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LAND MANAGEMENT ENVIRONMENT & SOLID-WASTE

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

Integrated Use of Remote Sensing Data in Land Management
PDF W15

Co-funded by the European Union

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1. SUMMARY OF KEY IDEAS

Integrated use of remote sensing data in land management means combining satellite, aerial, UAV, radar, LiDAR, field, cadastral, and statistical information inside a Geographic Information System. Remote sensing provides repeated observation of land surface conditions, while GIS organizes those observations together with boundaries, ownership or use information, infrastructure, water networks, soils, terrain, and planning zones. The result is not only a satellite image, but a decision-support system for land management.

This lesson explains how students can move from image interpretation to practical land management analysis. It shows how optical data such as Landsat and Sentinel-2 can be combined with radar, elevation models, field observations, cadastral layers, land-use plans, and socio-economic information. The lesson also introduces a standard workflow: define the land management question, select suitable data, preprocess imagery, derive indicators, integrate GIS layers, validate outputs, interpret results, and prepare maps or recommendations.

The Central Asian context is important because land management decisions are linked with irrigated agriculture, salinity, water scarcity, pasture degradation, urban growth, natural hazards, and ecosystem protection. Integrated RS-GIS analysis helps identify where change is happening, why it may matter, and what information decision-makers need before choosing a land-use action.

Key idea
Remote sensing helps observe land change; GIS helps connect that observation with legal, spatial, ecological, and management information. Integrated analysis turns data into decisions.

2. LEARNING OBJECTIVES

- Explain why remote sensing and GIS should be used together in modern land management.
- Identify the main remote sensing data inputs used for land-cover, degradation, agricultural, water, and hazard monitoring.
- Describe how GIS integrates satellite imagery with vector layers such as parcels, irrigation networks, roads, settlements, protected zones, and administrative boundaries.
- Outline a complete RS-GIS workflow from problem definition to decision-ready map products.
- Evaluate data quality, scale, spatial resolution, accuracy, field validation, and uncertainty before interpreting results.
- Apply integrated RS-GIS thinking to land management problems in Uzbekistan and Central Asia.

3. INTRODUCTION

Remote sensing is often introduced as a method for collecting information about the Earth without direct physical contact. In land management, however, the final goal is not simply to collect images. The goal is to understand land conditions, detect change, support planning, protect soil and water resources, and improve decisions. For this reason, remote sensing becomes much more powerful when it is integrated with GIS.

A satellite image can show vegetation, water, bare soil, urban surfaces, or burned areas. A GIS database can show the location of fields, canals, roads, districts, cadastral parcels, protected areas, and planned land-use zones. When these two sources are combined, students can ask practical questions: Which parcels show declining vegetation? Which irrigated areas are close to salinity risk? Where is urban expansion replacing agricultural land? Which villages are exposed to flood or landslide hazards? Which land-use plan conflicts with actual land-cover change?

In the previous lessons of this course, students studied land-use and land-cover mapping, degradation monitoring, agricultural and crop monitoring, environmental assessment, natural hazards, and the integration of remote sensing and GIS. This core PDF lesson connects those topics into one practical system for sustainable land management.

4. WHY INTEGRATION IS NEEDED

Remote sensing and GIS answer different but related questions. Remote sensing is strong at measuring what is visible or physically detectable from sensors: reflectance, temperature, radar backscatter, elevation, moisture-related signals, and change over time. GIS is strong at organizing the spatial context: boundaries, networks, ownership or use rights, land-use plans, administrative units, field observations, and other layers that explain where a detected change occurs and why it matters.

If remote sensing is used alone, the result may be a technically good image product but weak management interpretation. For example, NDVI may show lower vegetation vigor, but without field boundaries, crop type, irrigation data, or soil information, the analyst may not know whether the problem is drought stress, salinity, late planting, harvesting, grazing pressure, disease, or simply a different crop calendar. If GIS is used without updated observation data, land management may depend on old maps and reports that do not reflect current land conditions.

