ERASMUS-EDU-2023-CBHE
Project number: 101129032

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(01/01/2024 – 31/12/2026)

LESLIE

LAND MANAGEMENT
ENVIRONMENT &
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LAND MANAGEMENT IN CENTRAL ASIA

15.- Integrated Applications of Remote Sensing

Natural Hazard Monitoring

LM-W15-V103

Learning objectives

Explain how remote sensing supports natural hazard monitoring before, during, and after events.

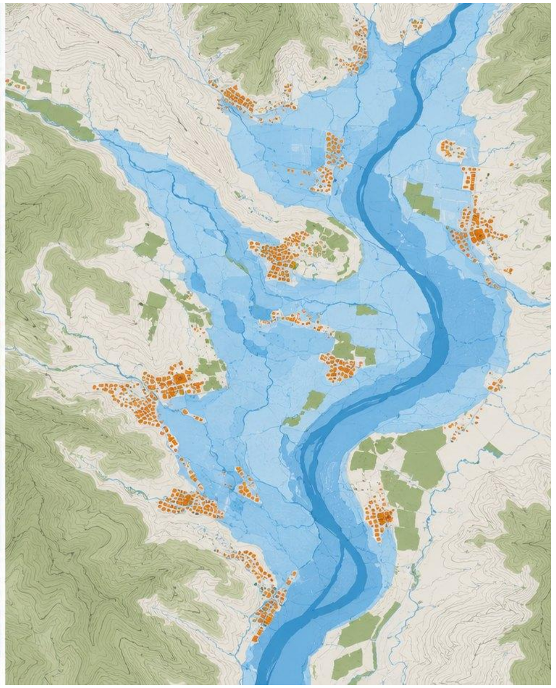
Identify satellite, radar, drone, terrain, and field data used for floods, droughts, fires, and landslides.

Describe the workflow from hazard detection to mapping, validation, warning, and recovery assessment.

Apply hazard monitoring concepts to land management and environmental planning in Central Asia.

Key idea: natural hazard monitoring is not only mapping damage after a disaster. It also supports preparedness, early warning, response, and recovery planning.

Why Natural Hazard Monitoring Matters



Hazards become disasters when exposed people, infrastructure, land, and ecosystems are vulnerable.

Remote sensing provides repeated observations over large areas, including mountains, deserts, river valleys, and remote settlements.

GIS combines hazard layers with population, roads, irrigation networks, land cover, and critical infrastructure.

Monitoring helps decision-makers move from reaction to risk-informed planning.

Before

risk mapping and preparedness

During

rapid situation awareness

Hazard Types and Remote Sensing Signals

Floods

Water extent, inundated fields, river migration, damaged infrastructure, wet soil.

Wildfire

Active fire, thermal anomalies, smoke, burned area, post-fire erosion risk.

Drought

Low vegetation vigor, soil moisture deficit, heat stress, crop stress.

Landslides

Slope failure, scarps, debris flows, terrain change, blocked rivers.

Snow & GLOF

Snow cover, glacier lake expansion, meltwater pathways, high-mountain risk.

Dust storms

Aerosol plumes, dry exposed soil, wind erosion source zones.

