LAND MANAGEMENT, ENVIRONMENT & SOLID-WASTE: INSIDE EDUCATION AND BUSINESS IN CENTRAL ASIA
ERASMUS-EDU-2023-CBHE Project Number: 101129032

MICRO-CREDENTIAL

LAND MANAGEMENT IN CENTRAL ASIA

15.- Integrated Applications of Remote Sensing

Activity

Mini project – Remote sensing–based land analysis

Co-funded by the European Union

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1. Purpose of this activity

This mini project helps students connect remote sensing theory with practical land resource management. Students will select a study area, prepare satellite and GIS inputs, calculate simple indicators, interpret land patterns, and prepare a map-based recommendation for a land-management problem.

Core idea

Remote sensing provides repeated observations of the Earth surface. GIS organizes these observations with boundaries, infrastructure, field notes, and administrative information so that land managers can make evidence-based decisions.

2. Learning objectives

- Define a practical land-management question that can be investigated with remote sensing and GIS.
- Select suitable satellite data and explain why spatial, spectral and temporal resolution matter.
- Prepare a basic RS-GIS workflow including preprocessing, index calculation and classification or interpretation.
- Use GIS layers such as parcels, roads, canals, settlements or administrative boundaries to support spatial analysis.
- Evaluate uncertainty using field notes, reference points or accuracy-assessment logic.
- Prepare a short map-based recommendation for land managers, farmers or local authorities.

Recommended classroom use	Time
Individual preparation and data review	20–30 minutes
Small-group GIS/interpretation work	60–90 minutes
Map design and result explanation	30–45 minutes
Presentation or short memo	15–20 minutes per group

Student workspace	Notes / response
Check your understanding	What land problem will remote sensing help to observe?
Key connection	Remote sensing = observation; GIS = organization, overlay and decision support.
Student note	Write one possible local example from Uzbekistan or Central Asia.
Additional project note 1	.....
Additional project note 2	.....

3. Mini project scenario

Students work as a small land-analysis team. Their task is to prepare a concise evidence-based assessment for one selected area in Uzbekistan or Central Asia. The area may be an irrigated farming zone, a peri-urban expansion zone, a degraded pasture, a wetland edge, or a river/canal command area.

Choose one project theme

Theme	Main question	Suggested output
Irrigated agriculture	Which fields show strong, moderate or weak vegetation condition?	Crop condition map + management note
Land degradation	Where are bare soil, salinity risk or vegetation decline most visible?	Risk map + restoration priority areas
Land-use change	Where has settlement, construction or bare land expanded?	Before/after map + change table
Water and wetlands	Where are surface water and riparian vegetation changing?	Water/vegetation map + protection note
Parcel-based monitoring	Which parcels need field verification or management attention?	Parcel ranking table + GIS map

Instructor option

The instructor may provide a prepared image, a Sentinel-2 composite, a Landsat scene, a Google Earth Engine link, or printed map screenshots. Students should not be graded on advanced software skills only; they should be graded on clear reasoning and correct interpretation.

Student workspace	Notes / response
Group planning workspace	Selected theme: .....
Study area	District / basin / parcel zone: .....
Main land problem	.....
Expected decision user	Farmer / land agency / municipality / water manager / other
Additional project note 1	.....
Additional project note 2	.....
Additional project note 3	.....

4. Suggested data package

The project can be completed using open satellite data and simple GIS layers. Students may use ArcGIS Pro, QGIS, Google Earth Engine, SNAP, or prepared screenshots if a full lab environment is not available.

Input	Examples	Purpose in the mini project
Satellite imagery	Sentinel-2 MSI, Landsat Collection 2, MODIS for broad trends	Base observation for land cover, vegetation, water and change analysis
GIS boundary data	District boundary, study area polygon, cadastral/parcel layer if available	Defines the analysis unit and supports area calculation
Infrastructure layers	Canals, roads, settlements, reservoirs, drainage network	Explains land-use pressure and water-access patterns
Reference information	Field photos, GPS points, Google Earth historical view, local knowledge	Supports interpretation and accuracy checking
Environmental context	DEM, soil/salinity map, land degradation notes, water information	Helps explain causes and management relevance