Component	Main strength	Typical limitation if used alone
Remote sensing	Repeated observation of vegetation, soil, water, terrain, urban areas, hazards, and environmental change.	May not explain land rights, local use, management decisions, or causes of change without supporting data.
GIS	Organizes spatial layers, boundaries, networks, field data, plans, and institutional information.	May become outdated if not connected to current observation and monitoring.
Integrated RS-GIS	Links observation, location, context, analysis, and decision-making in one workflow.	Requires careful preprocessing, metadata, validation, and interpretation.

Integration is therefore necessary because land management is both a physical and institutional field. Soil degradation, irrigation performance, crop growth, pasture condition, water bodies, urban expansion, and hazards have physical expressions visible in remote sensing data. At the same time, decisions about land depend on boundaries, users, categories, restrictions, infrastructure, and administrative responsibilities. GIS provides the structure that connects these two dimensions.

Practical interpretation

A pixel becomes meaningful for land management only when it is linked to place, time, land-use category, field condition, and management purpose.

Figure 1. Remote sensing imagery becomes more useful for land management when it is translated into GIS-ready land-use and land-cover information.

5. REMOTE SENSING DATA INPUTS

Integrated land management can use several types of remote sensing data. The best choice depends on the problem, required scale, available time, budget, cloud conditions, and the type of land feature being monitored. Optical imagery is widely used for vegetation, land cover, surface water, bare soil, and urban mapping. Thermal data can support surface temperature and crop water stress analysis. Radar can observe the surface under cloudy conditions and is useful for moisture, roughness, flood, and deformation studies. LiDAR and photogrammetric point clouds support detailed terrain and 3D structure analysis.

Data type	Typical examples	Land management use
Optical multispectral	Landsat, Sentinel-2, MODIS, high-resolution commercial imagery, UAV multispectral data.	Land-cover mapping, NDVI, crop condition, bare soil, water detection, urban expansion.
Thermal	Landsat TIRS, ECOSTRESS and other thermal products.	Surface temperature, evapotranspiration, crop water stress, heat island analysis.
Radar / SAR	Sentinel-1, ALOS PALSAR, RADARSAT and other microwave systems.	Flood mapping, soil moisture proxy, roughness, vegetation structure, ground deformation.
LiDAR / elevation data	Airborne LiDAR, spaceborne laser altimetry, DEM products.	Terrain analysis, slope, watershed modeling, drainage, erosion risk, canopy structure.
Field and reference data	GPS/GNSS points, survey forms, soil samples, crop records, photographs.	Training, validation, explanation of causes, accuracy assessment.

5.1 Optical data and spectral indices

Optical sensors record reflected solar energy in visible, near-infrared, and short-wave infrared wavelengths. Vegetation often absorbs red light for photosynthesis and reflects strongly in near-infrared wavelengths, which is why indices such as NDVI are useful for general vegetation monitoring. Water-related indices such as NDWI or MNDWI help separate water bodies from surrounding land. Soil and salinity studies often use combinations of visible, near-infrared, and short-wave infrared bands together with field observations.

Optical data are easy to interpret visually and are useful for teaching because students can connect color, tone, texture, pattern, and shape with real land-cover classes. Their main limitation is cloud cover, haze, shadow, and the need for atmospheric correction before reliable comparison over time.

5.2 Radar, LiDAR, and terrain data

Radar is an active remote sensing system. It sends microwave energy toward the surface and records the returned signal. Radar can be used day or night and is less affected by clouds than optical systems. This makes it valuable for flood monitoring, snow and ice studies, soil moisture proxy analysis, and emergency observation. LiDAR sends laser pulses and measures return time to create accurate elevation or 3D structure information. In land management, elevation products help calculate slope, aspect, flow accumulation, watershed boundaries, erosion risk, and terrain suitability.

6. GIS AS THE INTEGRATION ENVIRONMENT

GIS is the working environment where remote sensing outputs are organized, compared, overlaid, summarized, mapped, and converted into management information. In a GIS project, satellite-derived raster layers can be combined with vector data such as parcels, canals, roads, administrative boundaries, soil polygons, land-use zones, protected areas, settlements, field sampling points, and monitoring stations.

