Introduction

Assessment of land use changes is crucial for various tasks, including ecological and agricultural monitoring, land management, and sustainable development planning in different regions. While direct field surveys suffice for small areas, Earth remote sensing tools are recommended for larger regions. On a small scale, such assessments are feasible over a 40-year period (using images from the first series of Landsat satellites), whereas on a medium and large scale, assessments can be made every 10–15 years (and with access to commercial satellite data, it can extend up to 20–25 years). Presently, numerous new satellite data and processing tools are available, offering extensive opportunities for land use analysis for various purposes.

Both Ukraine and Poland provide notable examples of the development and successful application of Land Use Change assessment methods by individual researchers. For instance, D. Malchikova (2010) outlined the conceptual aspects of using GIS/RS (remote sensing) technologies to study the territorial structure of land use in Ukraine. Detailed assessment of landscape diversity based on RS data was described in the works of T. Kuchma (2016). The work of Zelyk Y. I., Kussul N. M., Shelestov A. Yu., Yaylimov B. Ya. (2017) investigates the features of deciphering satellite data for land use purposes, along with their validation using ground observations. It also shares their own experience in land cover mapping in Ukraine. In 2019, the large environmental organization "Ecoaction" published a comprehensive study on land use assessment based on space images. Additionally, the work of Malashevskyi, M., Kovalchuk, I., & Malashevska, O. (2021) provides examples of identifying the dynamics of rural settlements using GIS-RS methods.

Numerous publications have focused on assessing and modeling land use changes influenced by natural and socioeconomic factors. Works by T. Noszczyk, J. Hernik, A. Rutkowska (2020) and R.A.Castanho, J.M. Naranjo, J.Kurowska-Pysz (2019) stand as notable examples. Particularly intriguing are studies of changes in territories that have undergone socio-political transformations. For instance, there are interesting works on the assessment of land management changes in post-Soviet countries and their regions by J. Stefanski, B. Waske, Ol. Chaskovskyy (2014) and in post-socialist regions of Eastern Europe by T. Kuemmerle et al. (2008) and K. Cegielska et al. (2018). The detection of changes in such cases clearly indicates significant differences in approaches to land management and territorial administration.

In our work, we also aimed to evaluate changes in land use at the level of small administrative units in closely located areas of Ukraine and Poland. By focusing on these specific regions, we can gain valuable insights into the intricacies of land use dynamics and the influences of socio-political transformations on land management practices.

Method and/or Theory

The study selected Ratne Territorial Community in the Volyn region in the north-west of Ukraine (area 481.2 km2) and Łęczna County in the Lublin Voivodeship of Poland (area 636.7 km2) for examination. These territories share partially common natural conditions and are relatively close in proximity, approximately 100 km apart.

The assessment covered both long-term (about 100 years) and short-term (from 1 to 10 years) changes. To evaluate the original land use, topographic maps from the 1930s, published by the Polish WIG (Wojskowy Instytut Geograficzny), were analyzed. We utilized 1:100000 scale maps, combining 4 sheets (Maloryta, Dywin, Krymno, Ratno) to create a map of the Ratne Territorial Community in the 1930s, and 3 sheets (Łęczna, Rejowiec, Lublin) to create a map of the Łęczna County in the 1930s. All sheets were consistently referenced in coordinates using GoogleEarthPro and QGIS. Vector layers of the contours of the selected territorial units were then loaded, and cartometric measurements were subsequently carried out.

On the maps of the 1930s, forest areas, water bodies, swamps, agricultural lands, and settlements were manually delineated, and the area of each land type was measured within the allocated units.

The next stage involved a similar analysis of changes on the maps of the 2010s, using automatic classification. For the Polish part of the territory, the OSM Landuse service was also employed to determine the percentage value of the land use structure in a given window of the OpenStreetMap. However, for the Ukrainian part, this service is still incomplete with many unidentified lands. At the third stage, short-term changes within the selected units were compared using automatic classification of space images, including projects such as CORINE Land Cover (covers EU countries but does not

include Ukraine), LUCAS (Land use and Land cover survey), ESA WorldCover, and the "Sentinel-2 10 m Land Use/Land Cover Change from 2018 to 2021" layer in ArcGIS Online LivingAtlas. In cases where changes were detected in specific areas, a manual search of a number of Sentinel-2, Landsat-8, and PlanetLabs images was additionally conducted to clarify the nature and time of such changes.

Results

After classifying old topographic maps, we can assess the state and structure of the land cover in the region as of 1920-1930 and then compare them with data from the beginning of the 21st century. (Fig. 1, 2).

