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LAND SURVEYING AND GEODETIC SECTORS OF UKRAINE DURING WARTIME: TRANSFORMATIONS AND CHALLENGES

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Abstract: This article is dedicated to the current state of the land surveying and geodetic sectors in Ukraine, particularly in the context of the impact of the COVID-19 pandemic and Russian military aggression. The authors emphasize the critical role of these sectors in ensuring land and property rights, spatial planning, land resource management, and providing technological and environmental safety. The article examines the main transformations, challenges, and opportunities for the professional activities of land surveyors and geodesists during wartime, as well as their role in the post-war reconstruction of the country. Specifically, a detailed analysis of the certification dynamics of land surveyors and geodesists for the period of 2013–2024 has been conducted, allowing for an assessment of the sector considering both economic and social challenges. The increase or decrease in the number of newly certified specialists enables the evaluation of labor market activity and the impact of crisis factors on the sector's operations. The study also explores regional employment peculiarities, analyzing dynamics in front-line, de-occupied, rear, and support regions. The article highlights the significant role of gender balance in engineering professions, particularly noting the increasing access of women to technical specialties previously considered predominantly male. Analysis of gender ratios demonstrates progress in

ensuring equal opportunities for both genders in the land surveying and geodetic fields. The main conclusions of the study indicate that the land surveying and geodetic sectors require the integration of the latest technologies, such as Geographic Information Systems (GIS) and remote sensing, to enhance their efficiency during wartime and post-war recovery. The use of unmanned aerial vehicles for geodata collection in hazardous regions and the adaptation of educational programs to train new specialists considering new realities are key development directions for the sector. The article is an important contribution to understanding the current challenges and opportunities for the land surveying and geodetic sectors during wartime, providing scientific and practical recommendations for strategic development.

Keywords: *land surveying sector, geodetic sector, certified engineers, Geographic Information Systems (GIS), remote sensing, wartime, post-war reconstruction, gender balance, labor market, spatial planning.*

Problem Statement

The geodetic and land surveying sectors in Ukraine play a key role in guaranteeing land and real estate rights, ensuring the functioning of relevant real estate markets, spatial planning, public administration, environmental protection, technological safety, and more. Land surveyors and geodesists perform a wide range of exploratory, geodetic, and cartographic works, as well as all types of land surveying and land valuation activities [1].

Analyzing the dynamics of the number of certified land surveyors and geodesists based on state registry data is important for indirectly assessing the development of the land surveying and geodetic sectors. An increase or decrease in the number of certified specialists indicates the level of demand for these professions in the labor market, pointing to sector activity, expansion, and growing need for specialists. Additionally, this indicator allows for assessing the impact of various crisis factors, such as pandemics, economic instability, or war, on the sector's operations. For example, a decrease in the number of new certificates may indicate a slowdown in development or complications in the certification process due to external circumstances.

The geographical distribution of certified specialists also provides an opportunity to assess which regions are more or less active in the context of land surveying and geodetic works, which is especially relevant in conditions of military actions or population migration. This allows for conclusions about infrastructure development and investments in certain regions. Moreover, the number of new certified specialists reflects the effectiveness of the education system in the field, showing how well educational programs meet the current needs of the labor market. Such analysis helps understand how well educational institutions adapt to changes and prepare new specialists according to the demands of the time.

Overall, analyzing the dynamics of the number of certified engineers is a useful tool for assessing the current state of the sector and its prospects, as well as for strategic planning of future needs, educational programs, and projects aimed at restoring infrastructure and developing land resources.

Analysis of Recent Research and Publications

Before the full-scale Russian invasion of Ukraine, scientific publications on the development of the land surveying and geodetic sectors focused on improving cadastral accounting technologies, developing Geographic Information Systems (GIS), and optimizing land surveying processes. Among the main issues was the implementation of digital technologies in planning processes, the use of satellite imagery, and data analysis for territory management [2, 3, 4].

However, the onset of the war caused significant shifts in the focus of scientific research. Currently, many scientists emphasize the role of remote sensing and GIS for managing territories affected by hostilities, as well as for assessing the damage caused. In particular, researchers are exploring the possibilities of using unmanned aerial vehicles (UAVs) for data collection in hard-to-reach or dangerous regions [5, 6]. Many publications also highlight the need to adapt educational programs that should train specialists to work in the constantly changing realities of war and post-war reconstruction [7]. In a study by scientists [8], an assessment was conducted on the negative impact of the war on the land surveying and geodetic sector and the geoinformation infrastructure of Ukraine.