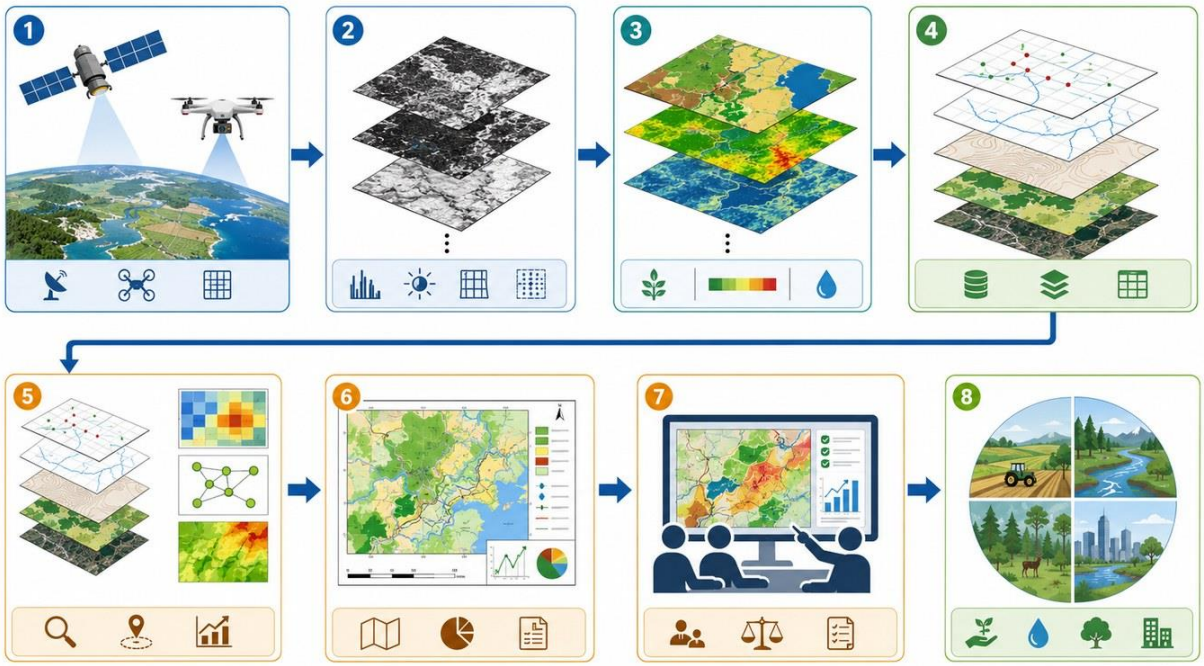
Data ethics and reliability

Use official or well-documented sources when possible. Record the date, sensor, resolution and processing level of every satellite image. Never present a visual impression as a verified fact without reference information.

Student workspace	Notes / response
Data log to complete	Sensor and date: .....
GIS layer log	Boundary / parcels / canals / roads / settlements: .....
Reference evidence	Field photo / GPS / official map / Google Earth history: .....
Reliability note	What is uncertain in the data package? .....
Additional project note 1	.....
Additional project note 2	.....
Additional project note 3	.....
Additional project note 4	.....

5. RS-GIS workflow for the mini project

A strong mini project follows a simple but complete workflow: define the problem, prepare the data, derive indicators, interpret or classify, check reliability, and communicate a land-management decision.



Step	Action	Student decision
1	Define study area and question	What exact land problem will be mapped?
2	Select imagery and GIS layers	Which date, sensor and spatial scale are suitable?
3	Preprocess and inspect data	Are clouds, shadows, projection and clipping handled?
4	Calculate indices or classify land cover	Which indicators best represent the problem?
5	Validate and interpret results	What evidence supports the map classes?
6	Prepare map and recommendation	What should land managers do next?
Student workspace		**Notes / response**
Workflow self-check		Did the group define one clear land question? Yes / No
Workflow self-check		Are all input layers listed with source and date? Yes / No
Workflow self-check		Is the final map linked to a management recommendation? Yes / No
Additional project note 1		.....
Additional project note 2		.....

6. Task 1 — Define the study area and land problem

Begin with a clear problem statement. A remote sensing project is weak when it only says “we made a map”. It becomes stronger when it connects the map to a real land-management need.

Worksheet item	Student response space
Study area name and location	.....
Main land-management issue	.....
Why this issue matters	Food security / soil quality / water use / urban pressure / biodiversity / disaster risk
Main land-cover classes expected	Agriculture / bare soil / water / settlement / vegetation / degraded area / other
Intended users of the result	Local authority / farmers / land cadastre body / water managers / environmental body
Final output scale	Parcel level / district level / watershed level / regional overview

Good problem statement example

“This project uses Sentinel-2 imagery and GIS layers to identify fields and adjacent bare-soil zones that may require field inspection for vegetation stress and land degradation risk in a semi-arid irrigated area.”

