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LAND MANAGEMENT
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LAND MANAGEMENT IN CENTRAL ASIA

15.- Integrated Applications of Remote Sensing

Land Use and Land Cover Mapping

LM-W15-V99

Learning objectives

By the end of this lecture, students should be able to explain the logic of land use and land cover mapping and apply a basic mapping workflow in GIS or remote sensing software.

1. Distinguish land cover from land use and explain why both are important for land management.
2. Select suitable data sources such as Landsat, Sentinel-2, radar, UAV, and field observations.
3. Design a simple classification legend and prepare training and validation samples.
4. Interpret accuracy assessment results and discuss uncertainty in LULC maps.

Key idea: LULC mapping converts remotely sensed data into thematic classes that support planning, monitoring, and decision-making.

Why land use and land cover mapping matters

LULC maps support four practical decisions:

Agriculture	crop area, field condition, irrigation planning
Urban growth	settlement expansion, infrastructure pressure
Water and wetlands	surface water change, riparian zones
Land degradation	bare soil, salinity risk, vegetation loss

For Central Asia: combine satellite data, field knowledge, and GIS boundaries to monitor irrigated land, settlements, pastures, and water bodies.

Land cover vs. land use

C Land cover

The physical material on the Earth surface that can be observed directly or indirectly by sensors.