It is worth noting that among modern studies, interest in gender issues in technical professions is also growing. In particular, ensuring equal access for women to the land surveying and geodetic sectors is a relevant topic that reflects the aspiration for a more inclusive and diverse professional environment [9].

The purpose of this study is to analyze the current state of the land surveying and geodetic sectors of Ukraine during the war, to identify the main challenges and transformations these sectors have faced, and to formulate strategic recommendations for further development and adaptation to new realities.

Materials and Methods

The study is based on the analysis of statistical data from the State Register of Certified Land Surveyors and the State Register of Certified Geodesists, published as open data sets by the State Service of Ukraine for Geodesy, Cartography, and Cadastre (Derzhgeokadastr), particularly information on the number of registered certified land surveyors and geodesists for the period 2013-2024. Quantitative analysis methods were used to assess the dynamics of changes, allowing for the identification of key trends in the sector. Special attention was paid to the gender balance of specialists, regional employment structures, and the impact of crisis factors such as the pandemic and war on the functioning of the sectors.

Main Material Presentation

In recent years, significant changes have occurred in the land surveying and geodetic fields. In particular, professional land surveyors have gained more independence and, simultaneously, greater responsibility for performing land surveying and geodetic works.

The land surveying and geodetic sectors, which are essential for infrastructure development, agriculture, and urban planning, have also been seriously affected by hostilities. Simultaneously, the COVID-19 pandemic and wartime have introduced adjustments both in specialist training and in obtaining qualification certificates.

In the context of martial law and post-war reconstruction of the country, the professions of geodesist and land surveyor are crucial. Currently, there is an increased demand in military units for tasks such as topographic and cartographic support of

military affairs, knowledge in military topography, work related to aerial reconnaissance and fire correction using unmanned aerial vehicles, the need for drone pilots, the ability to accurately determine coordinates on the terrain, and the use of remote sensing materials, among others.

During land surveying, geodetic and cartographic works are performed by individuals who have received a qualification certificate as a land surveyor in accordance with the Law of Ukraine "On Land Surveying" [10].

According to Article 66 of the Law of Ukraine "On Land Surveying," "certified land surveyors are individuals who have higher education in specialties and qualifications in the field of land surveying, have at least one year of work experience in the specialty, have passed a qualification exam, received a certificate, and are registered in the State Register of Certified Land Surveyors" [11].

The source of information on the number of certified land surveyors, geodesists, and land appraisers is the relevant state registers, which are available in open access on the website of the State Service of Ukraine for Geodesy, Cartography, and Cadastre (https://land.gov.ua).

According to the register, 6,062 certified land surveyors have been registered in Ukraine, who received their qualification certificates between 2013 and 2024, of which 56.32% are men and 43.68% are women (Fig. 1). The majority of land surveyors are employed in Kyiv city, Kyiv, Lviv, and Dnipropetrovsk regions. The smallest number is employed in Kherson, Luhansk, and Chernivtsi regions (Fig. 3).

Fig. 1. Gender Balance of Land Surveyors and Geodesists

We paid particular attention to studying the gender balance of land surveyors and geodesists, which reflects the ratio of men and women employed in these professions. This is an important indicator that allows assessing the level of gender equality in the sector, as well as women's access to technical professions that have traditionally been considered more male-dominated.

The COVID-19 crisis, according to the European Commission, disproportionately affected women and girls, leading to the proposal of a new EU Gender Action Plan for gender equality and women's empowerment in external relations for 2021–2025. Military actions in Ukraine have significantly impacted the assurance of equal rights and freedoms of individuals. Women's rights have become even more vulnerable due to forced relocations to safer places or temporary protection in other countries [12].

Gender balance analysis helps identify whether there are equal opportunities for representatives of both genders in the land surveying and geodetic fields, which may indicate progress or existing problems in ensuring equality in access to education, employment, and career development. Equal gender balance promotes greater inclusivity, diversity, and productivity in the work environment, as women and men can bring different approaches and ideas to work [13].

