoTiff
- NetCDF
- Hierarchical Data Format Release 5 (HDF5)
- ENVI
- IMG
- Etc.

https://gdal.org/en/stable/drivers/raster/index.html

Vector data: points, lines and polygons

Vector data represents discrete features — things with a definite shape and location.



SPATIAL DATA MODEL 1

Vector data: points, lines and polygons

Vector data represents discrete features — things with a definite shape and location.

Point	School, health facility, borehole, pumping station
Line	Road, canal, pipeline, transmission line
Polygon	Project boundary, irrigation command area, watershed, urban district, protected area

SPATIAL DATA MODEL 2

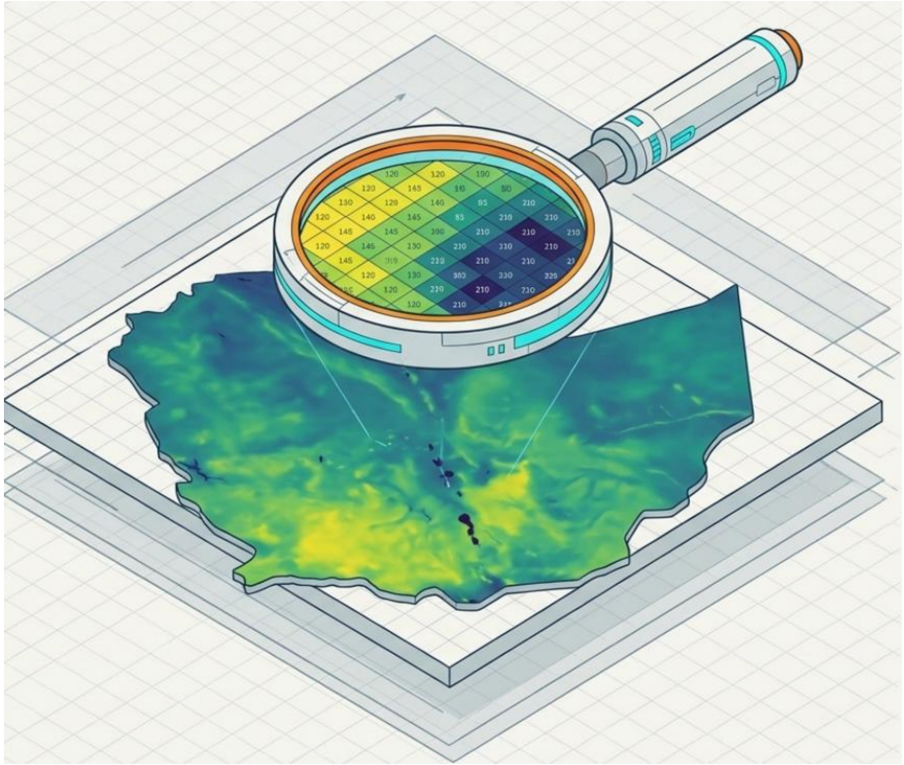
Raster data: grids of values

The Continuous Field Model

Represents phenomena that vary seamlessly across space without distinct boundaries (e.g., terrain elevation, rainfall).

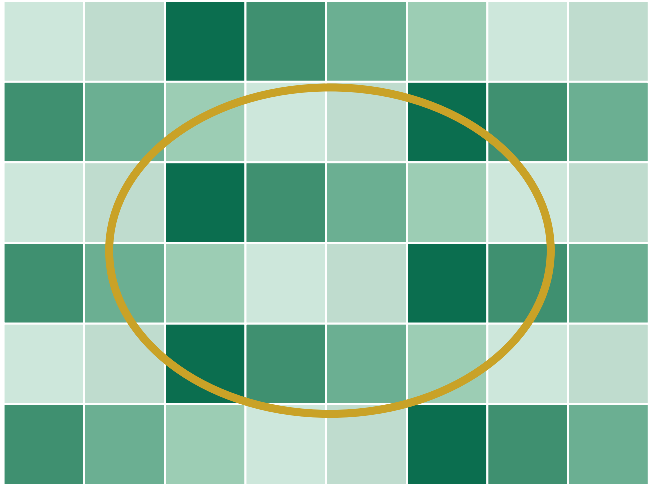
The Grid Structure

Consists of a matrix of identical cells. Each pixel contains a specific numerical value representing the real-world condition at that exact location.