- water
- forest
- bare soil
- cropland
- built-up surface

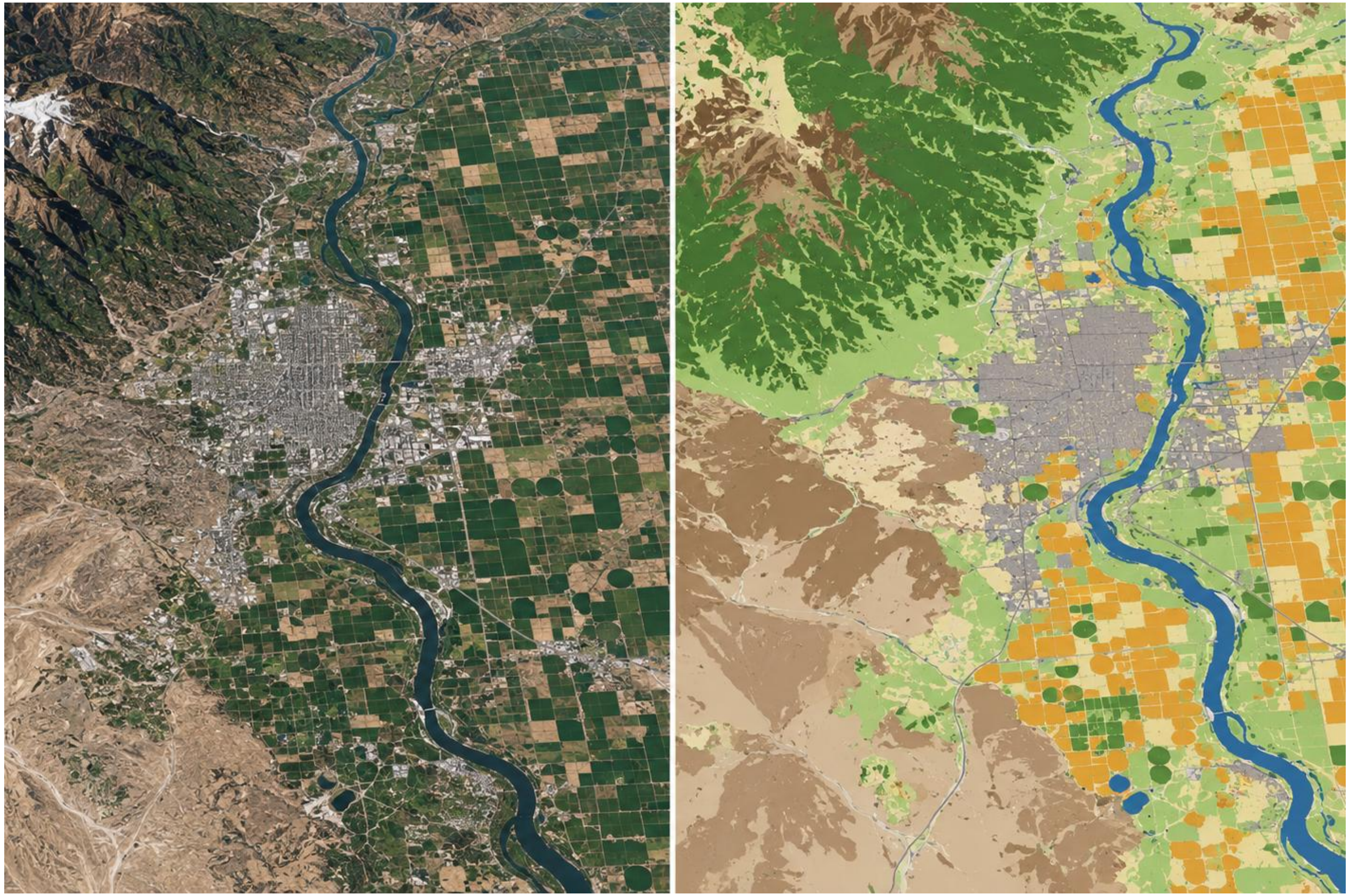
U Land use

The human purpose or management function assigned to an area. It may not always be visible from imagery alone.

- irrigated farming
- residential area
- industrial zone
- grazing land
- protected area

Example: a green field is land cover; wheat production or fodder production is land use.

From satellite image to thematic map



Interpretation logic

1. Image pixels contain spectral, spatial, and contextual information.
2. Similar land covers usually have similar spectral patterns.
3. Training samples help the classifier learn class signatures.
4. The final map is a simplified model of reality, not reality itself.

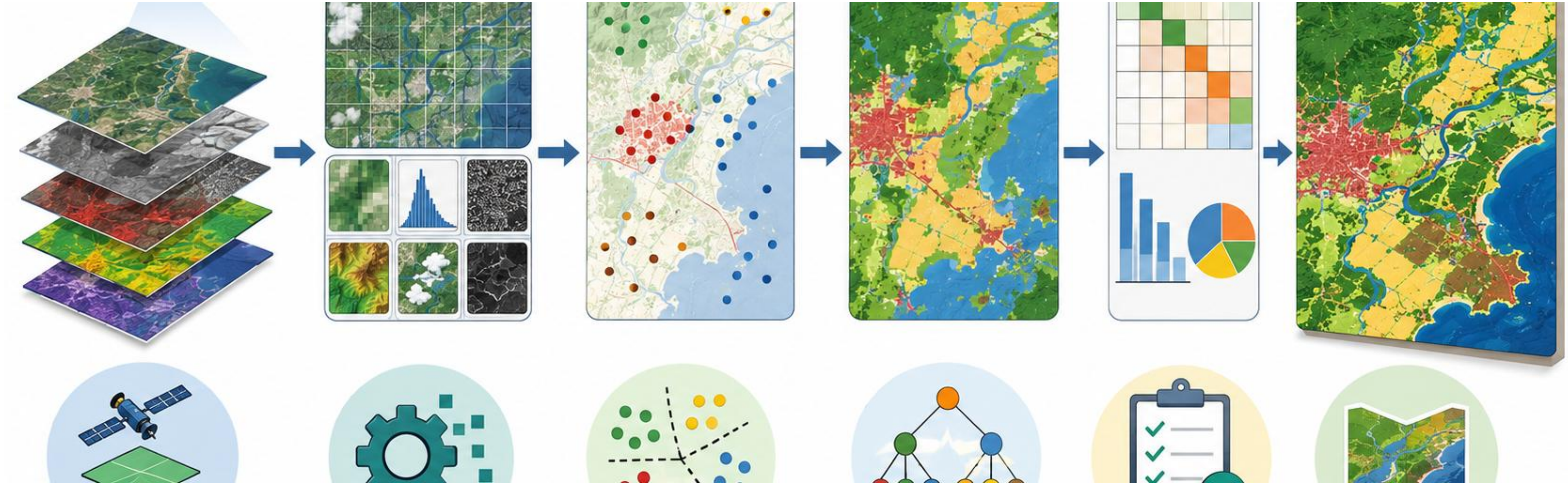
- Water
- Urban
- Cropland
- Bare soil
- Vegetation