Regarding the register of certified geodesists who received their qualification certificates between 2013 and 2024, 1,735 individuals are registered, of which 83.98% are men and 16.02% are women (Fig. 1). The majority of geodesists are employed in Lviv, Odesa, Dnipropetrovsk, and Kyiv regions and in Kyiv city. The smallest number is employed in Luhansk, Sumy, Kirovohrad, Kherson, Chernivtsi, and Chernihiv regions (Fig. 3).

As can be seen, the COVID-19 crisis, lockdowns, and hostilities (starting from 2014) have impacted the land surveying and geodetic sectors in Ukraine, as in 2020–2021, 251 individuals received land surveyor certificates, and in 2022–2023, 411 individuals. The majority are employed in Kyiv city, Kyiv, Lviv, Odesa, Poltava, and Ivano-Frankivsk regions. The situation regarding certified geodesists is as follows: in 2020–2021, 183 individuals received geodesist certificates, and in 2022–2023, 91 individuals. The majority are employed in Kyiv city, Kyiv, Lviv, Dnipropetrovsk, and Odesa regions (Fig. 2).

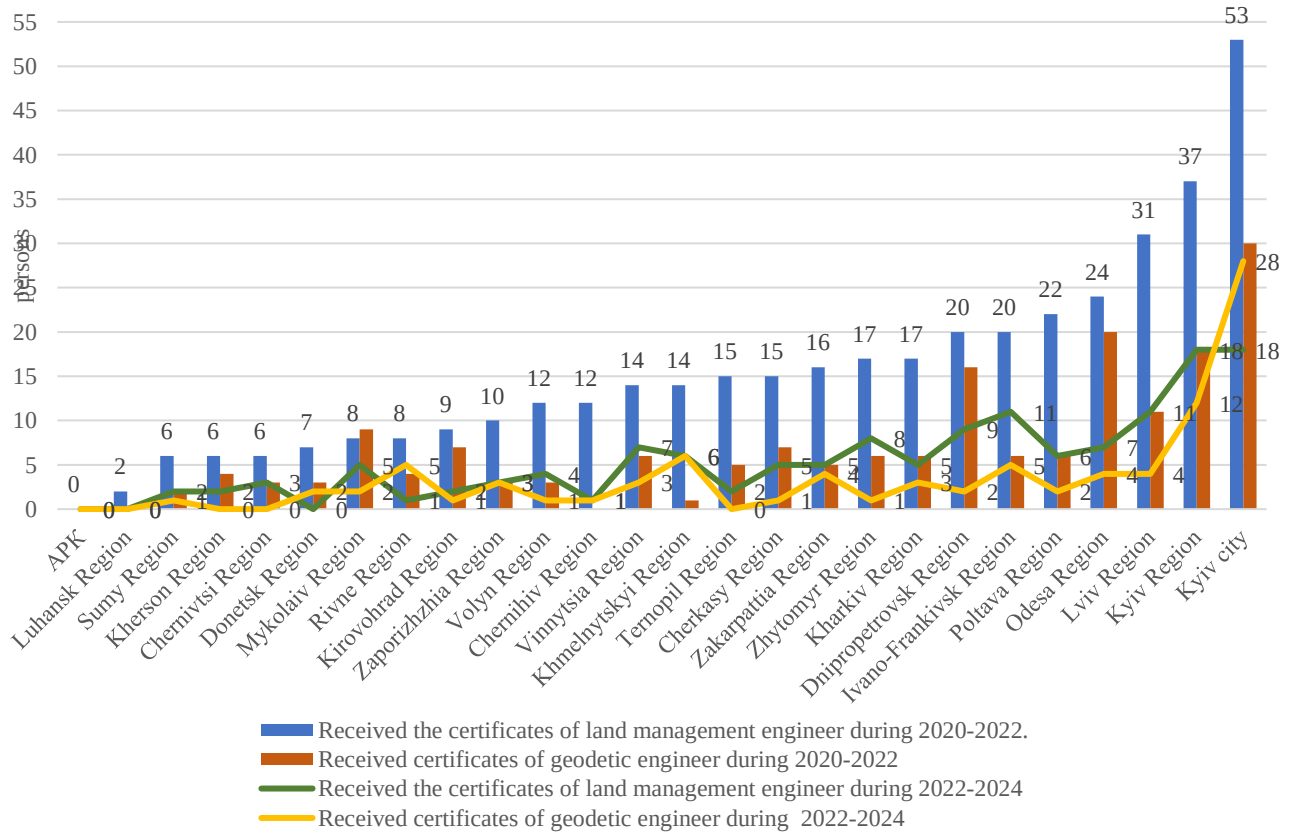

Fig. 2. Statistics of Certificate Acquisition by Land Surveyors and Geodesists During 2020–2024

The new phase of Russia's war against Ukraine has led to a change in the economic structure and caused a series of new challenges. In particular, there has been:

Mass migration of labor resources abroad and within the country due to the war.