The most important GIS function is not simply drawing a map. GIS supports spatial analysis. It can calculate how much degraded land exists inside a district, which fields have low vegetation index values, how close a settlement is to a flood zone, which canals are near saline areas, or how many hectares of agricultural land changed to built-up land during a specific period. These calculations are essential for land management because decisions are usually made by parcels, districts, water-management units, or planning zones rather than by individual pixels alone.

- Overlay analysis: combine land-cover maps with cadastral parcels, soil maps, irrigation networks, hazard zones, or protected areas.
- Zonal statistics: summarize raster values such as NDVI, salinity indicators, elevation, or slope inside parcels or administrative units.
- Proximity analysis: measure distance from fields to canals, roads, settlements, rivers, or environmental risk zones.
- Change detection: compare classified maps or indicators across years or seasons to identify trends.
- Suitability analysis: combine several criteria such as slope, soil, access, water availability, and restrictions to support planning.

Figure 2. GIS integrates satellite imagery, thematic layers, field locations, and analytical overlays for land management decisions.

For students, it is useful to imagine GIS as a table of location-based evidence. Every land unit can have attributes: land-cover class, land-use category, area, slope, mean NDVI, distance to water, salinity risk, legal restriction, ownership or user type, and monitoring status. The value of GIS appears when these attributes are combined to answer a management question.

7. INTEGRATED WORKFLOW FOR LAND MANAGEMENT

A good RS-GIS workflow begins with a land management question, not with random data download. The question determines the spatial scale, time period, sensor choice, preprocessing method, classification approach, validation design, and final map product. For example, mapping annual land-cover change may use Landsat and Sentinel-2 time series, while monitoring individual crop fields may require Sentinel-2, UAV imagery, field observations, and parcel boundaries.

1. Define the management problem. Examples: land degradation, crop stress, salinity, illegal land conversion, flood exposure, or pasture pressure.
2. Select spatial units. Decide whether analysis will be done by pixel, field, parcel, irrigation command area, district, watershed, or protected area.
3. Collect data. Combine satellite imagery, DEM, radar or LiDAR data, administrative layers, cadastral data, soil maps, land-use plans, and field observations.
4. Preprocess imagery. Apply atmospheric correction where needed, cloud and shadow masking, mosaicking, clipping, geometric alignment, and temporal compositing.
5. Create indicators and classifications. Derive NDVI, NDWI, NDBI, bare soil or salinity indicators, land-cover classes, slope, aspect, or flood extent.
6. Integrate with GIS layers. Overlay outputs with parcels, canals, roads, settlements, restricted areas, and management zones.
7. Validate and assess uncertainty. Use field data, high-resolution images, confusion matrices, independent samples, and expert review.
8. Prepare decision-ready outputs. Produce maps, tables, ranked priority areas, dashboards, reports, and recommendations.