Urban exposure

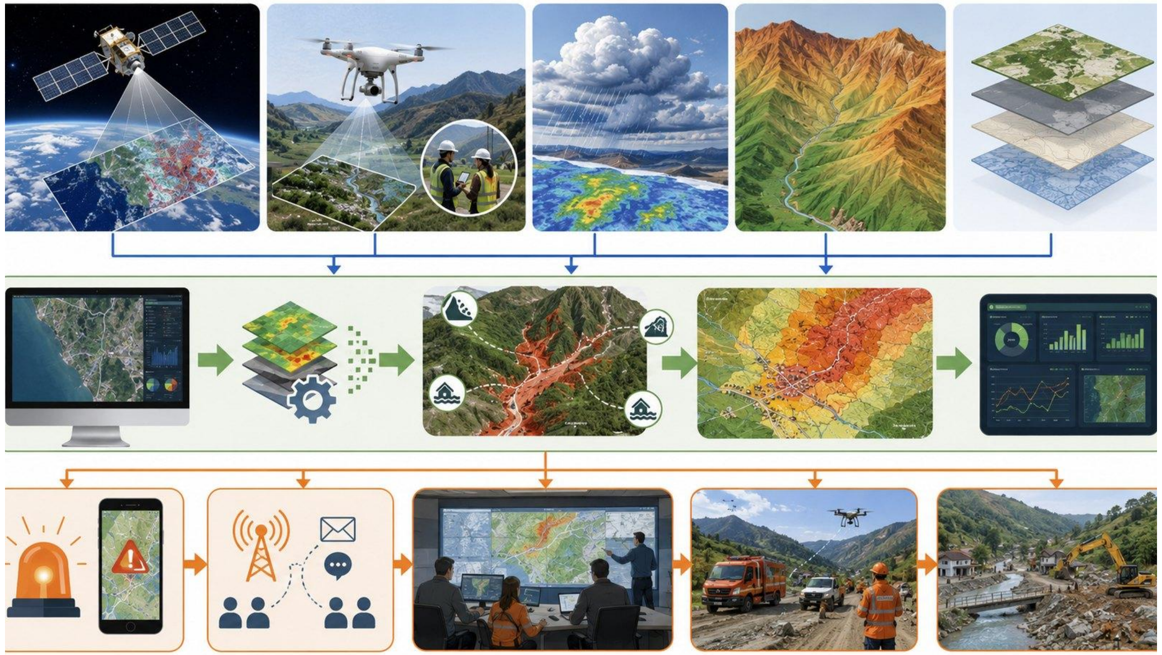
Buildings, roads, population density, hospitals, schools, lifeline networks.

Water stress

Reservoir level, wetland change, irrigation shortage, salinity risk.

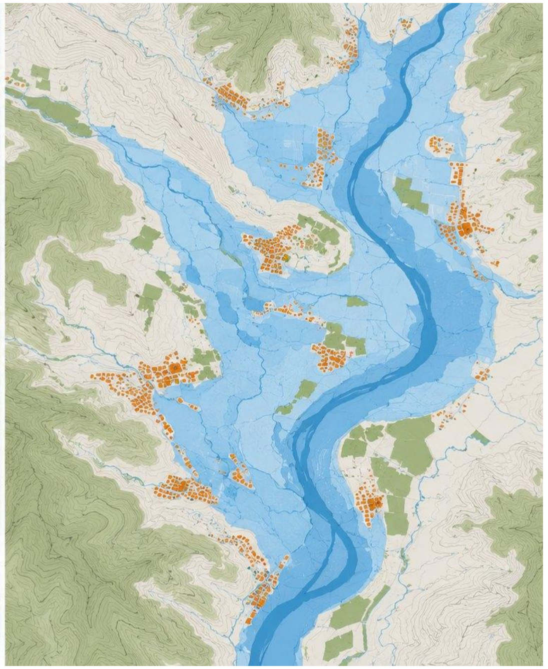
A useful hazard map links three components: hazard process + exposure + vulnerability.

Data Sources for Hazard Monitoring



Data type	Useful for	Main strength
Optical imagery	burn scars, water, land cover, vegetation stress	clear visual interpretation
SAR radar	floods, soil moisture, deformation, cloudy conditions	day/night and many-weather use
Thermal data	active fire, heat stress, drought indicators	temperature-sensitive hazards
DEM / LiDAR	slope, drainage, landslide susceptibility, flood routing	terrain detail
Field data	validation, local impact, damage reports	ground evidence

Flood Monitoring: From Water Detection to Exposure

Detect water extent using optical indices when clouds are limited, or SAR backscatter when clouds and night conditions limit optical imagery.

Compare current water extent with normal river, lake, and reservoir boundaries.

Overlay flood extent with settlements, roads, cropland, bridges, schools, and health facilities.

Classify results by response priority: isolated settlement, damaged road, irrigated crop loss, or reservoir risk.

Rainfall / river rise → Satellite image → Water mask → Exposure layer → Priority map

Drought Monitoring: Vegetation, Soil Moisture, and Water Stress

Drought is usually slow-onset, so monitoring depends on trends rather than one image.

NDVI/EVI help show vegetation condition and crop stress; thermal data can indicate heat stress.

Microwave and SAR data can support soil moisture assessment in cloudy or dryland regions.

For irrigation areas, drought analysis should include canal water supply, crop calendar, and field observations.

Common indicators: vegetation index anomaly • land surface temperature • soil moisture • rainfall anomaly • reservoir storage • crop condition reports

Landslide and Debris-Flow Monitoring

Landslide monitoring begins with terrain: slope, aspect, drainage density, lithology, and land cover.

