**Satellite and Airborne remote Sensing Technologies in the process of Long-term Monitoring of Urban Biologically Active Areas (UBAA) as a Tools for Mitigating Climate Changes – A case study of city of Krakow (Poland)**

Actions to mitigate the negative effects of climate change should be based on continuous monitoring, management and support of activities in urban green spaces (UGS) in all forms of ownership. The definition of urban forestry (UF), apart from tree stands, includes groups of trees and shrubs in parks, squares, recreational areas, cemeteries, roof gardens, individual street trees and shrubs, herbaceous vegetation, lawns, flower beds, greenery in allotment gardens and private gardens, monastery gardens and other locations. For the purposes of the presented project, the definition of UF has been extended to Urban Biologically Active Areas (UBAA), which additionally included agricultural crops (orchards, fruit plantations, vineyards), cereal crops, vegetables and permanent grasslands - capable of sequestering CO2 and producing oxygen, absorbing pollutants and limiting rain runoff. These key ecosystem services (ES) are provided by UBAA to the city’s residents

Advanced methods for monitoring the condition of urban greenery are satellite and airborne remote sensing technologies such as VHRS optical imaging or ALS LiDAR point clouds. In the process of UBAA satellite monitoring (period 2006-2021) of the entire city of Krakow (326 km2), the GEOBIA approach was used, which in addition to the MS and PAN satellite imaging bands, analyzed the vegetation index (NDVI), normalized surface models (nDSM/CHM), ALS LiDAR point clouds and vector GIS (buildings footprints, roads and railways, waters, etc.). The spatial resolution of the images ranged from 0.31 m GSD (WorldView-3), through 0.5 m GSD (SkySat), 0.64 m GSD (QucikBird-2), 0.7 m GSD (KOMPSAT-3), 1.0 m (IKONOS-2), 3.0 m GSD PlanetScope Dove, 5.0 m (RapidEye) to 10 m GSD (Sentinel-2, ESA). The density of the ALS LiDAR point cloud ranged from 18 to 30 points/m2 (2006, 2012, 2017, 2021).

The results clearly show that UBAA decreased in the area from 76.1% (2006) to 71.29% (2021) during the monitoring period, which shows a clear trend (-4.81%). Over 15 years, as much as 1,626 ha (4.99%) of UBAA disappeared in Krakow, representing 104 ha of UBAA transformed annually into infrastructure (buildings, roads and areas without vegetation cover). This corresponds to an area of approximately 150 soccer stadiums per year.

Analyses based only on ALS LiDAR point clouds showed an increase in the area (2-D) of high vegetation (H>2 m AGL) from 5,569.69 ha (17.04%) in 2006 to 9,206.27 ha (28.17%) in 2021. The tree crown area (CHM) increased (approx. 47%) from 10,131.85 m2 (2006) to 14,983.86 m2 (2021). The average annual increase of CHM was 323.47 ha. Detailed voxel analyzes in the period 2006-2021 for the ‘Planty Krakowskie’ Park (44 ha) showed a change in the volume of canopies (3-D) by approximately +21%, i.e. from 149,627 m3 (2006) to 181,399 m3 (2021), with an increase of 2-D area by approximately 14.6% (from 18.45 to 21.15 ha).

GEOBIA satellite image classification and GIS analyzes have shown that 71.5% of Krakow's UBAA is not in public ownership. Therefore, it is so important to continue satellite monitoring and work with owners to support them to preserve as much green infrastructure as possible.