Raster data: grids of values

Raster data divides the world into pixels. Each pixel contains a value.



project boundary

Examples of raster layers

- NDVI (vegetation index)
- Rainfall
- Evapotranspiration
- Elevation
- Surface temperature
- Population density
- Land cover

Operational question: *A project polygon can be used to extract statistics from any raster layer.*

THE FIRST OPERATIONAL STEP

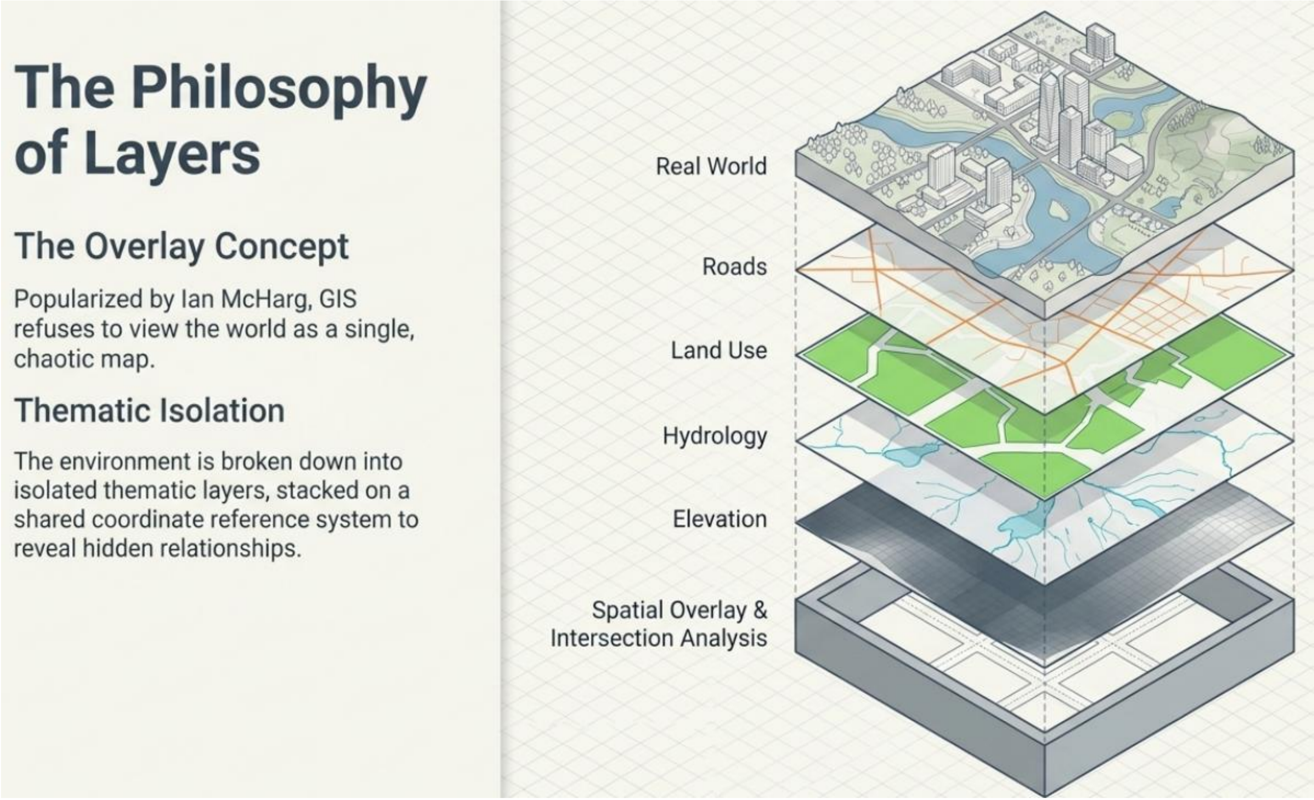
Define the project area

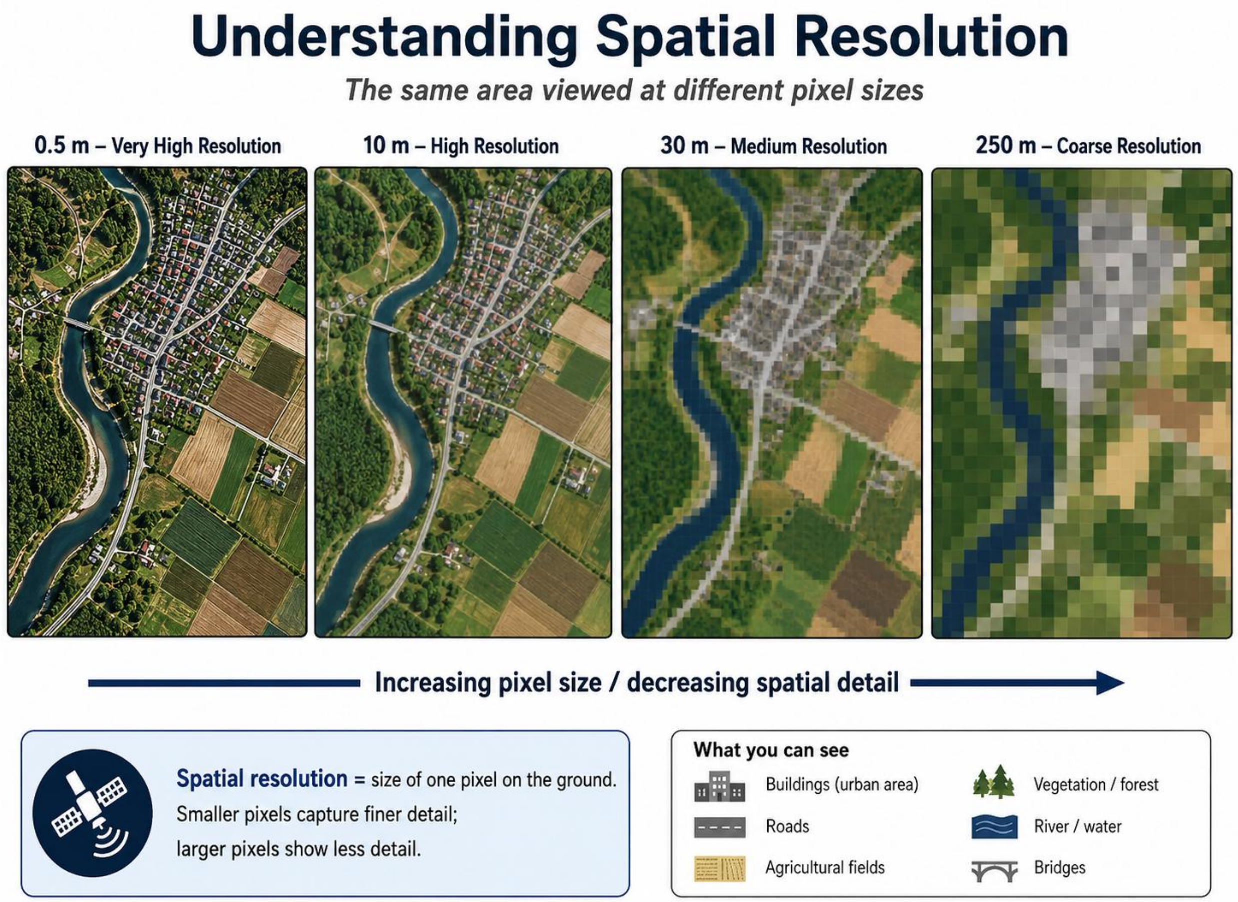
Without a project boundary, corridor or area of influence, satellite analysis cannot be linked properly to a project.

Irrigation project	→ Command-area polygon
Road project	→ Corridor line plus buffer
WASH project	→ Service-area polygon
School / health project	→ Point locations plus catchment area
Watershed project	→ Basin polygon
Urban project	→ District or municipal boundary

THE SECOND OPERATIONAL STEP

Spatial Analysis




Understanding Spatial Resolution
The same area viewed at different pixel sizes
0.5 m – Very High Resolution
10 m – High Resolution
30 m – Medium Resolution
250 m – Coarse Resolution
Increasing pixel size / decreasing spatial detail
Spatial resolution = size of one pixel on the ground.
Smaller pixels capture finer detail;
larger pixels show less detail.
What you can see
Buildings (urban area)
Roads
Agricultural fields
Vegetation / forest
River / water
Bridges

