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GEODETIC SUPPORT FOR MONITORING CHANGES IN THE LAND USE STRUCTURE OF UKRAINE DURING THE PERIOD OF RUSSIAN ARMED AGGRESSION AND POST-CONFLICT RECOVERY

H. Domashenko, *PhD of Technical Sciences, Associate Professor,*
Associate Professor of the Department of Geomatics, Land Management and Territorial Planning,
E-mail: halyna.domashenko@pdau.edu.ua

Poltava State Agrarian University

S. Monar D*, PhD, Associate Professor, Associate Professor of the Department of Geography and Tourism*
E-mail: molnar.d.istvan@kmf.org.ua

Ferenc Rákóczi II Transcarpathian Hungarian College of Higher Education

N. Prokopenko*, Candidate of Economic Sciences, Associate Professor*
E-mail: bilanp79@gmail.com
Sumy National Agrarian University

Annotation. *This article examines the geodetic support for monitoring land use changes in Ukraine during the war and post-war periods, which is a key element of national security, economic development, and social stability. The purpose of the article is to present an analysis of the current state and future development prospects of geodetic support for monitoring land resources. The research employs a comprehensive approach, including an analysis of scientific publications and practical examples of geodetic technologies used to monitor land use changes during armed conflict and the post-war reconstruction of Ukrainian territories. The practical research was based on land use in the Bilokrynytsia territorial community in the Rivne region. The study explores the use of Global Navigation Satellite Systems (GNSS),*

remote sensing (RS), and unmanned aerial vehicles (UAVs), which enable near real-time detection of land use changes and the effective use of geospatial data for decision-making. Special attention is given to LiDAR technologies that enable the creation of high-precision three-dimensional models of the Earth's surface and the identification of degradation processes, particularly in geographically complex environments. Hybrid positioning is discussed as well, integrating various data sources (satellite, radio frequency, inertial sensors, visual data) to enhance accuracy and reliability, especially under conditions of limited visibility or satellite signal blockage. The study emphasizes that the processing and interpretation of geodetic data includes preprocessing, spatial localization, GIS analysis and modeling, and the generation of cartographic materials. The practical significance lies in providing objective and up-to-date data for making informed decisions on land use, spatial planning, and emergency response. It is concluded that further research is needed to improve the use of digital technologies, automate data collection, and integrate various sources into GIS systems for reliable land use change monitoring during both active hostilities and reconstruction phases.
***Keywords**: geodetic support, monitoring, land use, war, post-war period, GIS, GNSS, UAV, remote sensing.*

Actuality. Land resource management is one of the key elements of national security, economic development, and social stability for any country. For Ukraine, which, as a result of the armed aggression of the Russian Federation, has suffered large-scale territorial losses, destroyed infrastructure, degradation of agricultural lands, and the displacement of millions of citizens, the task of ensuring effective control over land use has acquired unprecedented urgency. In this context, geodetic support becomes especially important as a set of technical, organizational, and methodological measures that ensure the collection, processing, and updating of spatial information about land plots and on-site objects. Thus, modern geodetic tools — including Global Navigation Satellite Systems (GNSS), Earth remote sensing (RS), unmanned aerial vehicles

(UAVs), and geographic information systems (GIS) — enable prompt and high-precision monitoring of territorial changes, even in hard-to-reach or dangerous areas..

Analysis of recent research and publications. Contemporary scientific thought is actively exploring geodetic support for monitoring land use changes, as evidenced by numerous publications in recent years. For instance, the issue of geodetic support for urban land monitoring, which has gained particular importance in the context of post-war city reconstruction, has been studied by A. Danyliuk and B. Pylypenko [1]. The researchers emphasize the role of GIS as the analytical core of monitoring, enabling near real-time tracking of land use changes. The works of K. Mamonov, O. Kanivets, V. Velychko, and others [2;3] focus on the tools of geodetic support for the land management of territorial communities. The authors propose approaches to utilizing geospatial data for managerial decision-making within communities, which is especially pertinent in the context of decentralization and the urgent need to respond to the consequences of the war, including shifts in land use caused by population displacement, infrastructure damage, and land reclamation efforts. Of particular note is publication [4], which analyzes the methodology for surveys using GNSS, laser scanning, and photogrammetry to assess the technical condition of roads, the extent of their damage, and to plan repair and restoration measures.