Closure and relocation of businesses from the eastern and southern territories of Ukraine to relatively safe areas (central and western regions).

Lack of safety during the execution of geodetic and land surveying works (hostilities have led to significant infrastructure destruction over large areas of Ukraine, loss or damage of equipment, archives, and documentation complicate the work on assessing and restoring land resources; mining of significant areas, especially in the combat zones, has created serious risks for the safety of land surveyors and geodesists).

According to the authors of the article [7], the main challenges for the geodetic and land surveying sectors of Ukraine in the wartime economy are the impossibility of performing works (including previously contracted ones) due to risks to the personal safety and lives of executors in temporarily occupied territories, in zones of active hostilities, as well as due to military restrictions or the risk of explosive objects; temporary or irreversible loss of highly qualified specialists due to their forced relocation within the country and abroad, mobilization into the Armed Forces, requalification due to economic instability, and inability to receive stable earnings working in their specialty.

At the beginning of 2018, according to data from the State Service of Ukraine for Geodesy, Cartography, and Cadastre (Derzhgeokadastr), a certain number of certified land surveyors and geodesists remained in territories that later became front-line or temporarily occupied regions: in Donetsk region – 90 people, in Luhansk – 35, in Kherson – 49, and in Kharkiv – 177. These regions already then felt the impact of the military conflict, which affected the employment and migration of specialists.

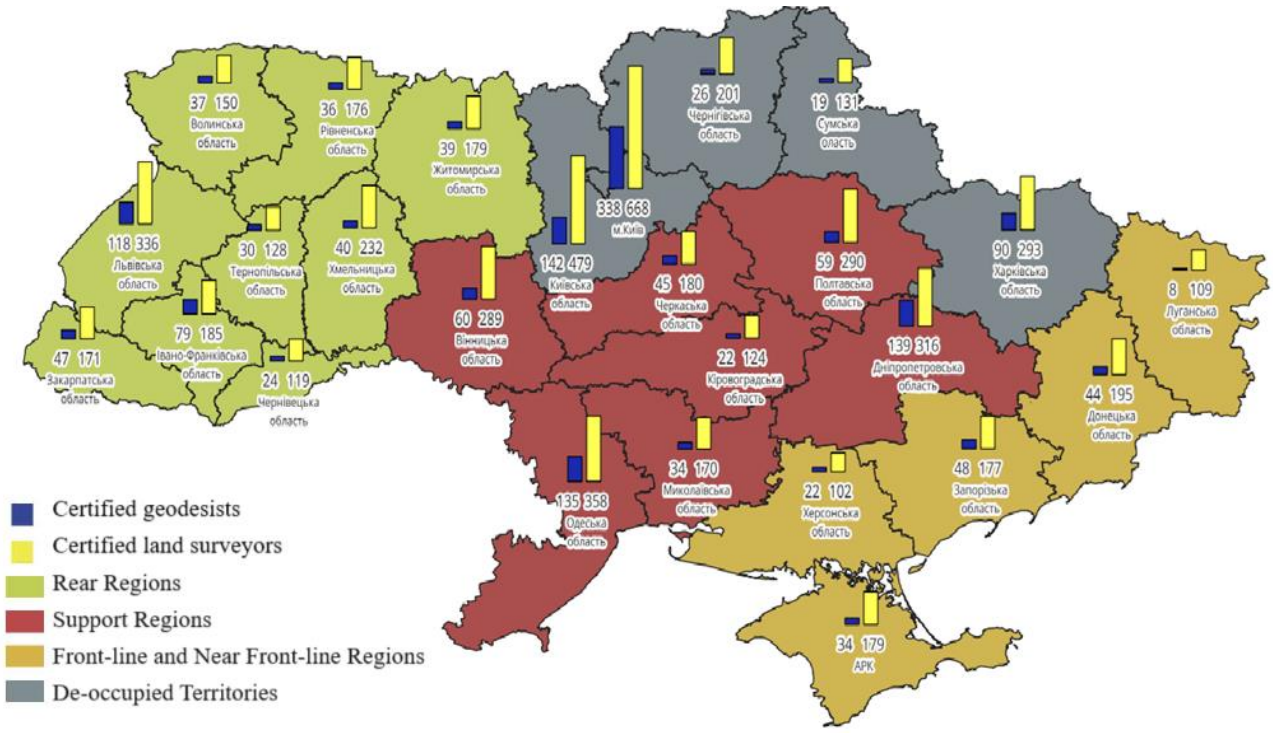

Fig. 3. Regional Distribution of Registered Certified Land Surveyors and Geodesists (According to Derzhgeokadastr of Ukraine, 2024)