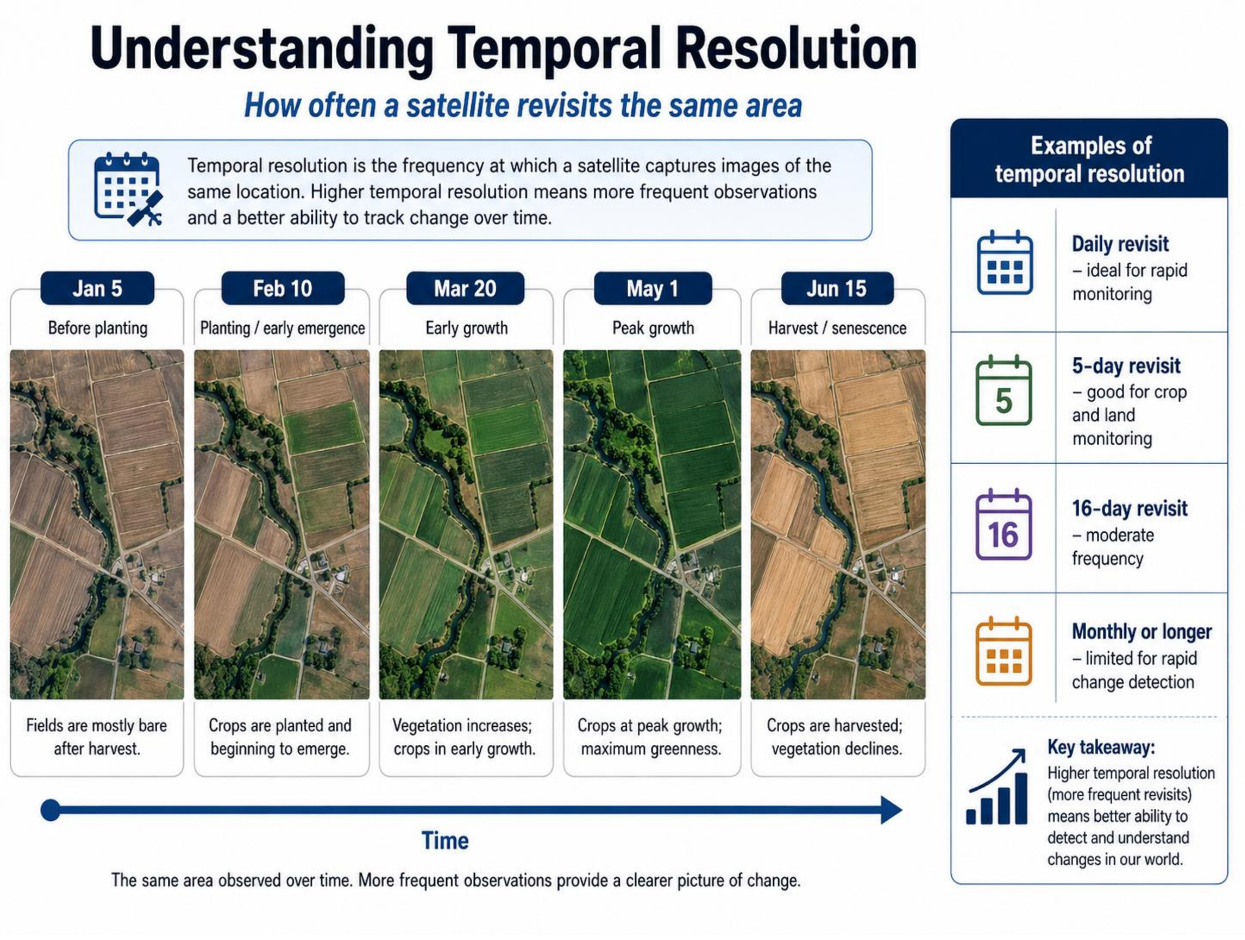
Can we see the feature?

Spatial resolution is the ground size represented by one pixel.

10 m	**Sentinel-2**	Field-level patterns, vegetation, water
30 m	**Landsat**	Long historical trends since the 1980s
250 m–1 km	**Climate products**	Regional trends (rainfall, temperature)
< 1 m	**Commercial data**	Detailed infrastructure — usually not free

Operational question: *Is the feature larger than the pixel?*

RESOLUTION 2 OF 3 · TEMPORAL



How often can we monitor?

Temporal resolution is how often a satellite revisits the same location.