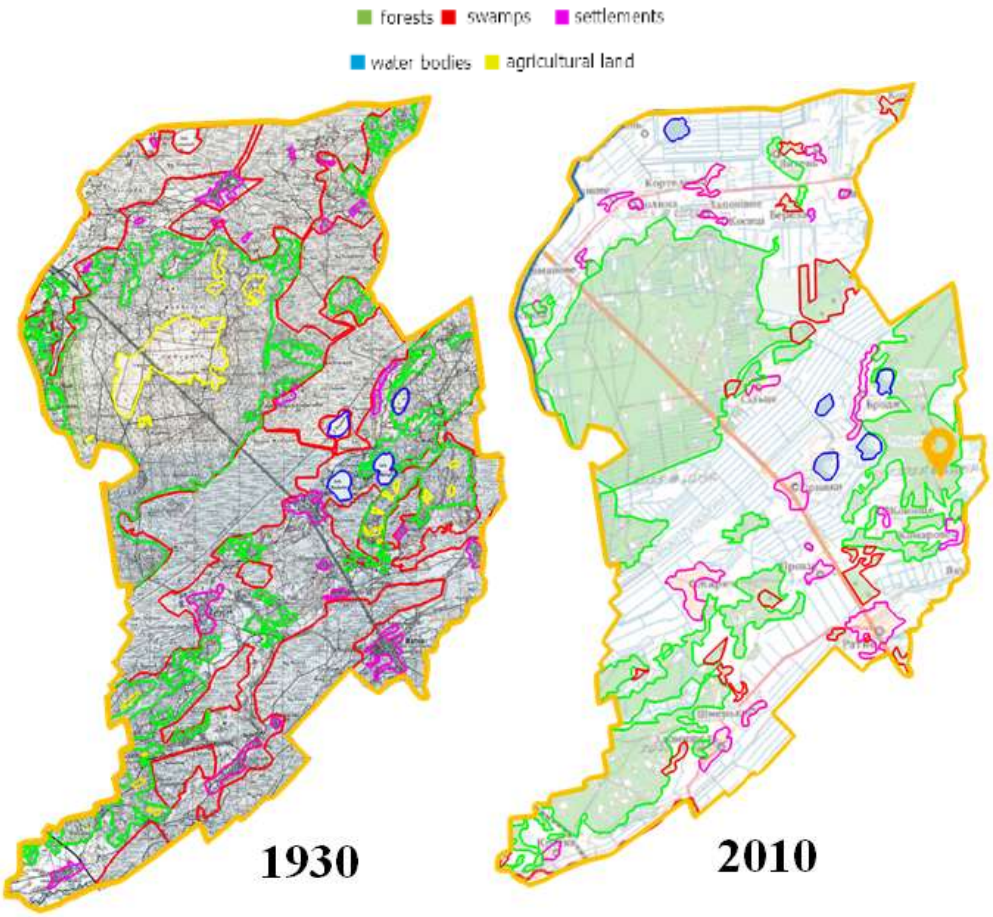

Figure 1 *The structure of the land cover within the Ratne Community*

As we can see from Fig. 1, in the 1930s the land cover was much more colorful and fragmented. 38% consisted of swamps, 32% - agricultural land (arable land and pastures, hayfields), 27% forests, less than 2% settlements, about 1% - water bodies. Later, the land structure was greatly transformed, primarily due to large-scale drainage reclamation (in the 1960s-1980s). As of 2010 the share of swamps is about 3%, agricultural land - 59%. Forest cover decreased by 1.5%, the share of territories under settlements increased to 3%.

In the 1930s, more than 70% of the area of Łęczna County was occupied by agricultural land, which amounted to 455 km^2 in total (Fig 2). The forest area was 54 km^2, and wetlands - 22 km^2. It was established that even now the largest area of the district territory is occupied by agricultural lands, but their area has decreased to 299 km^2. Instead, the area of forests and wetlands increased approximately twice to 98 km^2, and swamps - 48 km^2. This is partly due to the strengthening of nature protection programs and the creation of new protected areas (Park Krajobrazowy Pojezierze Łęczyńskie, Nadwieprzański Park Krajobrazowy), which is a positive practice. The number of settlements has remained unchanged, but their area has decreased significantly and is about 63 km^2.

Figure 2 *Assessment of the structure of land use within the Łęczna County (map of the 1930s)*

Modern automatic classification services allow tracking of recent land use changes. At the same time, as a rule, there are no large-scale transformations, but there are local changes in small areas (example in Fig. 3).