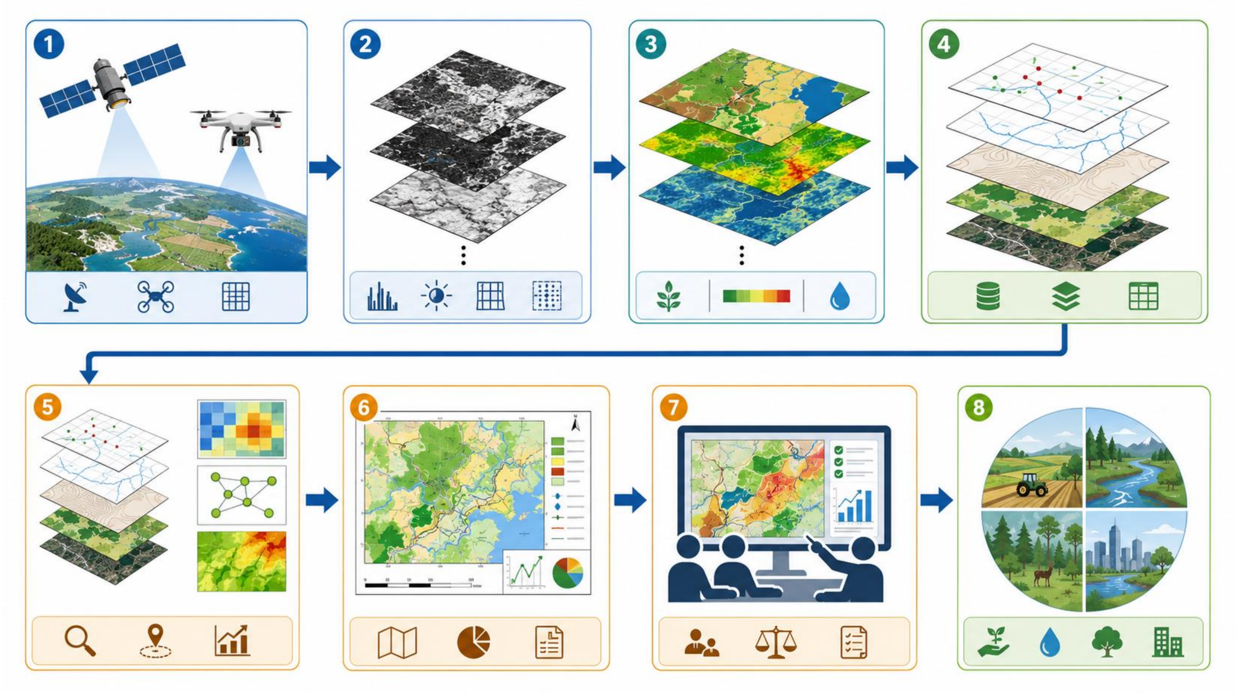

Figure 3. General workflow for turning remote sensing observations into GIS-based land management information.

> **Workflow rule**
> Do not start with "Which satellite image do I have?" Start with "What land management decision must this analysis support?"

7.1 Example workflow: irrigated agricultural land

In an irrigated agricultural district of Uzbekistan, a land manager may need to identify parcels where crop development is weak or uneven. A simple integrated workflow can use Sentinel-2 or Landsat imagery, parcel boundaries, canal and drainage layers, crop records, and field observations. The analyst creates a cloud-free seasonal composite, calculates NDVI and possibly NDWI or crop water stress indicators, summarizes values by parcel, and compares results with crop calendars and field reports.

Step	Data / method	Expected output
Problem	Weak crop growth in an irrigated command area.	Clear monitoring objective and time period.
Image data	Sentinel-2 or Landsat images during key crop stages.	Cloud-masked seasonal image composite.
GIS data	Parcel boundaries, canals, drainage, roads, soil map, administrative boundary.	Land units and context layers.
Indicators	NDVI, NDWI, surface temperature if available, and slope/elevation if relevant.	Raster indicators of vegetation and water-related conditions.
Zonal statistics	Mean, median, minimum, maximum, and standard deviation by parcel.	Field-level monitoring table.
Validation	GPS points, field photographs, crop type, farmer or agronomist notes.	Accuracy and interpretation confidence.
Decision	Rank parcels by risk and compare with canal proximity or soil class.	Priority areas for field inspection or advisory support.

This type of workflow is more useful than a simple image because it produces management units. A low NDVI pixel may not be enough for action, but a group of low-NDVI parcels located at the end of an irrigation canal can suggest a field inspection or water-delivery review. If low vegetation values occur repeatedly across years and match soil salinity information, they may suggest a land degradation issue rather than a temporary crop-stage difference.

7.2 Example workflow: land-cover change and planning

For land-use planning, a common task is to compare land-cover maps from two dates. The analyst classifies satellite images into classes such as cropland, bare soil, water, pasture, forest or shrubland, built-up areas, and wetlands. In GIS, the maps are cross-tabulated to identify transitions: cropland to built-up land, pasture to bare land, water to dry land, or bare land to restored vegetation. These transitions can be summarized by district, settlement buffer, road corridor, or protected area.

Central Asia link

In arid and semi-arid regions, map interpretation should always consider irrigation, seasonal crop calendars, salinity, water availability, and the difference between temporary bare soil and long-term degradation.

8. APPLICATIONS IN LAND MANAGEMENT

Integrated RS-GIS methods support many practical land management tasks. The same technical logic can be applied to agricultural monitoring, land degradation assessment, environmental protection, natural hazard analysis, cadastral support, infrastructure planning, and climate adaptation. The important point is to match the data product with the decision level. A national map may be useful for policy screening, but a district land office may need parcel-level summaries and field verification.