Study [5] focuses on the integration of object coordinate determination systems through the interpretation of satellite imagery, which is essential for the rapid detection of land use changes in combat zones where traditional field measurements are not feasible. The practical aspect of the work involves combining GNSS observations with automated analysis of Sentinel and ICEYE images to detect destruction, new developments, or land degradation. The publication by V. Stadnikov and a team of co-authors [6] analyzes the experience of using GIS technologies in updating digital topographic maps at a scale of 1:25,000. This research is important for updating the cartographic base for spatial monitoring, which is a prerequisite for accurately representing land use changes, especially in de-occupied or damaged areas.

It is worth noting that the reviewed studies demonstrate the active adaptation of geodetic science to wartime conditions and highlight the need for further research involving digital technologies, automation of data collection, and integration of various information sources into GIS systems, which will ensure reliable monitoring of land use changes both during hostilities and in the reconstruction period.

The purpose of the study is to present an analysis of the current state and future development prospects of geodetic support for monitoring land use changes in Ukraine under the conditions of war and post-war recovery.

Materials and methods of research. A comprehensive approach was used in the course of the research, involving the analysis of scientific publications as well as practical examples of the application of geodetic technologies for monitoring land use changes amid armed conflict and the post-war restoration of Ukrainian territories. The practical research material was based on the land use within the Bilokrynytsia territorial community of the Rivne region.

Research results and their discussion. Geodetic support for monitoring land use changes during wartime and post-war periods acquires particular strategic importance, characterized by a number of specific challenges and adaptations. Under conditions of active hostilities and an unstable security environment, traditional approaches to geodetic measurements and observations face significant limitations, necessitating the use of innovative methods and technologies (Table 1).

1. Key features of geodetic support for monitoring during wartime and post-war periods

Feature	Description	Methods and Technologies
Increased Risk and Limited Access	Critical need for rapid collection and processing of geospatial information to respond to dynamic changes and assess the consequences of hostilities.	Rapid GNSS measurement methods (RTK, PPK), operational processing of remote sensing data, use of UAVs for quick mapping..
Ensuring Work Safety	Safety measures during geodetic work in hazardous areas are of paramount importance.	Use of remotely operated systems (UAVs, robots), special protective equipment, coordination with military structures..
Monitoring Critical Infrastructure	Priority of observing the condition of transport, energy, and hydraulic engineering objects..	High-precision GNSS observations, laser scanning, aerial photography for detecting damage and deformations.

Damage Assessment	Documentation and quantitative determination of destruction to buildings, structures, and infrastructure..	Photogrammetry, 3D laser scanning, analysis of high-resolution satellite imagery..
Control of Restoration Works	Geodetic support for construction and installation works, control of geometric parameters and deformations..	Traditional geodetic methods (total station measurements, leveling), GNSS measurements
Use of Geographic Information Systems (GIS)	Integration, analysis, and visualization of various geospatial data to support decision-making.	Use of specialized GIS software, creation of thematic maps and models.
Regulatory and Legal Aspects	Possible temporary changes in the regulation of geodetic activities and data access.	Compliance with current regulations, coordination of works with relevant authorities.
Remote Observation Methods	Preferential use of methods that do not require direct presence at the monitoring object.	Aerospace surveying, satellite technologies, UAVs, radar..
Information Security	Ensuring the protection of geospatial data from unauthorized access and cyberattacks.	Application of cryptographic methods, restriction of access to information.

It should be noted that geodetic support for monitoring constitutes a set of scientific and technical measures aimed at obtaining highly accurate spatiotemporal data on the dynamics of the studied objects. The fundamental basis of this process is the creation and maintenance of a reference geodetic network, which provides a unified coordinate system for all subsequent measurements. The accuracy and density of the network points are key factors determining the reliability of monitoring results. The geodetic monitoring process involves the use of various methods and instrumental tools, the selection of which is determined by the specific characteristics of the observation object, the required measurement frequency, and accuracy criteria.