Optical imagery helps identify fresh scars, blocked roads, and debris deposits when cloud-free images are available.

Radar and InSAR can support deformation analysis where slow slope movement occurs.

Field validation is essential because shadows, snow, and bare rock can be confused with landslide scars.

Central Asian mountain valleys need special attention because steep relief, snowmelt, rivers, roads, and settlements often occupy the same narrow corridors.

Wildfire and Burned Area Monitoring

Active fire

thermal anomaly

smoke plume

near real-time alert

fire perimeter updates

Burned area

pre/post comparison

NBR and dNBR

severity classes

loss assessment

Post-fire risk

erosion risk

water quality impact

vegetation recovery

restoration monitoring

Fire monitoring is a sequence: detect the active event, map the burned area, then evaluate recovery and secondary hazards.

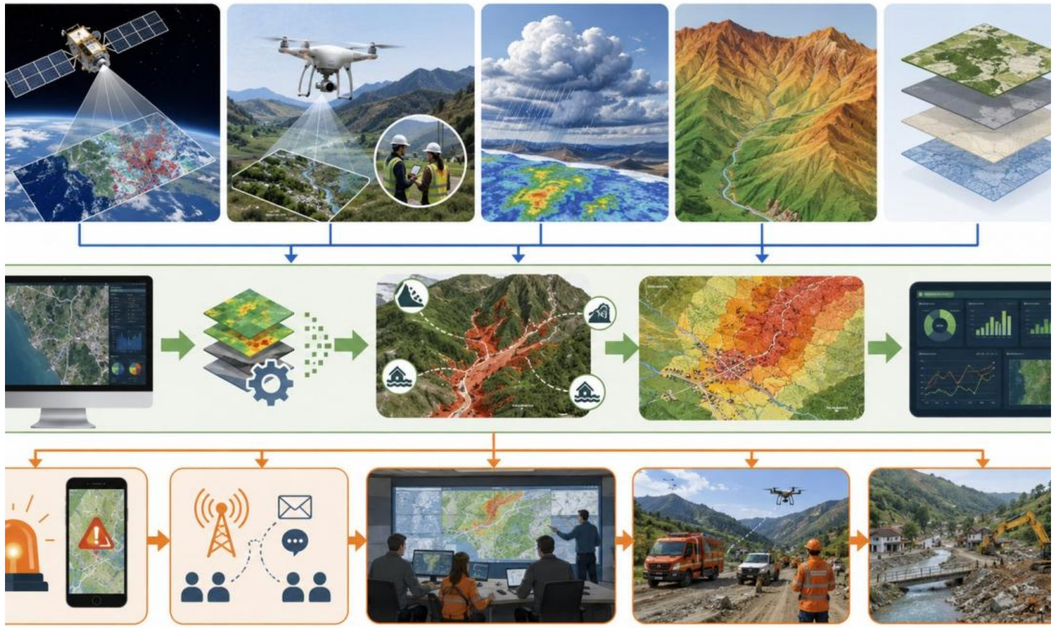
Exposure and Vulnerability Mapping

Hazard layer: where the physical event occurs or may occur.

Exposure layer: people, farms, houses, roads, bridges, canals, and services located in the hazard zone.