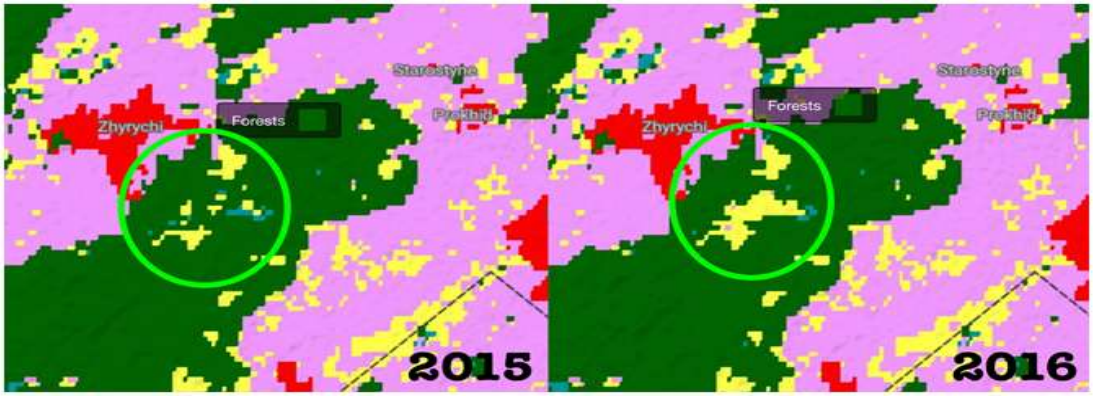

Figure 3 *Examples of detection of land use changes since 2015 in ArcGis LivingAtlas LandCover*
This classification makes it possible to identify the localization of changes, which can be used later to clarify the time and nature of changes based on specific space images (examples in Fig. 4, 5).

Figure 4 *Examples of clarification of changes in land use detected by automatic classification on the territory of Ratne TC (Sentinel-2, EO-Browser)*

Figure 5 *Examples of clarification of changes in land use detected by automatic classification on the territory of Łęczna County (PlanetExplorer)*

In these figures, we can see, in particular, examples of how it is possible to detect a specific place, area and approximate time of forest cutting (Fig. 4) and establish the fact of refusal to cultivate part of the areas in the river valley (Fig 5).

Conclusions

To assess land use changes in relatively small administrative units, it is beneficial to employ a combination of tools for analyzing and interpreting all available topographic maps and satellite images from different time periods. By conducting such an analysis for two small territories in Ukraine and Poland, it becomes possible to identify significant differences and trends in land use changes, particularly those linked to land management practices. The outcomes of these studies can be utilized to enhance plans for socio-economic and sustainable development within communities and to improve the effectiveness of land use monitoring efforts.

References

Biatov A., Prylutsky O., Amosov M. (2019). Large-scale investments and land use in Ukraine on space images: a study. Kyiv: Ecoaction, 52 p. (In Ukrainian).

Castanho, R. A., Naranjo Gómez, J. M., & Kurowska-Pysz, J. (2019). Assessing land use changes in Polish Territories: Patterns, directions and socioeconomic impacts on territorial management. Sustainability, 11(5), 1354.

Cegielska, K., Noszczyk, T., Kukulska, A., Szylar, M., Hernik, J., Dixon-Gough, R., ... & Kovács, K. F. (2018). Land use and land cover changes in post-socialist countries: Some observations from Hungary and Poland. *Land use policy*, *78*, 1-18.

Kuemmerle, T., Hostert, P., Radeloff, V. C., van der Linden, S., Perzanowski, K., & Kruhlov, I. (2008). Cross-border comparison of post-socialist farmland abandonment in the Carpathians. *Ecosystems*, *11*, 614-628.

Kuchma, T. (2016). Combined Use of SAR and Optical Satellite Images for Landscape Diversity Assessment. In *Living Planet Symposium* (Vol. 740, p. 159).

Malashevskyi, M., Kovalchuk, I., & Malashevska, O. (2021). Land Reallotment over the Course of the Development of a Rural Settlement in Ukraine. *Geomatics and Environmental Engineering*, *15*(3), 115-127.

Malchykova, D. (2010). Use of GIS/RS technologies to study the territorial structure of land use in the region. *Problems of continuous geographical education and cartography*, (12), 123-128. (In Ukrainian).

Noszczyk, T., Rutkowska, A., & Hernik, J. (2020). Exploring the land use changes in Eastern Poland: statistics-based modeling. *Human and Ecological Risk Assessment: An International Journal*, *26*(1), 255-282.

Stefanski, J., Chaskovskyy, O., & Waske, B. (2014). Mapping and monitoring of land use changes in post-Soviet western Ukraine using remote sensing data. *Applied Geography*, 55, 155-164.

Zyelyk Ya., Kussul N., Shelestov A., Yailymov B. (2017). Analytical review of European projects LUCAS and CORINE for monitoring and validation of land cover and land use on the basis of satellite and ground observations and experience of land cover mapping in Ukraine. *Ukrainian Journal of Remote Sensing*, (12), 10-36.(In Ukrainian).