In situations where traditional points of the State Geodetic Network (SGN) are damaged or destroyed, satellite technologies (GNSS) become particularly important, providing continuous access to coordinate information in both static and kinematic modes. GNSS (Global Navigation Satellite System) is a satellite-based navigation system intended for the positioning of objects and the determination of their spatial location, i.e., their coordinates [7]. One of the significant advantages of using GNSS technologies is the considerable reduction in time required for geodetic surveying tasks. GNSS technologies have proven especially effective for planning work in terrain modeling for the construction sector, topographic surveying, and geodetic measurements at sites remote from SGN points [8]. However, limitations must be taken into account, particularly the inability to conduct surveys under conditions of limited visibility of the sky. GNSS technologies rely on several widely used systems and software solutions, such as GPS (USA), Galileo (EU), and BeiDou (China), which consistently provide high-precision (up to centimeters) spatial positioning — a critical requirement for geodetic research [9]. For example, in the dissertation study by S. Tretiak, a methodology was presented for using GNSS technologies to monitor deformation of the Dniester River channels and its right- and left-bank tributaries, and to determine their characteristics [10].

Unmanned aerial vehicles (UAVs) enable detailed surveys of small areas with high precision. They are particularly relevant in areas that are inaccessible due to hostilities or landmines [1]. The implementation of UAV technology allows for high-resolution digital aerial imaging, which makes it possible to obtain highly accurate visualizations of land surfaces and the objects located on them. A notable example is the study conducted in the settlement of Solotvyno [11], which resulted in a catalog of modified (reconstructed, renovated, dismantled, etc.) and new objects within the Solotvyno salt mine area.

Professional UAVs equipped with dual-frequency GPS, PPK/RTK technologies, large-matrix cameras, and lenses free from distortion and chromatic aberrations make it possible to digitize stereo images and meet the requirements for creating topographic plans at scales of 1:5000 to 1:1000, and partially 1:500. Accordingly, this enables the monitoring of agricultural and forestry land, the study of archaeological and cultural heritage, and the inspection of the technical condition and safe operation of energy and utility infrastructure based on UAV aerial survey data. An interesting example of UAV survey application is the topographic and geodetic support for assessing the technical condition of roads damaged as a result of military aggression in the Beryslav district of Kherson region [4]. Using 733 drone-captured images of the study area, taken from an altitude of 35 meters at a resolution of 1.5 cm/pixel, an assessment was carried out to evaluate the extent of damage to geodetic markers and to detect the impacts of military actions on roads, including traces of heavy machinery, shell craters, and burn marks. The aerial images were processed and analyzed using software packages such as Agisoft Metashape Professional, Global Mapper, and Pix4D Mapper. These tools are effective photogrammetric solutions for creating 3D models from 2D images, allowing for accurate detection and measurement of pavement defects. The results indicated that the surface condition of the examined road T0403 was unsatisfactory and required restoration.

Remote sensing (RS) methods are among the most effective tools for studying urban landscapes. An example of urban land monitoring using Sentinel-2 satellite imagery is presented in [12]. Interpretation of the satellite images made it possible to assess the current state of urban landscapes in the city of Poltava, identify the spatial characteristics of the city-such as the condition of green spaces, areas completely lacking vegetation, and building density – and to classify the city's territory according to four categories: built-up area, urban vegetation, bare soil, and water bodies.

The application of LiDAR technologies is an effective and well-justified solution for monitoring land use changes, especially in conditions characterized by increased complexity. LiDAR (Light Detection and Ranging) is an advanced remote sensing technology that uses laser pulses to measure the spatial coordinates of objects. Modern LiDAR systems can be mounted on various platforms, including aircraft, unmanned aerial vehicles (UAVs), and ground vehicles. The data obtained using LiDAR technology make it possible to generate detailed and highly accurate three-dimensional models of the Earth's surface, representing a significant breakthrough in the methodology for assessing the value and functional purpose of land plots and natural resources. The effectiveness of LiDAR systems is especially evident in geographically complex environments, including dense forests, mountainous areas, and terrains with variable topography. This is due to LiDAR's unique ability to penetrate through foliage, allowing for the creation of high-accuracy digital surface models, unlike the limitations inherent to conventional photogrammetric approaches, as presented in scientific work [13]. The use of LiDAR for geodetic monitoring allows for the rapid detection of sudden changes in relief and land cover, the identification of erosion and landslide processes, as well as other degradation phenomena that can potentially deteriorate land resources. LiDAR technologies are characterized by a high level of accuracy and rapid digital data collection, supporting their application in all types of geodetic research—especially in the context of assessing the condition of land resources in hard-to-reach areas. This ensures the timely acquisition of high-quality geospatial data. The ability to integrate LiDAR imagery with data from other sources, such as GNSS or UAVs, enables the creation of comprehensive geographic information systems that implement a multifaceted approach to land resource assessment [9].