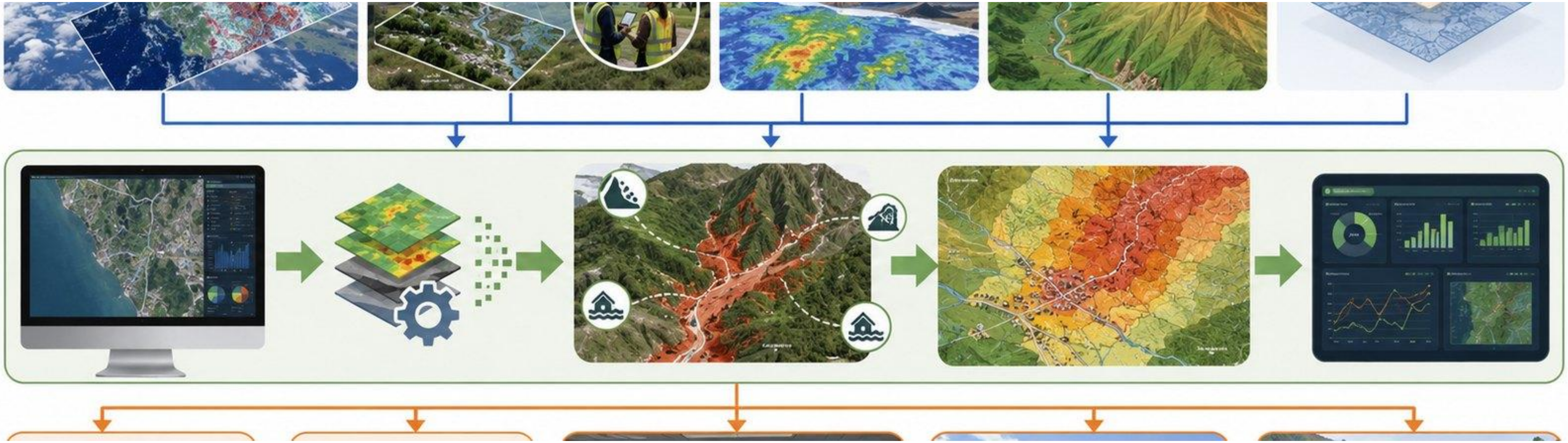
Vulnerability layer: sensitivity and capacity to cope, such as housing quality, access routes, irrigation dependence, or social services.

Risk assessment combines these layers to support priority setting and resource allocation.



Hazard → Exposure → Vulnerability → Risk → Action

Operational Workflow: Detection to Decision



Step	Main question	Example output
1. Trigger	What event or warning requires attention?	rainfall alert, fire alert, earthquake report
2. Image selection	Which sensor is suitable now?	Sentinel-1 SAR, Landsat/Sentinel-2, MODIS/VIIRS
3. Processing	How do we map the hazard?	water mask, burn severity, deformation, slope map
4. Validation	How reliable is the map?	field points, photos, local reports, error matrix
5. Decision support	Who needs the information?	response map, risk zone, recovery plan

Central Asia and Uzbekistan Relevance

Mountain hazards: landslides, mudflows, snowmelt floods, glacial lake risks, and road corridor exposure.

Lowland hazards: drought, heat stress, dust storms, river flooding, salinity, and irrigation infrastructure pressure.

Urban and peri-urban growth increases exposure around roads, canals, reservoirs, and informal drainage paths.

Local validation from universities, agencies, and communities improves the usefulness of satellite hazard products.

For LESLIE, hazard monitoring should connect remote sensing outputs with land management, environment, water resources, and practical decision-making.

Accuracy, Validation, and Uncertainty

✓ Validation data

Ground observations, photos, drone images, official reports, and local expert checks.

⚠ Uncertainty sources

Clouds, shadows, radar speckle, mixed pixels, outdated land cover, and wrong thresholds.

↻ Iterative improvement

Update maps as new imagery, field data, and damage reports become available.

A hazard map should include date, sensor, method, scale, and known limitations.

Binary maps such as “flooded / not flooded” may hide uncertainty near boundaries.

Decision-makers need confidence levels, priority categories, and clear map legends.

Fast maps are useful, but rapid products must be updated as better data arrive.

Student Task: Design a Hazard Monitoring Plan

Scenario

A mountain district reports heavy rainfall after several dry weeks. A river valley contains villages, crop fields, roads, and irrigation canals. Local authorities ask your team to prepare a rapid hazard monitoring plan.

Working questions

Which hazard is most likely and which data would you request first?

Which map layers are needed to estimate exposure?

How would you validate the map quickly and safely?

What final product should be delivered to decision-makers?

Expected output: a one-page monitoring plan with data sources, processing steps, validation method, and decision-support map products.

References

NASA Earthdata. Natural Hazards and Disasters data resources; SAR and disaster management training materials.

USGS. Natural Hazards science resources; Landsat missions and hazard monitoring materials.

Copernicus Emergency Management Service. On Demand Mapping and Rapid Mapping services for disasters and humanitarian crises.

UNDRR. Sendai Framework for Disaster Risk Reduction 2015–2030 and Sendai Framework Monitor.

ESA / Copernicus Sentinel missions. Sentinel-1 SAR and Sentinel-2 optical data for land and hazard applications.

FAO and UNCCD guidance on land degradation, drought, and land management where linked to hazard risk.

Recommended independent study: compare one hazard map from Copernicus EMS or NASA Earthdata with local field knowledge from your region.

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