Application	Integrated RS-GIS approach	Decision support value
Land-use and land-cover mapping	Classify satellite images, integrate with boundaries, land-use categories, and planning zones.	Update land information, detect conversion, support planning and reporting.
Land degradation monitoring	Combine vegetation trends, bare soil, salinity indicators, erosion risk, DEM, soil, and field data.	Identify hotspots, prioritize restoration, monitor land degradation neutrality.
Agricultural and crop monitoring	Use NDVI/EVI/NDWI time series, parcel boundaries, crop calendars, irrigation layers, and field observations.	Detect weak crop performance, support advisory services, estimate risk areas.
Water and wetland monitoring	Use water indices, radar flood extent, DEM, rivers, reservoirs, and protected-area layers.	Monitor seasonal water changes, wetland condition, flood exposure.
Urban and infrastructure planning	Map built-up growth, road proximity, land categories, terrain restrictions, and hazard zones.	Guide spatial planning and protect productive agricultural land.
Natural hazard management	Integrate flood, landslide, drought, erosion, and exposure layers with settlements and infrastructure.	Support risk maps, early response, and land-use restrictions in hazardous areas.

For example, a district may need to protect productive irrigated land from unplanned conversion. Remote sensing can detect new construction or bare soil expansion. GIS can compare those changes with cadastral parcels, land-use categories, road corridors, and planning restrictions. The result can support inspection, legal review, or adjustment of land-use planning. Similarly, a pasture management project may combine vegetation trends, slope, distance to water points, settlement locations, and community boundaries to identify overgrazing risk and restoration priorities.

Figure 4. Field validation connects RS-GIS outputs with real land conditions, local knowledge, and ground measurements.

8.1 Uzbekistan and Central Asia examples

In Uzbekistan and Central Asia, integrated RS-GIS analysis is especially relevant because many land management challenges are linked with water and climate. Irrigated agriculture depends on canals, drainage, pumping, and soil quality. Drylands and pastures are vulnerable to overuse and vegetation decline. Mountain and foothill areas may face erosion, landslides, mudflows, and flood hazards. Urban and peri-urban areas are expanding, sometimes near productive land or sensitive ecosystems.

A practical RS-GIS exercise for students could focus on a selected district or irrigation command area. Students can download Sentinel-2 or Landsat images for the growing season, derive vegetation and water indices, overlay a boundary layer, and summarize results for fields or settlements. A second exercise can compare two years to detect land-cover change. A third exercise can combine DEM-based slope, land cover, and river proximity to produce a simple hazard or erosion-risk map.

Central Asia challenge	Useful RS data	Useful GIS layers	Possible output
Irrigated crop stress	Sentinel-2, Landsat, UAV images, thermal data where available.	Parcel boundaries, canals, drainage, crop calendar, soil salinity.	Field-level crop condition map and inspection priority list.
Salinity and bare soil expansion	Optical SWIR bands, vegetation trends, multi-year composites.	Soil map, drainage network, groundwater depth, land-use plan.	Salinity-risk or degradation hotspot map.
Pasture degradation	Vegetation index time series, precipitation context, high-resolution imagery.	Pasture boundaries, water points, settlements, slope and elevation.	Grazing pressure and restoration priority zones.
Urban expansion	Landsat/Sentinel time series, high-resolution images.	Settlement boundaries, roads, cadastral data, agricultural land categories.	Map of conversion from cropland to built-up areas.
Flood or mudflow exposure	Radar flood extent, optical water mapping, DEM.	Settlements, roads, canals, rivers, land-use restrictions.	Exposure map for emergency planning and zoning.

These examples show that integration is not only a technical exercise. It also supports governance. If land information is updated regularly, institutions can better coordinate planning, environmental protection, agriculture, water management, cadastral control, and public communication.

Important caution
A map does not automatically prove a legal violation or a management failure. It identifies evidence that must be checked with field data, administrative records, and local context.