Hybrid positioning is a method of determining the spatial location of an object that uses a combination of several data sources: satellite (GPS, GLONASS, Galileo), radio frequency (Wi-Fi, Bluetooth, RFID), inertial sensors (accelerometers, gyroscopes), and visual data (camera, LiDAR). This approach helps to compensate for the weaknesses of individual technologies and achieves greater accuracy, stability, and reliability in positioning. The main goal of this approach is to ensure high accuracy and data reliability in situations where a single technology is insufficient to meet the requirements of geodetic work or when its functionality is diminished due to external factors [14]. Such conditions may arise, for example, in adverse weather conditions or in urbanized areas where satellite signals may be blocked or weakened. In these cases, hybrid positioning employs INS.

Inertial Navigation Systems (INS) are autonomous navigation systems that determine the position, orientation, and velocity of an object without the use of external reference points. Their operation is based on measuring accelerations and angular velocities using built-in accelerometers and gyroscopes, respectively. The working principle of an INS involves integrating the measured parameters from a known initial state.

The key advantages of using hybrid positioning include:

- increased accuracy in recording changes in land parcel boundaries through synchronization of data from GNSS, drones, and photogrammetric images;

- continuous updating of cartographic information via mobile Geographic Information Systems (GIS) based on hybrid positioning;

- the ability to promptly detect and document land use violations, such as unauthorized construction, illegal logging, or alterations of watercourse channels;

- integration with Earth remote sensing (RS) — satellite and aerial imagery is supplemented by ground data, enabling comprehensive spatiotemporal analytics.

An example of the integration of object coordinate determination systems and remote sensing image interpretation is presented in study [5].

Technological innovations contribute to the formation of a new paradigm of digital efficiency in the geodetic field, which is manifested in reduced operational costs when conducting various types of geodetic surveys and exploratory work. A summary of the geodetic technologies used for monitoring land use changes in Ukraine is provided in Table 2 [9].

2. Comparative analysis of geodetic support for monitoring land use changes

Geodetic Support	Characteristic	Key advantage of use	Achieved geodetic effect	Analysis of digitalization vector
1. Global Navigation Satellite Systems (GNSS)	Universal precise determination of spatial coordinates..	High precision and resistance to meteorological factors.	Optimization of cadastral surveys and monitoring of land cover changes.	High
2. Unmanned Aerial Vehicles (UAVs) and RS	Acquisition of high-resolution aerial photographs.	Data collection over significant territories and in hard-to-reach regions.	Optimization of economic costs and reduction of risks in geodetic processes.	High
3. LiDAR Technologies	Remote determination of distances to objects by using laser radiation.	Development of high-precision digital three-dimensional models of the Earth's surface.	Monitoring of relief transformations and degradation processes that worsen the condition of land resources.	High
4. Hybrid Positioning	Synergistic use of multiple technologies to achieve optimal accuracy.	Elimination of disadvantages of autonomous positioning systems.	Support for continuous monitoring with high precision.	Very high

5. Inertial Navigation Systems (INS)	Maintaining data continuity on the position and trajectory of an object's movement.	Autonomous operation independent of satellite navigation.	Ensuring stable accuracy in the presence of satellite signal interference.	Medium

Thus, well-grounded and specialized geodetic support technologies are critically important for significantly enhancing the capabilities of land use change monitoring, especially under wartime and post-war conditions. This is due to the fact that certain areas of Ukraine are characterized by limited access or complex field conditions, making the use of traditional methods impossible. A crucial stage of monitoring is the processing and interpretation of geodetic data. This process, which is an integral component of geodetic research, should encompass several fundamental stages, including:

- preprocessing: Involves the initial validation and correction of collected data through filtering, removal of noise and visual errors in the measurements. This minimizes the impact of random and systematic errors and eliminates visual aberrations that could distort the interpretation of results;
- spatial localization and coordination, or geospatial referencing: Ensures accurate positioning of data within a defined coordinate system. This is achieved using modern Global Navigation Satellite System (GNSS) technologies or other relevant geospatial information sources;
- geoinformation analysis and modeling: Involves a comprehensive study of data relationships and patterns through modeling and interpretation. Within this research process, it is essential to integrate the following methods to identify patterns, determine land use relief changes, or assess other characteristics of the study area: mathematical modeling, statistical analysis, and machine learning.
- cartographic material generation: The creation of digital maps, 3D terrain models, or interactive Geographic Information Systems (GIS) in the context of land use. These digital tools offer high efficiency in visualizing collected geospatial data, conducting comparative analysis with other spatial datasets, and supporting informed decision-making.