Sentinel-2

Frequent revisit — vegetation monitoring through the season

Landsat

Decades of archive — long-term historical analysis

Daily rainfall products

Drought and flood monitoring in near-real time

Monthly composites

Cloud-free trend analysis

Operational question: *How often does the project condition change?*

What can the sensor detect?

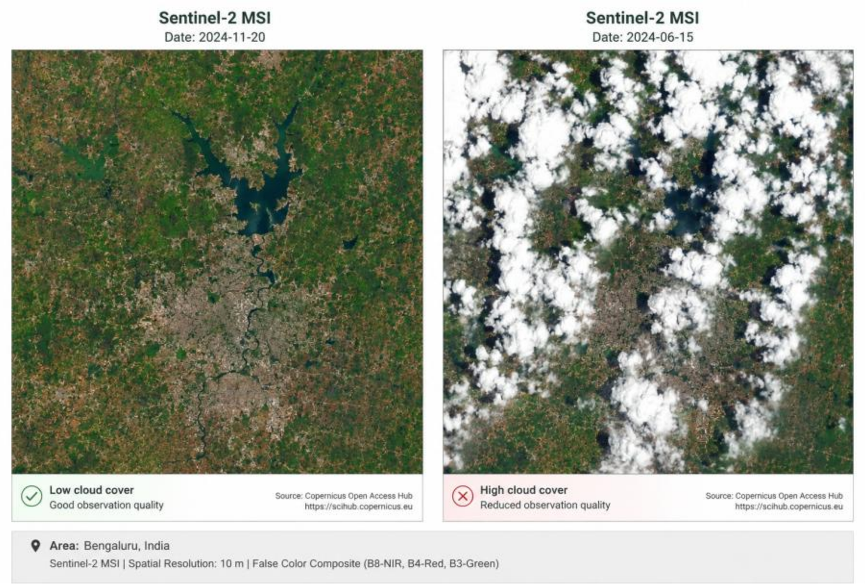
Spectral resolution is the number and type of wavelength bands a sensor records.

RGB	Visible land surface
Near-infrared (NIR)	Vegetation health
Shortwave infrared (SWIR)	Moisture, burn scars, dry vs wet surfaces
Thermal	Surface temperature
Radar	Surface roughness, moisture, flood extent

Operational question: *What physical condition are we trying to detect?*

A road block is generally represented as :

Optical data: vegetation, land cover and visible change



- Sentinel-2 and Landsat (open data)
- NDVI and vegetation condition
- Land cover and land-use change
- Water extent and urban expansion
- Crop condition monitoring

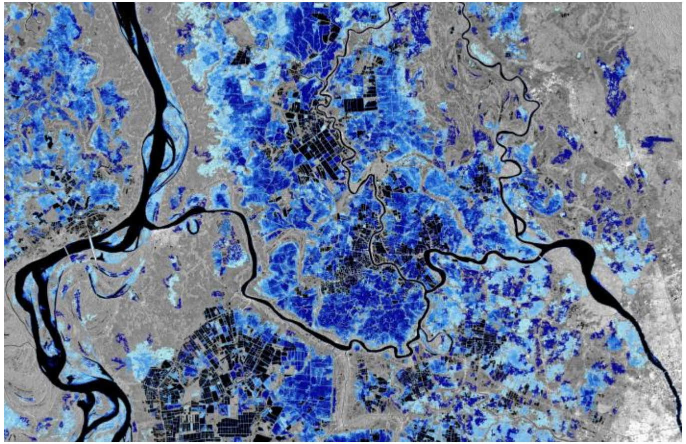
Strengths

- Intuitive to interpret
- High value for agriculture, water, environment, infrastructure

Limitations

- Affected by clouds
- Needs daylight
- Cannot see below pixel size

Radar data: cloud-independent monitoring



- Sentinel-1 (open data)
- Active sensor — sends its own signal
- Works at night
- Penetrates cloud cover
- Floods, surface moisture, deformation, construction change

