ERASMUS-EDU-2023-CBHE
Project number: 101129032

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LESLIE
LAND MANAGEMENT
ENVIRONMENT &
SOLID-WASTE

MICRO-CREDENTIAL

LAND MANAGEMENT IN CENTRAL ASIA

15.- Integrated Applications of Remote Sensing

Integration of Remote Sensing and GIS

LM-W15-V104

Co-funded by
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Integration of Remote Sensing and GIS

From satellite observations to spatial decisions in land management

Remote sensing provides measurements. GIS gives location, context, and decisions.

Learning objectives

By the end of the lesson, students should be able to explain the integration workflow.

1. **Define integration** — Explain how remote sensing raster data and GIS vector layers complement each other.
2. **Build a workflow** — Describe the main steps from image acquisition to map production and interpretation.
3. **Apply analysis tools** — Use overlay, zonal statistics, change detection, and field validation in land studies.
4. **Evaluate quality** — Recognize common errors related to scale, projection, resolution, and classification accuracy.

Core competence for land management students

Practical skill

Students learn to convert Earth observation data into maps that can support land-use planning, agriculture, water management, and environmental monitoring.

Decision-making value

Integrated RS–GIS analysis helps compare satellite indicators with parcels, roads, canals, settlements, administrative boundaries, and field observations.

Why integration is necessary

Remote sensing and GIS answer different parts of the same spatial question.

Remote sensing answers: "What changed on the surface?"

Spectral values, vegetation indices, water indices, temperature, texture, and change over time.

GIS answers: "Where, how much, and who is affected?"

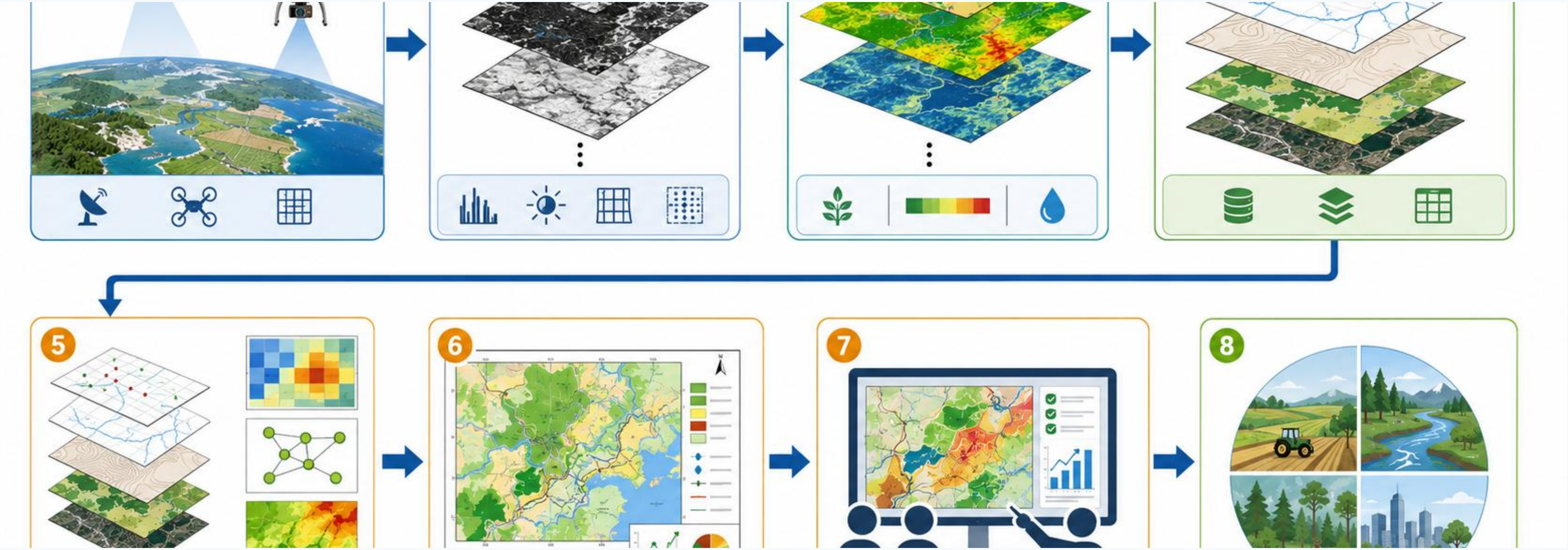
Administrative areas, land parcels, irrigation networks, roads, settlements, soils, and legal zones.