The results of the practical application of this geodetic data processing and interpretation methodology are presented through the example of digital maps created for the Bilokrynytsia territorial community in the Rivne region (Figure 1). The digital maps of the community developed by the authors using QGIS software – namely, the land use plan and the digital elevation model-constitute integral components of the 'Land Resources and Land Cadastre' database within the community’s geographic information system (GIS). The maps have spatial (geographic) referencing, which enables, if necessary, the analysis of the geomorphological structure of the area in relation to land use. It should be noted that all data are presented in a single coordinate system, ensuring representative coordinate accuracy.

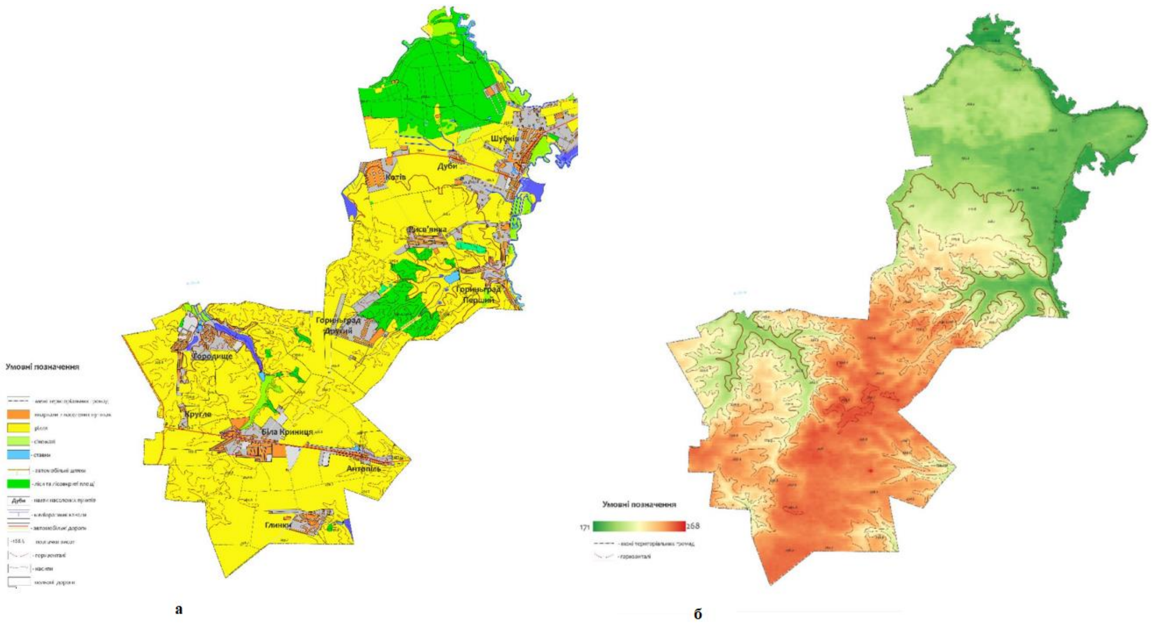

Fig. 1. Digital maps of the Bilokrynytsia territorial community, Rivne region: a – existing land use plan; b – digital terrain model of the community area with color coding.

Conclusions and prospects. The analysis of the current state and development prospects of geodetic support for land use change monitoring in Ukraine–particularly under wartime conditions and during post-war recovery–allows for the formulation of several key conclusions and the identification of future research directions. Land resource management is a fundamental component of national security, economic development, and social stability in any country. Geodetic support is viewed as a complex of technical, organizational, and methodological measures for obtaining data to monitor land use. Modern geodetic tools-including Global Navigation Satellite Systems (GNSS), Earth Remote Sensing (ERS), Unmanned Aerial Vehicles (UAVs), and Geographic Information Systems (GIS)-enable prompt and highly accurate monitoring of territorial changes, even in hard-to-reach or hazardous areas. The processing and interpretation of geodetic data is an integral component of the monitoring process. It includes several essential stages: preprocessing, spatial localization and coordination, geoinformation analysis and modeling, and the generation of cartographic materials.