Strengths

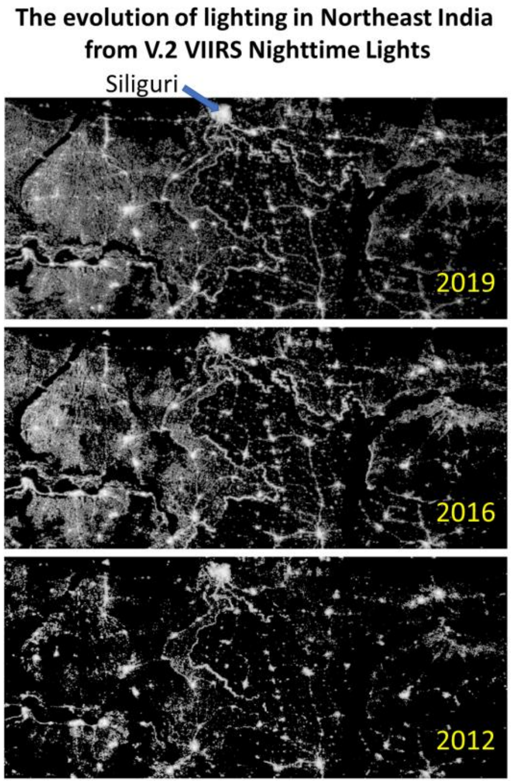
- All-weather, day and night
- Reliable in cloudy and monsoon regions

Limitations

- Less intuitive visually
- More complex processing
- Interpretation requires care

Radar complements optical — it does not replace it.

Nighttime lights: human activity and infrastructure proxy



- VIIRS nighttime lights (open data)
- Electrification monitoring
- Urban growth
- Economic-activity proxy
- Conflict / disaster disruption and recovery

Strengths

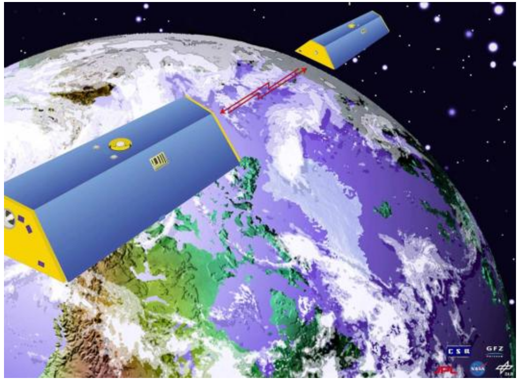
- Useful where admin data is delayed or incomplete
- Comparable across countries

Limitations

- A proxy, not a direct measure
- Coarser resolution
- Needs careful interpretation

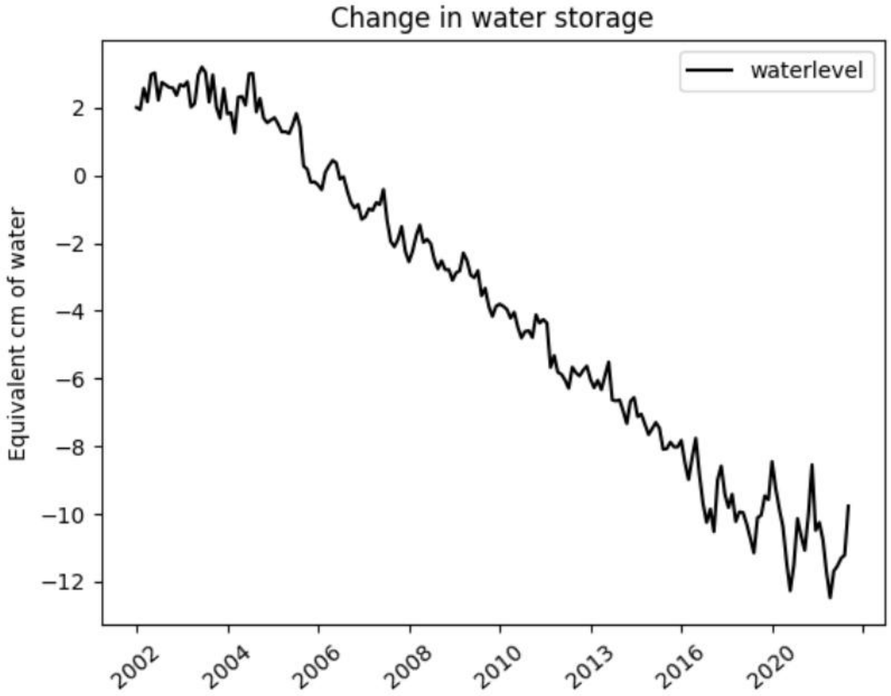
Especially valuable for development finance where statistics are hard to compare.

Can satellites measure ground water?



GRACE Satellite – source: JPL

Not directly, By understanding changes in gravity anomalies, due to change in Earth mass, We can get an idea about Ground water table.