Main data sources for LULC mapping

1	2	3	4	5
Landsat	**Sentinel-2**	**Sentinel-1 SAR**	**UAV / drone**	**Field survey**
30 m archive, long-term change	10–20 m optical bands, frequent revisit	Microwave signal, useful under cloud conditions	Very high spatial detail	GPS points, photos, local knowledge
Long trend analysis	Field-scale vegetation and water mapping	Flood, soil moisture, roughness-related patterns	Training data, validation, small area mapping	Reference samples and map validation

Best practice: combine image data with field reference data and existing GIS layers instead of relying on pixels alone.

Standard LULC mapping workflow



1 **Define classes**
What classes are useful for the decision?

→

2 **Prepare data**
Cloud mask, composite, indices, bands

→

3 **Collect samples**
Training and validation data

→

4 **Classify**
Rule-based, supervised, or machine learning

→

5 **Assess accuracy**
Confusion matrix, overall accuracy, user/producer accuracy

→

6 **Use the map**
Planning, monitoring, reporting

Classification legend: keep it useful and realistic

A good legend is:

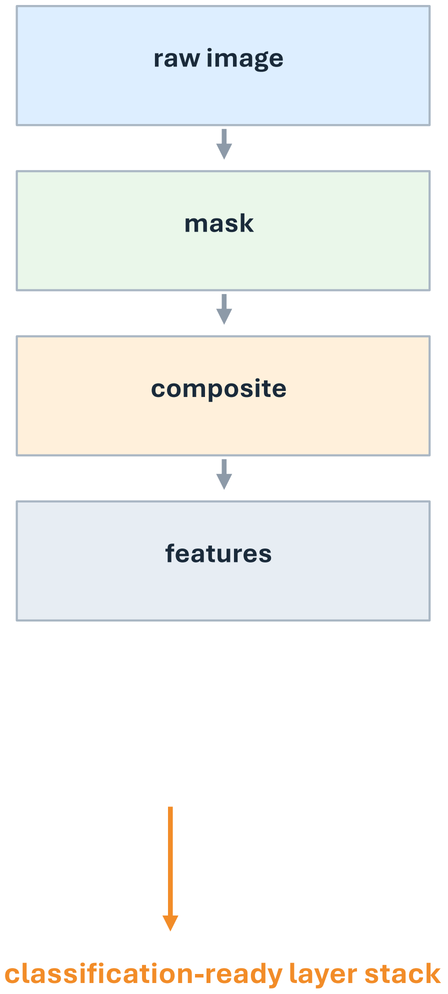
- relevant to the mapping purpose
- observable in the selected data
- not too detailed for the image resolution
- consistent with field knowledge
- documented with clear class definitions

Example legend for irrigated landscapes

Class	What it represents	Common image clues
Water	canals, reservoirs, ponds	dark blue/black, smooth texture
Cropland	active or recently cultivated fields	rectangular plots, seasonal vegetation
Built-up	settlements, roads, facilities	bright/gray, angular pattern
Bare / saline soil	exposed ground, salt crusts	light tone, low vegetation signal
Natural vegetation	forest, shrubs, riparian vegetation	green tone, irregular pattern

Preprocessing: prepare reliable input data

1. **Atmospheric correction** — Use surface reflectance when possible for optical data.
2. **Cloud and shadow masking** — Remove clouds, shadows, and haze before classification.
3. **Geometric consistency** — Use the same projection, pixel size, and area of interest.
4. **Seasonal compositing** — Select dates that best separate classes, especially crops.
5. **Feature creation** — Add NDVI, NDWI, NDBI, texture, DEM, or SAR bands if useful.