Student workspace	Notes / response
Problem statement draft	The main land-management problem in this area is: .....
Why it matters	This problem matters because: .....
Evidence needed	The most important evidence we need is: .....
Additional project note 1	.....
Additional project note 2	.....
Additional project note 3	.....

7. Task 2 — Select satellite data and GIS layers

Students should justify their data choice. The selected sensor must match the land-management problem, the size of the study area, the season, cloud conditions, and the required map detail.

Criterion	Guiding question	Your choice
Spatial resolution	Is 10–30 m enough, or is parcel-level detail required?	.....
Spectral bands	Do you need NIR, SWIR, red-edge, thermal or radar information?	.....
Temporal resolution	Is one date enough, or do you need seasonal comparison?	.....
Processing level	Surface reflectance preferred for indices and comparisons?	.....
Cloud and shadow	Is the image sufficiently clear over the area of interest?	.....
Projection / CRS	Do raster and vector layers align correctly?	.....

Data selection tip

For crop and land-cover work, students often use cloud-free Sentinel-2 or Landsat surface reflectance scenes from the growing season. For larger regional trends, lower-resolution time-series products may be more appropriate.

Student workspace	Notes / response
Data selection justification	Why was this satellite image selected? .....
Seasonal logic	Is the image date suitable for the land-cover or crop stage? .....
GIS layer value	Which GIS layer explains the pattern best? .....
Additional project note 1	.....
Additional project note 2	.....
Additional project note 3	.....

8. Task 3 — Preprocessing and quality control

Before analysis, the image must be prepared so that different layers align and the results can be interpreted. Preprocessing does not need to be advanced, but basic quality control is essential.

Preprocessing check	Why it matters	Done?
Clip to study area	Keeps the project focused and reduces file size	□
Use surface reflectance when available	Improves comparability for vegetation and water indices	□
Cloud/shadow check	Avoids false classification or wrong NDVI values	□
Band selection or composite	Helps visual interpretation and index calculation	□
Projection check	Ensures raster, parcels and field points overlay correctly	□
NoData and edge check	Prevents false values in statistics and maps	□

Common composite	Use
Natural color: Red-Green-Blue	Useful for visual comparison with familiar landscape appearance
False color: NIR-Red-Green	Highlights vegetation strongly and helps separate crops from bare soil
SWIR-NIR-Red	Useful for moisture, burned areas, bare soil and degradation interpretation

Student workspace	Notes / response
Quality-control notes	Cloud/shadow issue: None / minor / serious
Geometry issue	Are raster and vector layers aligned? Yes / No / not checked
Preprocessing decision	Correction or masking step applied: .....
Additional project note 1	.....
Additional project note 2	.....

9. Task 4 — Calculate indicators and interpret patterns

Vegetation, water and built-up indicators are simple tools for turning spectral information into interpretable land-management evidence. Students should explain what each indicator shows and what it does not show.

Indicator	Formula / idea	Typical interpretation	Caution
NDVI	(NIR − Red) / (NIR + Red)	Vegetation greenness and crop vigor	Low values may mean bare soil, water, cloud shadow or harvested fields
NDWI / MNDWI	Green-NIR or Green-SWIR contrast	Open water or moisture-related patterns	Confusion may occur with shadows or wet soil
SAVI	NDVI adjusted for soil background	Useful where vegetation is sparse	Requires soil-adjustment factor selection
NDBI	SWIR-NIR contrast	Built-up or dry surface patterns	Can confuse bare soil and construction areas
Bare soil / salinity clues	High brightness, SWIR response, field context	Potential degradation or exposed soil	Requires field verification before final diagnosis