Change in ground water table - KSA

EO is part of a wider geospatial evidence ecosystem

CHIRPS
Rainfall

ERA5
Climate reanalysis

FAO WaPOR
Evapotranspiration & water productivity

DEM
Elevation & topography

WorldPop
Population

OpenStreetMap
Roads & accessibility

Admin boundaries
Countries, regions, districts

Protected areas
Conservation constraints

Hazard layers
Flood & drought exposure

GEIDA combines EO with these open datasets to answer project questions.

HONEST EXPECTATIONS

What EO can and cannot do

✓ EO can

- ✓ Map physical conditions
- ✓ Provide consistent baselines
- ✓ Monitor large areas
- ✓ Detect change over time
- ✓ Support remote supervision
- ✓ Provide independent evidence

✗ EO cannot

- ✗ Replace all field verification
- ✗ Confirm every small asset
- ✗ Identify beneficiaries directly
- ✗ Prove causality without study design
- ✗ Solve poor project-location data
- ✗ Bypass data governance

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Study Area map

Q1 Do you often need to develop study area maps?

Q2 How do you create them?

Q3 Which tools are you using?

APPLICATION

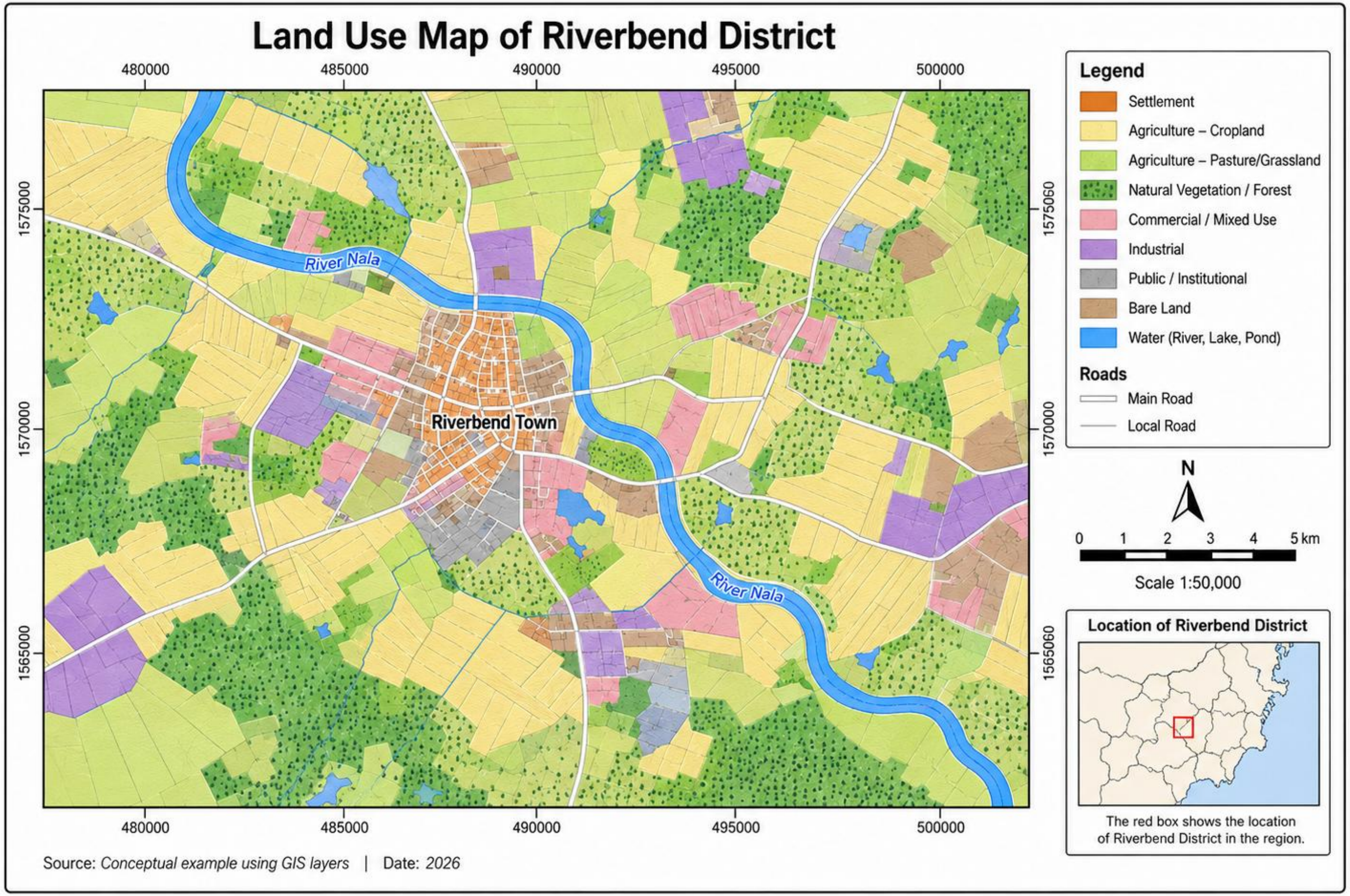
Study Area map

- ✓ Scale
- ✓ North Arrow
- ✓ Legend
- ✓ Title
- ✓ Overview
