Romania: UAV- and AI-Based Monitoring of Biodiversity and Habitat Structure

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Funded by
the European Union

BIOCLIMA: Assessing Land use, Climate and Biodiversity impacts of land-based climate mitigation and biodiversity policies in the EU - Grant Agreement No. 101181408

Case study : AI-Driven UAV Monitoring of Biodiversity and Habitat Degradation

Background

Romanian Stepic and Sub-Mediterranean landscapes include complex mosaics of grasslands, shrubs, forests, and protected habitats. These areas are increasingly affected by climate variability, land-use pressure, and habitat degradation, while fine-scale biodiversity and vegetation-structure information remains limited.

Gap of knowledge

There is still limited knowledge on how fine-scale biodiversity patterns and habitat degradation interact across heterogeneous Romanian landscapes under climate and land-use pressures. In particular, robust AI methods for integrating multi-sensor UAV data to detect species, map degradation, and derive transferable EBVs and ECVs remain insufficiently tested in Stepic, Continental, and Sub-Mediterranean environments

Objective

The Romanian case study aims to develop *an AI-driven UAV workflow for monitoring biodiversity, vegetation structure, and habitat degradation using RGB, multispectral, thermal, and LiDAR data*.

Case study 1/2 Dobrogea (Steppic)

- Dobrogea include protected areas and Natura 2000 sites, representing one of the most important Stepic biodiversity regions in Romania.
- Main habitat types:
  - Steppe and dry grasslands
  - Shrubland and forest-steppe mosaics
  - Rocky and calcareous habitats
  - Wetlands and coastal habitats near the Black Sea
- The region is exposed to increasing pressure from drought, rising temperatures, land-use change, grazing, invasive species, and habitat fragmentation.

Case study 2/2 Iron Gate (Submediteranean)

- Iron Gate National Park is part of the Natura 2000 protected area network and represents a key Sub-Mediterranean biodiversity hotspot along the Danube Gorge.
- Main habitat types:
  - Thermophilous forests and shrublands
  - Dry grasslands and rocky habitats
  - Riparian and Danube-related habitats
  - Forest–grassland transition zones
- The area is affected by climate variability, vegetation stress, land-use pressure, and changes in habitat structure, making it suitable for UAV-based biodiversity and vegetation monitoring.

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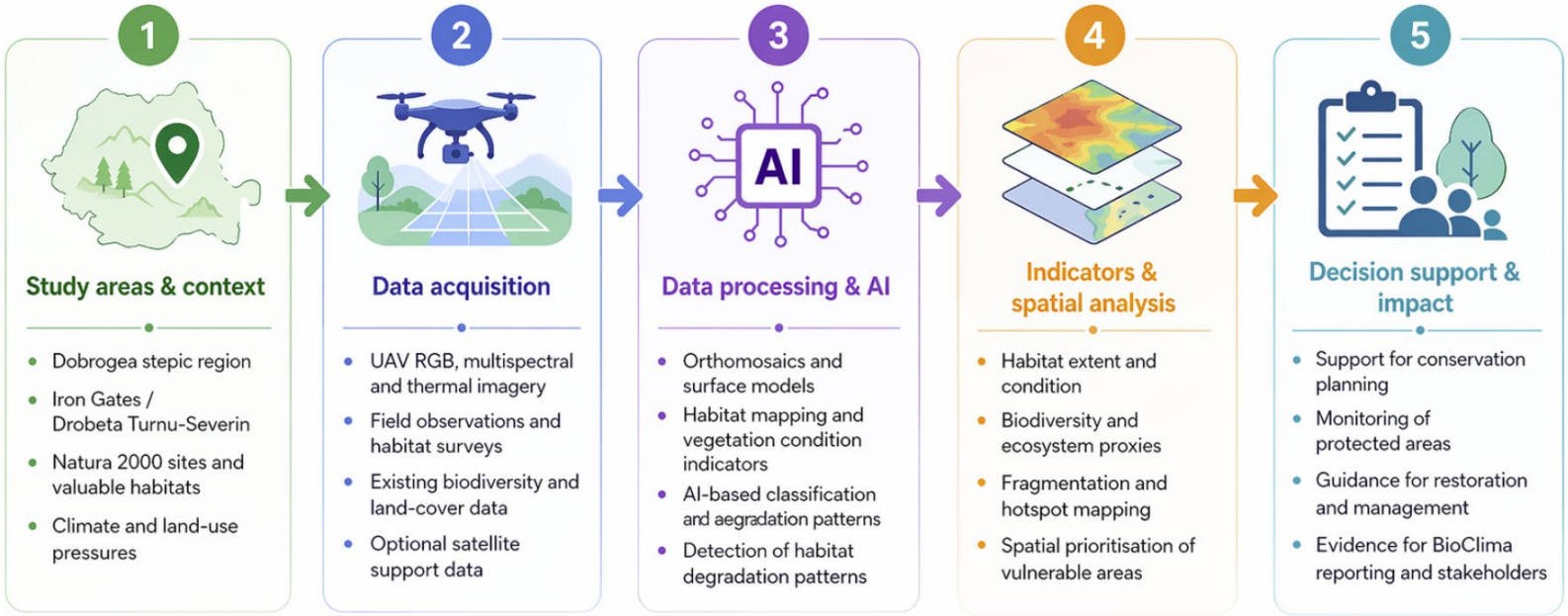
Workflow