The applied significance of using geodetic technologies for monitoring land use changes lies in their ability to provide objective and up-to-date data for informed decision-making on the rational use of land resources, territorial planning, assessment of anthropogenic impacts, and rapid response to emergencies and recovery efforts during the post-war period. These technologies not only detect changes but also allow for forecasting their dynamics, which is crucial for sustainable development and environmental security.

Further scientific research is required on the use of digital technologies, the automation of data collection, and the integration of diverse information sources in GIS systems. This will ensure reliable monitoring of land use changes both during active conflict and in the reconstruction phase.

References

1. Pilicheva, M.O., Danylyuk, A.A. (2025) Analiz heodezychnykh metodiv ta danykh dystantsiynoho zonduvannya dlya formuvannya kartohrafichnoho zabezpechennya mistobudivnoyi dokumentatsiyi [Analysis of geodetic methods and remote sensing data for the formation of cartographic support for urban planning documentation]. Municipal Economy of Cities, 189 (1), 271-279. DOI: 10.33042/2522-1809-2025-1-189-271-279

2. Mamonov, K.A., Kanivetsʹ, O.M., Velychko, V.A., Hoy, V.V. (2024) Instrumentariy zabezpechennya zemleustroyu obʺyednanykh terytorialʹnykh hromad [Toolkit for ensuring land management of united territorial communities]. Highways and road construction, 115, 81-88. DOI:10.33744/0365-8171-2024-115.1-081-088

4. Tsvyk, O. V., Kravchenya, V. M. (2024) Topohrafo-heodezychne zabezpechennya otsinky tekhnichnoho stanu dorih, poshkodzhenykh unaslidok viysʹkovoyi ahresiyi [Topographic and geodetic support for assessing the technical condition of roads damaged as a result of military aggression] Technical Sciences and Technologies, 4(38), 350-358. DOI: 10.25140/2411-5363-2024-4(38)-350-35

5. Sakhno, YE., Shcherbak, YU., Kovalenko, S., Khristodulopulos, A. (2024) Intehratsiya system vyznachennya koordynat ob'yektiv ta deshyfruvannya znimkiv dystantsiynoho zonduvannya zemli. [Integration of systems for determining the coordinates of objects and decoding images of remote sensing of the earth.] Technical Sciences and Technologies. 1(35), 329-336. DOI: 10.25140/2411-5363-2024-1(35)-329-336

6. Stadnikov, V., Likhva, N., Konstantinova, O., Kolosyuk, A. (2023) Dosvid zastosuvannya HIS-tekhnolohiy pry stvorenni (onovlenni) tsyfrovykh topohrafichnykh kart masshtabu 1:25000 [Experience in using GIS technologies in creating (updating) digital topographic maps at a scale of 1:25000]. Tekhnichni nauky ta tekhnolohiyi, (34), 255-264. DOI: 10.25140/2411-5363-2023-4(34)-255-264

7. Shevchuk, S. M., Domashenko, H. T., Rozhi, T. A. (2024) Suchasni metody heodezychnoho kartohrafuvannya terytoriy: vykorystannya GPS ta HNSS tekhnolohiy [Modern methods of geodetic mapping of territories: use of GPS and GNSS technologies]. Prostorovyy rozvytok. KNUBA, 8, 506–517. DOI: https://doi.org/10.32347/2786-7269.2024.8.506-517

8. Zavorotnyy, S.M. (2024) Analiz. suchasnykh inzhenerno-heodezychnykh metodiv monitorynhu budivelʹ ta sporud obʺyektiv istoryko-kulʹturnoyi spadshchyny [Analysis of modern engineering and geodetic methods for monitoring buildings and structures of historical and cultural heritage sites]. Tekhnichni nauky ta tekhnolohiyi, 3(37), 228-235. DOI: 10.25140/2411-5363-2024-3(37)-228-23

9. Herasymchuk, O.L., Hoy, V.V., Khariv, V.V. (2024) Vykorystannya suchasnykh heodezychnykh tekhnolohiy dlya provedennya otsinky zemelʹnykh resursiv u viddalenykh rayonakh [Using modern geodetic technologies for assessing land resources in remote areas] Tekhnichni nauky ta tekhnolohiyi, 4(38), 313-324. DOI: 10.25140/2411-5363-2024-4(38)-313-32

10. Tretyak, S.K. (2018) Monitorynh hidrohrafichnykh ob″yektiv shlyakhom dystantsiynoho zonduvannya zemli ta heoinformatsiynykh tekhnolohiy [Monitoring of hydrographic objects by means of remote sensing of the earth and geoinformation technologies]. Lviv, 213