For a detailed analysis, in our study, the regions of Ukraine were conditionally divided into four groups: rear, support, front-line, and de-occupied. Using data from the state registers of Derzhgeokadastr, the dynamics of registration of certified land surveyors and geodesists in these regions during 2020–2024 were analyzed. The identified trends allow drawing important conclusions about structural changes in the land surveying and geodetic sectors under the influence of the war.

Group I – Front-line and Near Front-line Regions

This group includes regions where active hostilities are currently taking place, particularly the Autonomous Republic of Crimea, Kherson, Zaporizhzhia, Donetsk, and Luhansk regions. In these territories, 762 certified land surveyors and 156 geodesists are employed. During the period 2020–2022, 25 individuals received land surveyor certificates, and 10 received geodesist certificates. During 2022–2024, the number of certified specialists decreased: only 5 new specialists received certificates.

Such dynamics indicate a serious impact of military actions on the human resources of the sector in these regions, caused by risks to life and safety of specialists.

Group II – De-occupied Territories

This group includes Kharkiv, Sumy, Chernihiv, and Kyiv regions, where recovery processes are underway after de-occupation. Here, 1,104 certified land surveyors and 277 geodesists are employed. In 2020–2022, 72 land surveyors and 26 geodesists received certificates. During 2022–2024, 26 land surveyors and 17 geodesists received certificates. This indicates a gradual recovery of the sector in liberated regions, but the pace of registration of new specialists remains limited due to the prolonged process of infrastructure restoration and safety risks.

Group III – Support Regions

Support regions include Cherkasy, Poltava, Dnipropetrovsk, Mykolaiv, Odesa, Kirovohrad, and Vinnytsia regions. Here, 1,877 certified land surveyors and 531 geodesists are employed. In 2020–2022, 124 land surveyors and 74 geodesists received certificates. During 2022–2024, the number of new certified specialists decreased: only 45 individuals became land surveyors, and 16 became geodesists. Despite a relatively stable situation, the decrease in the number of new specialists indicates limited sector capabilities in the context of the ongoing war, particularly due to general uncertainty and economic difficulties.

Group IV – Rear Regions

Rear regions include Zhytomyr, Rivne, Volyn, Lviv, Ternopil, Chernivtsi, Ivano-Frankivsk, and Zakarpattia regions. Here, 1,526 certified land surveyors and 413 geodesists are employed. During 2020–2022, 127 land surveyors and 41 geodesists received certificates. In 2022–2024, 47 land surveyors and 28 geodesists received certificates. This indicates stable sector development in rear regions, where risks associated with military actions are minimal, promoting more active employment and certification of specialists.

Analyzing the dynamics of certification of land surveyors and geodesists in different regions of Ukraine revealed significant differences depending on the degree of military impact. The greatest difficulties with employment and certification of new

specialists are observed in front-line and near front-line regions, caused by both safety risks and infrastructure destruction. In de-occupied territories, the situation is gradually stabilizing, although recovery rates remain slow.

Support and rear regions demonstrate more stable indicators regarding employment and certification of specialists, indicating relative resilience of the sector in these regions. However, even here, a decrease in the number of new certified engineers is observed, which may be a sign of a general slowdown in economic activity in the country.

Overall, the recovery of the sector will depend on the further course of military actions, infrastructure restoration, and implementation of state programs to support specialists. The use of modern technologies such as remote sensing and GIS is an important step for effective recovery and development of the land surveying and geodetic sectors in Ukraine.