Training and validation samples

Training samples

Used by the classifier to learn spectral and spatial patterns of each land-cover class.

- Collected from field GPS points, high-resolution imagery, or expert interpretation.
- Should represent the full variability of each class.
- Must not be mixed with validation samples.

Validation samples

Used after classification to estimate map accuracy and identify class confusion.

- Should be independent from training data.
- Must be spatially well distributed.
- Help calculate confusion matrix and accuracy metrics.

Rule: never judge map quality only by visual appearance; use independent validation.

Classification methods: from rules to machine learning

1	**Visual interpretation**	Expert draws or edits classes manually	high local knowledge; slower for large areas
2	**Unsupervised classification**	Algorithm groups pixels by similarity	useful for exploration; classes need interpretation
3	**Supervised classification**	Samples teach class signatures	clear workflow; depends on sample quality
4	**Machine learning**	Random Forest, SVM, gradient boosting, neural networks	strong with many features; still needs validation

For bachelor-level practice, Random Forest is often a good starting point because it works well with multi-band imagery and additional features, but it still requires good samples and accuracy assessment.

Accuracy assessment: how good is the map?

Confusion matrix concept

	Map: Water	Map: Crop	Map: Urban
Ref: Water	42	3	0
Ref: Crop	2	55	6
Ref: Urban	0	5	37

Diagonal cells are correct classifications. Off-diagonal cells show confusion between classes.

Main metrics

Overall accuracy share of all validation samples mapped correctly

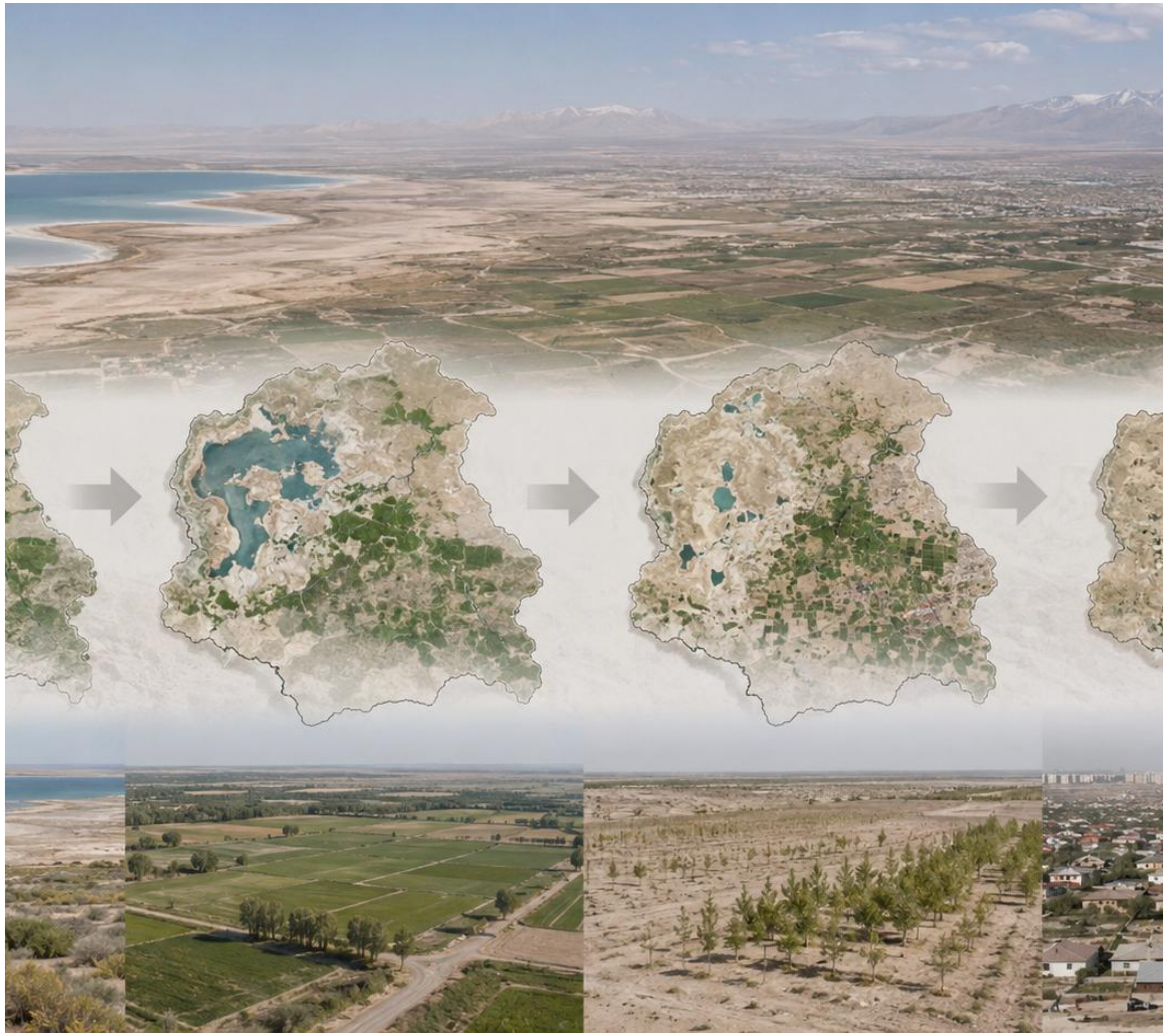
Producer's accuracy how well reference class is captured