- ✓ Title
- ✓ Source & date
- ✓ Coordinates

Best practices in maps

Good Map Example

The same map with essential map elements for clear interpretation



Eight elements every project map needs

1. **Title & project code**
   What, where, which project, which stage

2. **Locator inset**
   Where the study area sits in the country

3. **Project boundary / AOI**
   The single most important layer on the map

4. **Legend**
   Every symbol on the map, nothing more

5. **North arrow**
   Orientation at a glance

6. **Scale bar**
   Real-world distance (never just a ratio)

7. **Data sources & CRS**
   Which datasets, which dates, which projection

8. **Author, date, version, classification**
   Who made it, when, and who may see it

The numbers match the annotated example on the next slide.

A project boundary is usually represented as:

Do not edit
How to change the design

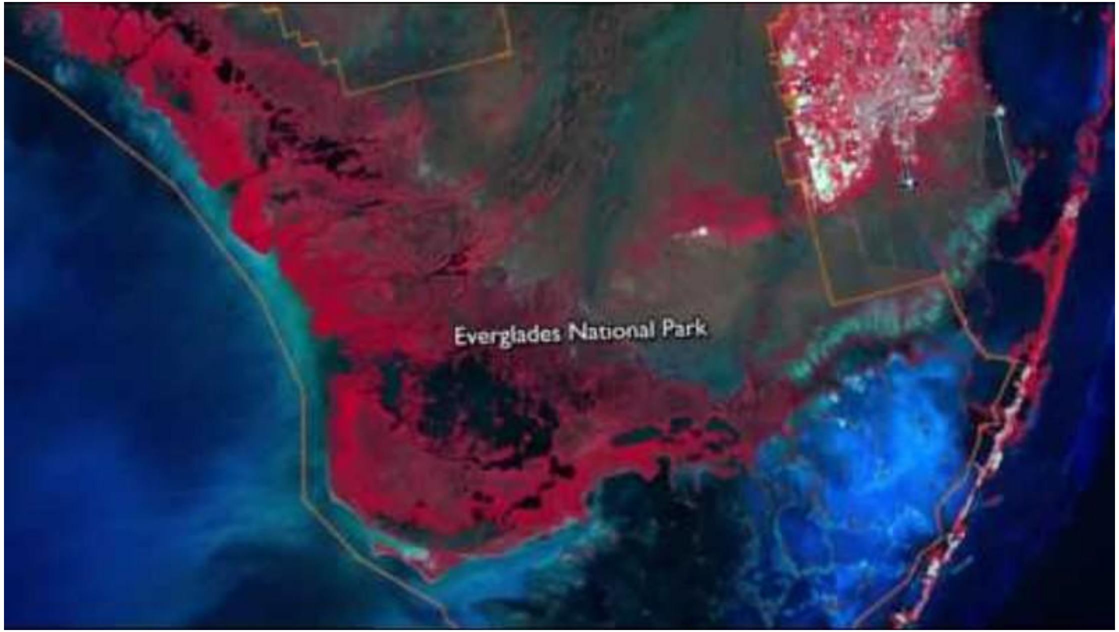
Do not edit
How to change the design

Data from Satellite based Radars are useful, because:

NDVI is mainly used to assess:

VIDEO 2 · 3–4 MINUTES

Watch: Earth Observation in action



“Which data type would be most useful for your sector — optical, radar, climate, nighttime lights, or water productivity?”