Together they support evidence-based land decisions

Example: an NDVI decline is more useful when linked to exact fields, canals, soils, ownership/use rights, and field observations.

Conceptual workflow: observation to action

An integrated workflow connects pixels, layers, analysis, and decisions.



Integration means linking image-derived indicators with real GIS layers: parcels, administrative boundaries, roads, canals, soil maps, DEMs, and field points.

Data models: raster meets vector

Remote sensing usually starts as raster; GIS often adds vector context.

Raster image

Pixels
Bands
Digital values
Indices: NDVI, NDWI, NDBI

→

Vector layers

Points
Lines
Polygons
Attributes: land user, soil, canal, zone

→

GIS result

Statistics
Maps
Risk zones
Management recommendations

Key principle: all data must share a correct coordinate reference system, spatial scale, and metadata.

Preparing remote sensing data for GIS

Before analysis, satellite images must become GIS-ready.

1 **Select data**

Choose sensor, date, bands, and cloud conditions.

2 **Preprocess**

Apply atmospheric correction, cloud mask, and mosaicking if needed.

3 **Georeference**

Check projection, coordinate system, pixel size, and alignment.

4 **Extract indicators**

Compute NDVI, NDWI, NDBI, LST, salinity or degradation proxies.

5 **Clip and export**

Clip to study area and export GeoTIFF or cloud raster.

Common GIS-ready products

- surface reflectance composite
- classified land-cover raster
- vegetation or water index map
- change raster between two dates
- statistics table joined to parcels

If preprocessing is weak, GIS analysis may look professional but still be wrong.

Typical data sources for integration

Different sources add different types of evidence to the GIS database.

Satellite imagery

Landsat, Sentinel-2, MODIS, Sentinel-1 SAR

GIS layers

parcels, canals, roads, settlements, protected zones

Terrain data

DEM, slope, aspect, elevation, flow direction

Field data

GPS points, crop type, soil salinity, field photos

Administrative data

districts, land users, land categories, statistics

Integration quality depends on time match, spatial resolution, projection, metadata, and field validation.

Analysis methods after integration

GIS tools turn image values into spatial information for land management.

Overlay

Combine raster indicators with parcels, soils, roads, or protected areas.

Zonal statistics

Calculate mean, median, maximum, or variability of NDVI/NDWI inside each field.

Change detection

Compare maps from different dates to detect expansion, degradation, or recovery.

Suitability analysis

Weight criteria such as slope, water access, salinity risk, and land cover.

Risk mapping

Classify areas by hazard, exposure, vulnerability, and management priority.

Reporting

Produce maps, tables, dashboards, and evidence for decisions.

Central Asia example: irrigated agriculture

Integrated RS–GIS analysis is especially useful where land and water are tightly linked.

Possible question

Which fields show reduced crop vigor, and are they near canals, saline soils, or drainage problems?