9. DATA QUALITY, VALIDATION, AND ETHICS

Integrated RS-GIS analysis must be technically reliable and professionally responsible. Students should not treat map outputs as absolute truth. Every dataset has resolution, projection, time, accuracy, and interpretation limits. A satellite image may be affected by clouds, haze, shadows, seasonal differences, sensor calibration, mixed pixels, or errors in preprocessing. A GIS layer may have outdated boundaries, incomplete attributes, different coordinate systems, or uncertain legal status. When these datasets are combined, errors can also combine.

9.1 Resolution and scale

Spatial resolution determines the size of the smallest image unit, but it does not automatically determine management accuracy. A 10 m pixel may be useful for many agricultural and land-cover tasks, but it may be too coarse for narrow canals, small orchards, or fragmented household plots. Temporal resolution matters when vegetation changes quickly or when flood events occur over a short time. Spectral resolution matters when separating land-cover classes with similar visual appearance. Radiometric resolution affects how well small differences in reflectance can be recorded.

9.2 Field validation and accuracy assessment

Field validation is essential because remote sensing signals must be interpreted in relation to real land conditions. Ground data can include GPS points, field photographs, crop type records, soil samples, salinity measurements, irrigation status, farmer interviews, and expert interpretation of high-resolution images. For classification tasks, students should use independent validation samples and calculate accuracy indicators such as overall accuracy, user’s accuracy, producer’s accuracy, and confusion matrix results.

- Use independent validation points; do not validate a classification only with the same samples used for training.
- Record date, location, method, observer, and uncertainty for field data.
- Check coordinate systems before overlaying rasters and vectors.
- Compare remote sensing indicators with crop calendar, rainfall, irrigation schedule, and management events.
- Report uncertainty honestly; avoid presenting a visually attractive map as exact evidence without validation.

9.3 Ethical and institutional issues

Land management data can affect people, property, livelihoods, and public trust. Analysts should use data responsibly, respect privacy and legal rules, and avoid overclaiming. If an RS-GIS product is used to support inspection or policy decisions, the map must be accompanied by metadata, methods, limitations, and a clear explanation of how conclusions were derived. Ethical land management requires transparency, reproducibility, and fair interpretation of evidence.

9.4 Checklist for student projects

Question	What the student should check
Purpose	What land management decision or learning task does the analysis support?
Data suitability	Are spatial, temporal, spectral, and thematic resolutions appropriate?
Preprocessing	Were atmospheric correction, cloud masking, clipping, projection, and mosaicking completed correctly?
GIS integration	Do raster and vector layers align? Are boundaries, attributes, and units consistent?
Validation	Are field data or independent reference samples used? Is accuracy reported?
Interpretation	Are alternative explanations considered, such as crop calendar, irrigation timing, or seasonal change?

Question	What the student should check
Communication	Does the final map include title, legend, scale, north arrow, date, data sources, and limitations?

This checklist helps students develop a professional habit: every map must be traceable. A reader should be able to understand what data were used, when they were collected, how they were processed, what accuracy is expected, and what decision the map supports.

10. PRACTICAL CLASSROOM TASK

The following task can be used as a short laboratory activity after students read this lesson. It is designed for ArcGIS Pro, QGIS, or Google Earth Engine combined with a desktop GIS. The instructor may provide a small study area in Uzbekistan or another Central Asian country, but the same logic can be used for any region where land-use change, irrigated agriculture, or land degradation is important.

Stage	Student action	Expected result
1. Study area	Choose a district, irrigation command area, watershed, or urban expansion zone.	A clear boundary layer for clipping and reporting.
2. Image selection	Download or access two cloud-free images from different years or seasons.	Comparable remote sensing scenes.
3. Index creation	Calculate NDVI and one water or built-up index depending on the problem.	Indicator rasters for vegetation, water, or urban surfaces.
4. GIS overlay	Overlay the indicators with parcels, canals, roads, settlements, or administrative boundaries.	Integrated spatial database.
5. Statistics	Calculate zonal statistics for each parcel or management unit.	Table of mean, minimum, maximum, and change values.
6. Validation	Check at least 20 reference points using field data, high-resolution images, or instructor-provided points.	Short accuracy and uncertainty note.
7. Output	Prepare one map, one table, and a 200-word interpretation.	Decision-ready mini-report.