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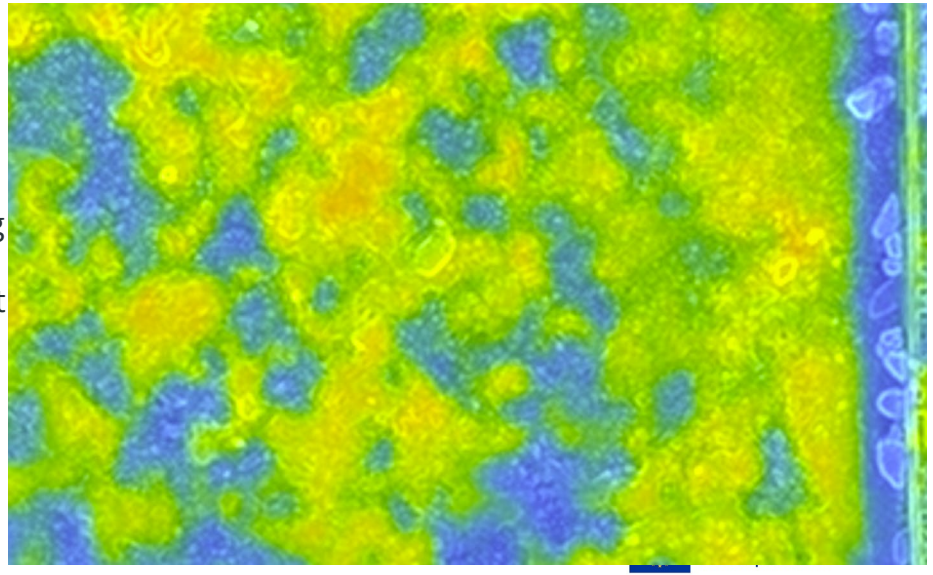
In situ data

- At the Eșelnița Research Station, in-situ observations were collected to support the interpretation and validation of UAV-derived products. The site includes a controlled turtle observation area, where turtle presence, position, and habitat use can be directly documented and compared with RGB, thermal, multispectral, and LiDAR UAV data.
- Field observations focus on identifying turtle microhabitats, including open ground, short grass, shrub patches, shaded areas, scattered trees, and nearby access or movement corridors. These observations provide reference information for testing UAV-based turtle detection and for assessing how vegetation structure, surface temperature, and habitat configuration influence turtle behaviour and habitat suitability.



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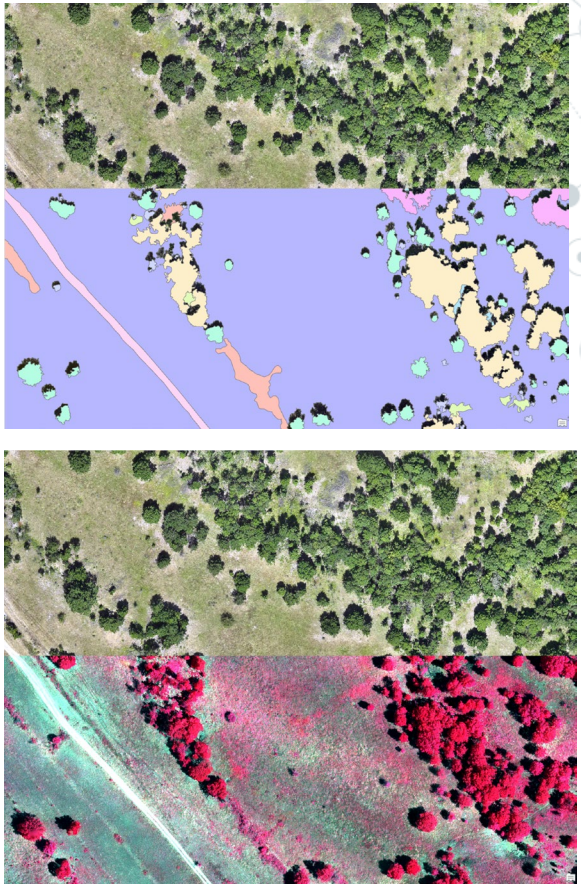
In situ data

Detailed field mapping was carried out using a habitat and land-cover classification scheme adapted to the Romanian UAV monitoring sites. The field classes include:

- Dead trees
- Forest with closed canopy
- Forest clearing
- Hayfield with *Rubus* and *latyrus*
- Isolated trees
- Pasture with short grass
- Road or track, including dirt roads
- Scattered trees in pasture areas
- Shadows
- Woody shrubs below approximately 3 m height