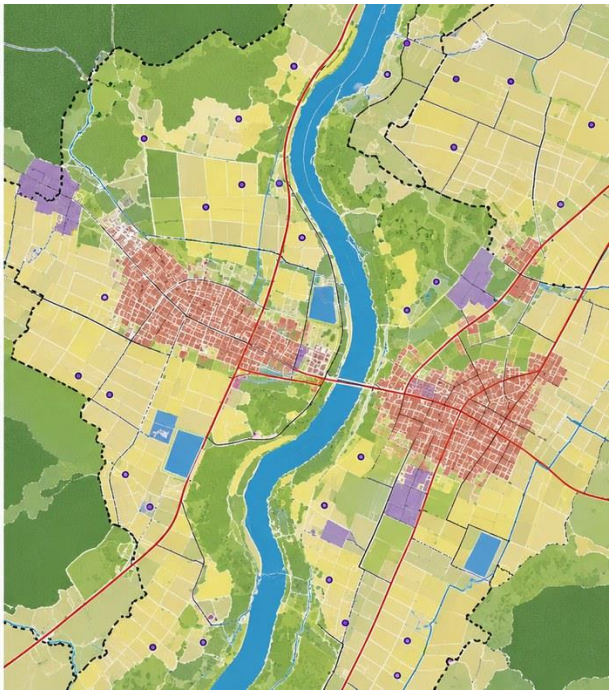
Interpretation rule

An index is not a final diagnosis. Use it together with field evidence, season, crop calendar, water availability, soil conditions and GIS context.

Student workspace	Notes / response
Index interpretation note	High values mean: .....
Index interpretation note	Low values may indicate: .....
Avoid overclaiming	What cannot be concluded from the index alone? .....
Additional project note 1	.....
Additional project note 2	.....
Additional project note 3	.....

10. Task 5 — Produce a land analysis map

Students may use supervised classification, unsupervised classification, threshold-based index mapping, or visual interpretation. The method should be simple enough to explain and strong enough to support the project question.



Required map elements	Check
Title that clearly states the mapped theme and date	☐
Legend with 4–7 readable classes	☐
Study area boundary and main reference layers	☐
Scale bar, north arrow and coordinate/grid note where appropriate	☐
Data source and sensor/date information	☐
Short note about uncertainty or limitations	☐

Student workspace	Notes / response
Map peer review	Can another student understand the legend without explanation? Yes / No
Map peer review	Are map classes logically named? Yes / No
Map peer review	Is the data source/date visible? Yes / No
Additional project note 1	.....
Additional project note 2	.....

11. Task 6 — Overlay results with GIS layers

GIS transforms an image result into land-management information. Overlay analysis can connect vegetation condition or land-cover change with parcels, canals, roads, settlements or administrative units.

GIS analysis option	Example output
Zonal statistics by parcel	Mean NDVI, minimum NDVI, % bare soil, % water or dominant land-cover class
Distance analysis	Vegetation stress by distance from canal, road, settlement or drainage line
Overlay with land categories	Which official land categories contain mapped changes or risk areas?
Change summary by area	Hectares of agriculture, water, bare soil, settlement or degraded land by year/date
Priority ranking	Fields or zones ranked as high, medium or low priority for field inspection

Student workspace	Notes / response
GIS statistics workspace	Total study area: ..... ha
GIS statistics workspace	Largest class or risk zone: .....
GIS statistics workspace	Priority area for action: .....
Additional project note 1	.....
Additional project note 2	.....

12. Task 7 — Check accuracy and uncertainty

The project should include a simple reliability check. Students do not need a complex statistical design for a classroom mini project, but they must show how they checked whether their map is reasonable.

Reference source	How to use it	Limitation
Field GPS points or photos	Compare class labels with actual observed land cover	Small number of points may not represent the whole area
High-resolution imagery	Use as visual reference for settlements, water, roads and field boundaries	Date may differ from the satellite image date
Local knowledge / crop calendar	Explain seasonal patterns and harvested fields	Must be documented, not assumed
Existing maps or official layers	Compare broad land-use categories or administrative boundaries	May be outdated or generalized
Confusion matrix sample	Count correct and incorrect class labels at selected reference points	Requires consistent sampling and clear class definitions

Minimum expectation

Every group should identify at least three possible sources of error: cloud/shadow, seasonal timing, mixed pixels, class confusion, outdated GIS layers, insufficient reference points, or unclear class definitions.

Student workspace	Notes / response
Uncertainty statement	Our result is reliable for: .....
Uncertainty statement	Our result is less reliable for: .....
Recommended verification	Field check / official layer / more dates / expert review
Additional project note 1	.....
Additional project note 2	.....
Additional project note 3	.....

13. Mini-case options for Central Asia

The instructor may assign one case or allow students to choose. Each case is designed for undergraduate-level analysis and can be completed using satellite images, GIS layers, and a short written explanation.