A strong student output should not only describe the colors on the map. It should explain what the results mean for land management. For example, if NDVI declines in several fields close to the end of an irrigation canal, the interpretation should mention possible irrigation delivery issues but should also state that field verification is required. If built-up land expands inside an agricultural zone, the student should compare the change with the official land-use plan or cadastral information before drawing conclusions.

Student output checklist

Final maps should include title, date, coordinate system, scale, north arrow, legend, data sources, and a short limitation note. Tables should use clear units such as hectares, percent change, or mean index value.

11. CONCLUSIONS

Integrated use of remote sensing and GIS is now a basic requirement for evidence-based land management. Remote sensing provides repeated, spatially continuous observation of the Earth's surface. GIS connects those observations with boundaries, infrastructure, land-use plans, administrative units, and field evidence. Together, they support better mapping, monitoring, assessment, and decision-making.

For land management students, the most important lesson is that integration begins with a clear question. A good analyst does not simply download data and produce a colorful map. A good analyst defines a land management problem, selects suitable data, applies correct preprocessing, integrates spatial layers, validates results, explains uncertainty, and communicates conclusions in a way that can support responsible decisions.

In Uzbekistan and Central Asia, integrated RS-GIS methods can support sustainable land use, irrigated agriculture, degradation monitoring, water and wetland assessment, hazard exposure analysis, and environmental planning. These methods are especially valuable when combined with field knowledge, institutional data, and transparent interpretation.

Final message

Integrated RS-GIS analysis is not only a technical skill. It is a professional way of connecting Earth observation, land governance, and sustainable development.

Independent study task

Choose one land management problem in your region, such as crop stress, pasture degradation, urban expansion, flood risk, or salinity. Identify three remote sensing layers, three GIS layers, and one field validation method that would be needed to analyze the problem responsibly. Prepare a one-page concept map showing the workflow from data to decision.

Self-check questions

- Why is a satellite image alone not enough for a land management decision?
- What GIS layers would you combine with NDVI to evaluate crop stress in an irrigated area?
- How can cadastral parcels change the way remote sensing results are interpreted?
- What is the difference between land-cover change and land-use change?
- Why should field validation be planned before producing the final map?
- What uncertainty should be reported when using RS-GIS products for public decisions?
- How can RS-GIS integration support sustainable land management in Central Asia?

Key term	Short reminder
Remote sensing data	Measurements from sensors that observe the Earth surface or atmosphere from a distance.
GIS layer	A spatial dataset such as parcels, roads, canals, elevation, soil, or administrative boundaries.
Decision unit	The land unit used for reporting: pixel, parcel, field, district, watershed, or protected area.
Uncertainty	The part of the result that may be affected by data quality, method, scale, or interpretation limits.

Common mistakes to avoid

- Using images from different seasons without explaining the phenological difference.
- Comparing maps with different resolutions as if they had the same level of detail.
- Ignoring clouds, shadows, sensor noise, or geometric misalignment.
- Using parcel boundaries or administrative layers without checking whether they are current.
- Presenting an attractive map without accuracy assessment, metadata, or field validation.

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Suggested online sources for students

- NASA Earthdata GIS
- NASA Land Management data topic
- USGS Landsat Missions
- USGS EarthExplorer
- ESA Sentinel-2
- Copernicus Land Monitoring Service
- FAO

Glossary

Term	Meaning
Remote sensing	Collecting information about objects or areas without direct physical contact, usually using sensors on satellites, aircraft, or UAVs.
GIS	A system for storing, analyzing, and presenting geographically referenced data.
Zonal statistics	A GIS method that summarizes raster values inside defined vector zones such as parcels or districts.
Validation	The process of checking map outputs against independent reference or field data.
Metadata	Information about dataset origin, date, coordinate system, processing level, and known limitations.

Useful datasets for practice

Dataset family	Typical classroom use
Landsat Collection 2	Long-term land-cover and vegetation change analysis.
Sentinel-2 MSI	Detailed land-cover, vegetation, crop, and water monitoring.
Sentinel-1 SAR	Flood mapping and cloudy-season observation.
DEM / elevation products	Slope, watershed, drainage, erosion, and terrain suitability analysis.
Field GPS/GNSS points	Training, validation, and interpretation of map results.

End of PDF W15 lesson