UAV data - Case Study 1: Dobrogea - / Coastal and Wetland

- Study sites:
  - Histria and MicroRezervație Constanța
- Monitoring period:
  - June–October 2025
- Flight dates and platforms
  - MicroRezervație Constanța: 20 June 2025
    - Platforms: Matrice 350, DJI Phantom 4 Multispectral
    - Sensors: H20T thermal, P4M multispectral
  - Histria: 21 June 2025 – 2 October 2025
    - Platforms: Matrice 350, DJI Phantom 4 Multispectral, DJI Mavic 3 Multispectral
    - Sensors: L2 LiDAR, H20T thermal, P4M multispectral, M3M multispectral
- Earth Observation data produced so far
  - RGB and multispectral UAV imagery for habitat and vegetation mapping
  - Thermal imagery for land surface temperature and microclimatic patterns
  - LiDAR point clouds for vegetation structure and terrain characterisation
  - Preliminary orthomosaics, multispectral composites, and LiDAR visualisations
  - AI-ready training samples for habitat and vegetation classification

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UAV data - Case Study 2: Iron Gate / Inland UAV Monitoring

- Study sites:
  - Bahna, Oglanic, and Eșelnița
  - Monitoring period: July–September 2025
- Flight dates and platforms
  - Bahna: 12 July 2025 – 30 September 2025
    - Platforms: Matrice 350, DJI Phantom 4 Multispectral
    - Sensors: L2 LiDAR, H20T thermal, P4M multispectral
  - Oglanic: 11 July 2025 – 29 September 2025
    - Platforms: Matrice 350, DJI Phantom 4 Multispectral
    - Sensors: L2 LiDAR, H20T thermal, P4M multispectral
  - Eselnița: 30 September 2025
    - Platform: Matrice 350
    - Sensors: L2 LiDAR, H20T thermal
- Earth Observation data produced so far
  - RGB and multispectral UAV imagery for habitat and vegetation mapping
  - Thermal imagery for land surface temperature and microclimatic patterns
  - LiDAR point clouds for vegetation structure and terrain characterisation
  - Preliminary orthomosaics, multispectral composites, and LiDAR visualisations
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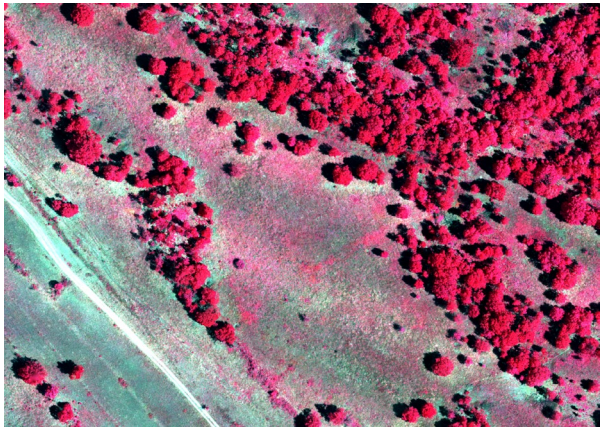
UAV data - Case Study 2: Iron Gate / Inland UAV Monitoring

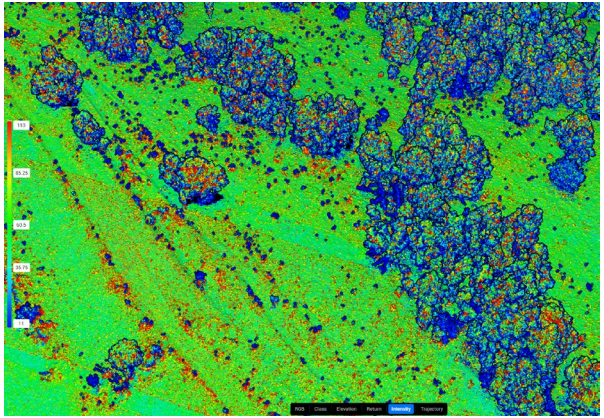
RGB orthomosaic



Multispectral imagery

LiDAR RGB point cloud

LiDAR intensity point cloud



Conclusions and expected results

- The Romanian case studies have already produced a consistent UAV-based Earth Observation dataset covering RGB, multispectral, thermal, and LiDAR observations across coastal/wetland and inland pilot sites. These data provide a strong basis for analysing habitat structure, vegetation condition, land surface temperature patterns, and turtle habitat characteristics at very high spatial resolution.
- Preliminary work has also advanced the preparation of detailed field and AI training datasets, including habitat and land-cover classes such as forest canopy, clearings, shrubs, pasture, scattered trees, tracks, shadows, and dead trees. These reference data are essential for training and validating AI models for habitat classification, vegetation structure mapping, and degradation detection.
- The expected results include validated UAV-derived products for EBVs and ECV proxies, including ecosystem extent, habitat condition, vegetation structure, species/habitat distribution proxies, land surface temperature, and local microclimatic patterns. The planned LAI measurements using a 180° fisheye camera will further strengthen field validation and improve the interpretation of UAV-derived vegetation indicators.