Case	Land-management focus	Suggested analysis
A. Irrigated field condition	Crop condition, irrigation access and vegetation vigor	NDVI map + parcel statistics + field inspection priorities
B. Peri-urban land conversion	Expansion of settlements or construction into agricultural land	Two-date comparison + land-use change table
C. Bare soil and salinity risk	Dryland degradation, exposed soil and possible salinity signals	False-color interpretation + risk zones + verification plan
D. Canal command area	Relationship between water infrastructure and land productivity	Distance-to-canal overlay + vegetation condition map
E. Wetland or river edge	Surface water, riparian vegetation and land-use pressure	NDWI/MNDWI + land-cover interpretation + protection note

Short fieldwork extension

Students may collect 5–10 GPS/photo points from accessible areas, record land cover and visible management issues, and use these points as reference evidence. Field data should be collected safely and only in permitted locations.

Student workspace	Notes / response
Mini-case response	Chosen case: A / B / C / D / E
Management recommendation	The first recommended action is: .....
Fieldwork note	Where should field verification be done first? .....

14. Final deliverables and assessment rubric

Each group submits a compact project package. The emphasis is on logical workflow, correct interpretation, readable mapping and practical relevance for land management.

Deliverable	Required content
Map 1: study area and inputs	Boundary, key GIS layers, image date/sensor and brief data note
Map 2: analysis result	Land cover, vegetation condition, water/bare soil, change or risk classes
Statistics table	Area by class, parcel ranking, change area or summary indicators
Short memo	300–500 words: problem, method, key findings, recommendation and limitations
Oral presentation	3–5 minutes per group with one clear land-management message

Criterion	Excellent	Good	Developing
Problem definition	Clear land-management question and study area	Mostly clear question	Question too broad or vague
Data and workflow	Sensor/layers justified; workflow reproducible	Some justification	Data choice unclear
Analysis quality	Correct indices/classes; GIS overlay used well	Minor technical gaps	Mainly descriptive
Accuracy and uncertainty	Errors and limitations explained honestly	Some limitations noted	Little reliability check
Communication	Readable maps and practical recommendation	Readable but limited	Hard to follow

Student workspace	Notes / response
Final submission checklist	Two maps prepared: □ Statistics table: □ Short memo: □
Final submission checklist	Uncertainty explained: □ References included: □
Oral presentation	Main message in one sentence: .....
Additional project note 1	.....
Additional project note 2	.....

15. Glossary, references and instructor notes

Term	Working meaning in this activity
Analysis-ready data	Satellite data prepared so that users can compare pixels more reliably across time and space.
AOI	Area of interest; the selected boundary for the project.
Classification	The process of assigning pixels or objects to land-cover classes.
Ground reference data	Field observations, photos or trusted reference information used to check interpretation.
Index	A band calculation that highlights vegetation, water, built-up surfaces or other land properties.
Mixed pixel	A pixel containing more than one land-cover type, common near boundaries or at coarse resolution.
Zonal statistics	GIS method for summarizing raster values inside polygons such as parcels or districts.

Selected references and source anchors

- Shokirov, Sh.S., Musaev, I.M., and Akbarov, M.S. (2015). Masofadan zondlash. Tashkent. User-uploaded course guide.
- NASA Earthdata. Data Tools and Earthdata GIS resources. https://www.earthdata.nasa.gov/data/tools
- U.S. Geological Survey (USGS). Landsat Collection 2 and Landsat Science Products. https://www.usgs.gov/landsat-missions/landsat-collection-2
- Copernicus / ESA. Sentinel-2 Mission: multispectral imaging, revisit and land applications. https://sentiwiki.copernicus.eu/web/s2-mission
- FAO. Land resources planning and land-use planning resources. https://www.fao.org/land-water/land/land-governance/land-resources-planning/en/
- FAO. Land Resources Information Management Systems (LRIMS) and GIS-based land information support. https://www.fao.org/geospatial/resources/tools/lrims/

Instructor notes

For grading, prioritize a clear link between land problem, data choice, analysis method, map result and practical recommendation. Encourage students to state uncertainty openly instead of overclaiming.

Student workspace	Notes / response
Independent study	Review NASA, USGS, ESA/Copernicus and FAO resources after class.
Closing note	Use remote sensing results carefully and always connect them with field or official reference data.
Additional project note 1	.....