Conclusions

The study of transformations and challenges faced by the land surveying and geodetic sectors of Ukraine in the conditions of war and pandemic revealed a number of important aspects regarding the current state and future development of these professions. The analysis showed significant changes in the professional environment, a substantial impact of military actions, and the need for adaptation to ensure sector resilience in difficult conditions. Based on the obtained data, the following generalized conclusions can be drawn:

1. **Critical Role of the Sectors:** The geodetic and land surveying sectors play a critical role in ensuring property rights, land market development, and spatial planning. In wartime conditions, their activities have acquired strategic importance, especially in the military sphere.

2. **Impact of Hostilities:** Military actions significantly complicate the execution of land surveying and geodetic works due to the danger of mines, infrastructure destruction, and loss of documentation. Specialist safety has become a key factor limiting the ability to perform previously contracted works, especially in occupied and front-line territories.

3. **Need for Technological Integration:** The COVID-19 pandemic and wartime have introduced serious changes in training and involving new specialists in professional activities through certification procedures. There is a growing need to apply remote sensing technologies to ensure the functioning of cadastral systems, spatial planning, and supervisory activities in the field of natural resource use, which requires adaptation of educational programs and enhancement of engineer qualifications.

4. **Regional Disparities:** The highest concentration of certified land surveyors and geodesists is observed in Kyiv and western regions, indicating internal migration of specialists due to hostilities and business relocation. The least number of employed engineers is in the east and south of the country, associated with high danger levels, decreased economic activity, and temporary occupation of certain territories.

5. **Strategic Recommendations:** The recovery of the land surveying and geodetic sectors in Ukraine should be based on the integration of modern technologies such as GIS, remote sensing, and the activation of topographic surveying to record war-inflicted damages and destructions, spatial planning, and military needs, as well as on further support of professional development of specialists through the adaptation of educational programs to new challenges.

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ЗЕМЛЕВПОРЯДНА ТА ТОПОГРАФО-ГЕОДЕЗИЧНА ГАЛУЗІ УКРАЇНИ В УМОВАХ ВОЄННОГО ЧАСУ: ТРАНСФОРМАЦІЇ ТА ВИКЛИКИ

Анотація: Дана стаття присвячена сучасному стану землевпорядної та топографо-геодезичної галузей в Україні, зокрема в контексті впливу пандемії COVID-19 та російської збройної агресії. Автори підкреслюють критичну роль цих галузей у забезпеченні прав на землю та нерухомість, просторовому плануванні, управлінні земельними ресурсами, забезпеченні техногенної та екологічної безпеки. Стаття розглядає основні трансформації, виклики та можливості для професійної діяльності інженерів-землевпорядників і геодезистів у воєнний час, а також їхню роль у післявоєнній відбудові країни. Зокрема, здійснено детальний аналіз динаміки сертифікації інженерів-землевпорядників та геодезистів за період 2013–2024 років, що дає змогу оцінити стан галузі, враховуючи як економічні, так і соціальні виклики. Збільшення чи зменшення кількості нових сертифікованих фахівців дозволяє визначити активність ринку праці, а також вплив кризових факторів на роботу галузі. У дослідженні також розглянуто регіональні особливості працевлаштування фахівців, аналізуючи динаміку у фронтових, деокупованих, тилових та опорних регіонах. У статті підкреслено значну роль гендерного балансу в інженерних

професіях, зокрема виявлено, що зростає доступ жінок до технічних спеціальностей, які раніше вважалися переважно чоловічими. Аналіз гендерного співвідношення показує прогрес у забезпеченні рівних можливостей для представників обох статей у землевпорядній та топографо-геодезичній сферах. Основні висновки дослідження свідчать про те, що землевпорядна та топографо-геодезична галузі потребують інтеграції новітніх технологій, таких як геоінформаційні системи (ГІС) та дистанційне зондування Землі для підвищення ефективності їхньої роботи в умовах війни та післявоєнного відновлення. Використання безпілотних літальних апаратів для збору геоданих у небезпечних регіонах та адаптація освітніх програм для підготовки нових фахівців з урахуванням нових реалій є ключовими напрямами розвитку галузі. Стаття є важливим внеском у розуміння сучасних викликів і можливостей для землевпорядної та топографо-геодезичної галузей в умовах війни, надаючи наукові та практичні рекомендації для стратегічного розвитку.

Ключові слова: *землевпорядна галузь, топографо-геодезична галузь, сертифіковані інженери, геоінформаційні системи (ГІС), дистанційне зондування, воєнний час, післявоєнна відбудова, гендерний баланс, ринок праці, просторове планування.*