11. Kolb, I., Kolodiy, P., Ryzhov, YE., Urbanavičius, V. (2024) Monitorynh vykorystannya zemelʹ zasobamy dystantsiynoho zonduvannya [Monitoring of land use by means of remote sensing. Bulletin of the Lviv National University of Environmental Management. Series «Architecture and Construction»]. Bulletin of the Lviv National University of Environmental Management. Series «Architecture and Construction». 25. 188-197 https://doi.org/10.31734/architecture2024.25.188

12. Shevchuka, S.M. (2025) Zemlekorystuvannya ta prostorove planuvannya u terytorialʹnykh hromadakh Poltavsʹkoyi oblasti [Land use and spatial planning in territorial communities of Poltava region]. Poltava: PDAU, Ukraine, 210.

13. Lyulʹchyk V.O., Rusina N.H., Petrova O.M. (2019) Lidary: suchasni tekhnolohiyi u sferi heodeziyi ta zemleustroyu [Lidars: modern technologies in the field of geodesy and land management.]. Scientific notes of the V.I. Vernadsky TNU. Series: technical sciences, 6, 30 (69), 215-220. DOI: 10.25140/2411-5363-2024-4(38)-313-32.

14. Delva, P., Altamimi, Z., Blazquez, A. (2023) GENESIS: co-location of geodetic techniques in space. Earth Planets Space, 75. 5. https://doi.org/10.1186/s40623-022-01752-w

Г.Т. Домашенко, С.С. Молнар Д, Н.І. Прокопенко

ГЕОДЕЗИЧНЕ ЗАБЕЗПЕЧЕННЯ ПРОЦЕСІВ МОНІТОРИНГУ ЗМІН У СТРУКТУРІ ЗЕМЛЕКОРИСТУВАННЯ УКРАЇНИ В ПЕРІОД ЗБРОЙНОЇ АГРЕСІЇ РОСІЇ ТА ПОСТКОНФЛІКТНОГО ВІДНОВЛЕННЯ

Анотація. *У статті розглянуто геодезичне забезпечення моніторингу змін землекористування в Україні в умовах воєнного та повоєнного періодів, що є ключовим елементом національної безпеки, економічного розвитку та соціальної стабільності. Метою статті є представлення аналізу сучасного стану і перспектив розвитку геодезичного забезпечення моніторингу земельних ресурсів. У процесі дослідження використано комплексний підхід, що передбачає аналіз наукових публікацій, а також практичних прикладів застосування геодезичних технологій для моніторингу змін землекористування в умовах збройного конфлікту та повоєнного відновлення територій України. Матеріалом практичного дослідження слугувало землекористування Білокриницької територіальної громади Рівненської області. Досліджено використання глобальних навігаційних супутникових систем (GNSS), дистанційного зондування Землі (ДЗЗ) та безпілотних літальних апаратів (БПЛА), які дозволяють фіксувати зміни землекористування в режимі, близькому до реального часу, та ефективно використовувати геопросторову інформацію для прийняття управлінських рішень. Окрему увагу приділено лідарним технологіям, що дозволяють створювати високоточні тривимірні моделі земної поверхні та виявляти деградаційні процеси, особливо в географічно складних середовищах. Розглянуто гібридне позиціювання, яке поєднує різні джерела даних (супутникові, радіочастотні, інерційні сенсори, візуальні дані) для підвищення точності та надійності позиціювання, особливо в умовах обмеженої видимості або блокування супутникового сигналу. У дослідженні акцентовано, що процес обробки та інтерпретації геодезичних даних включає попередню обробку, просторову локалізацію, геоінформаційний аналіз та моделювання, а також генерацію картографічного матеріалу. Практична важливість дослідження полягає у наданні об'єктивних та* *актуальних даних для прийняття обґрунтованих рішень щодо раціонального використання земельних ресурсів, планування територій та оперативного реагування на надзвичайні ситуації. Визначено, що подальші дослідження необхідні для вдосконалення використання цифрових технологій, автоматизації збору даних та інтеграції різних джерел інформації у ГІС-системах для надійного моніторингу змін землекористування як під час бойових дій, так і в період відбудови.*

Ключові слова: *геодезичне забезпечення, моніторинг, землекористування, війна, повоєнний період, ГІС, GNSS, БПЛА, дистанційне зондування*.