User's accuracy how reliable a mapped class is for the user

Kappa / F1 / IoU optional metrics used in advanced projects

Acceptable accuracy depends on purpose: a planning map, a legal boundary, and a scientific study do not require the same tolerance.

Change detection: mapping land transformation over time



Common approaches

1. **Post-classification comparison** — Compare classified maps from two dates.
2. **Index differencing** — Compare NDVI, NDWI, NDBI, or other indices.
3. **Time-series analysis** — Track seasonal and annual trajectories.
4. **Change matrix** — Quantifies from-class to to-class transitions.

Central Asia example: monitor conversion of irrigated land, expansion of settlements, vegetation recovery, and water surface changes.

Applied example: Uzbekistan and Central Asia

Irrigated agriculture

Map active cropland, fallow areas, canal corridors, and seasonal vegetation dynamics.

- Water
- Urban
- Cropland
- Bare soil
- Vegetation

Urban expansion

Identify built-up growth, road development, and pressure on agricultural or peri-urban land.

- built-up
- roads
- new construction
- industrial areas

Water & wetlands

Support monitoring of rivers, reservoirs, wetlands, salinity-prone areas, and riparian vegetation.

- NDWI / MNDWI
- seasonal water
- wetland vegetation
- bare/saline soil

Practical task: choose one district, create a 5-class map, and explain where map uncertainty is highest.

Summary and references

Key messages

- Land cover describes physical surface materials; land use describes human purpose or function.
- Good LULC maps start with clear classes, suitable imagery, and reliable reference samples.
- Classification is not finished until accuracy and uncertainty are evaluated.
- For Central Asia, LULC mapping supports agriculture, water management, urban planning, and land degradation monitoring.

Selected references

1. USGS Landsat Missions. Landsat archive and land surface observation.
2. NASA Earthdata. Land Use / Land Cover data and tools.
3. Copernicus Land Monitoring Service. Land cover, vegetation, water and surface variables.
4. Copernicus Data Space / ESA. Sentinel-2 mission overview.
5. FAO. Land Cover Classification System (LCCS).
6. Congalton, R.G. & Green, K. Assessing the Accuracy of Remotely Sensed Data.

End of 14-slide teaching package. Add your own title slide before this file to make 15 slides.

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