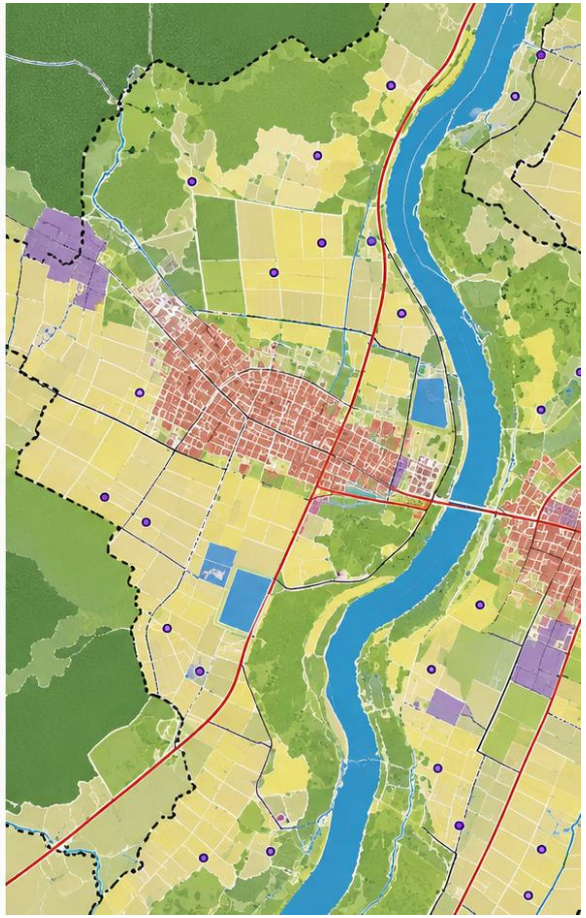
Integrated evidence

- Sentinel-2 NDVI time series by field
- canal and drainage network layers
- soil salinity or soil texture maps
- field survey points and farmer observations

Output: field-level priority map for irrigation advice, monitoring, or further ground inspection.

From image interpretation to GIS mapping

Remote sensing interpretation becomes stronger when linked to thematic GIS layers.



Interpretation checklist

- Are land-cover classes spectrally separable?
- Do class boundaries follow real parcel or landform boundaries?
- Do GIS layers explain why the pattern appears?
- Do field observations confirm the classification?
- Is the result useful for a decision, not only a map?

A classified raster becomes more meaningful when its classes are connected to places, land users, and management zones.

Validation and accuracy assessment

Integrated maps must be checked before they support real decisions.

Validation sources

- independent field points
- GPS and mobile survey data
- high-resolution imagery
- existing cadastral or land-use records
- local expert review

Confusion matrix

	Map A	Map B
Ref A	42	6
Ref B	8	44

Accuracy is not only a number. It shows whether a map is reliable for its intended use.

Quality questions

- Was validation independent?
- Are classes balanced?
- Are field dates close to image dates?
- Are mixed pixels considered?
- Are uncertainty and limitations reported?

Common challenges and good practice

Many GIS errors begin before the map is drawn.

Challenge	Why it matters	Good practice
Different projections	Layers do not align correctly	Define and transform CRS before analysis
Different resolutions	Pixel and parcel scales may not match	Choose analysis unit carefully
Clouds and shadows	False change can appear in optical imagery	Mask clouds; use composites or SAR
Date mismatch	Field data and image data may represent different conditions	Plan field survey close to image acquisition
Weak metadata	Results cannot be reproduced	Record sensor, date, bands, processing steps

Good GIS integration is transparent, repeatable, and documented.

Students can complete this exercise using QGIS, ArcGIS Pro, or Google Earth Engine + GIS.

Task: field-level vegetation assessment

- Download a cloud-free Sentinel-2 or Landsat image for an agricultural area.
- Calculate NDVI and clip it to a district or farm boundary.
- Overlay field parcel polygons and calculate mean NDVI per parcel.
- Classify parcels into low, medium, and high vegetation vigor.
- Prepare a map and a short paragraph explaining possible causes and limitations.

Expected output: one map + one table + 150-word interpretation.

Key lesson: integration changes satellite images into spatial knowledge for decisions.

Three key points

- RS measures surface conditions.
- GIS adds location, attributes, and context.
- Validated integration supports land-use, agriculture, environmental, and hazard decisions.

Reflection question

Which is more dangerous in land management: using satellite images without GIS context, or using GIS boundaries without recent remote sensing evidence? Explain your answer with one example.

Selected references

- NASA Earthdata GIS. Earthdata Geographic Information System resources and GIS-ready services.
- USGS Landsat Missions and Landsat Data Access resources.
- Copernicus Data Space Ecosystem. Sentinel-2 mission and land surface monitoring.
- FAO. Geospatial information and land cover/crop monitoring resources.
- Shokirov, Sh.S., Musaev, I.M., & Akbarov, M.S. (2015). Masofadan zondlash. Tashkent.

Thank you. Please review the references and practice the workflow independently with a local study area.

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