# RESILIENCE IN FACE OF ADVERSITY: ASSESSING RUSSIAN AGGRESSION IMPACT ON LAND SURVEYING ENGINEERING SECTOR IN UKRAINE

**Andrii Martyn, Liudmyla Hunko, Liudmyla Kolosa, Nataliia Medynska, Anatolii Poltavets**
National University of Life and Environmental Sciences of Ukraine, Ukraine
martyn@nubip.edu.ua, liudmyla_g@ukr.net, kll_ludmila@ukr.net, natazv@ukr.net, afzy@ukr.net

**Abstract.** The article examines the critical role of the surveying engineering industry in Ukraine, a sector pivotal in upholding land and real estate rights, facilitating real estate markets, spatial planning, public administration, environmental protection, and man-made safety. The outbreak of war poses significant challenges to this industry, primarily driven by economic growth, as armed conflicts result in a marked decrease in the country's economic activities. Understanding these challenges is essential for maintaining the continuity of surveying services during such conflicts. The primary objective of the article is to evaluate the detrimental impact of the Russian Federation's armed aggression on Ukraine's surveying engineering market and propose potential recovery pathways. The methodology employed involves analyzing public data on cadastral administrative services and leveraging business analytics tools for public procurement, specifically focusing on the procurement of topographic survey services between 2022 and 2023. This approach allows for a first-of-its-kind quantitative assessment of the war repercussions on Ukraine's topographic-geodetic and land surveying sectors. The article meticulously analyzes the main challenges faced by these industries and suggests directions for post-war recovery. By thoroughly understanding the impact of war on the land surveying sector, the article aims to equip policymakers, industry professionals, and stakeholders with the knowledge to make informed decisions. Such insight is crucial for developing effective strategies to navigate and mitigate the challenges posed by the conflict, thereby ensuring the resilience and continuity of vital surveying engineering services in Ukraine.

**Keywords:** geodesy, land management, wartime economy, post-war reconstruction.

## Introduction

The extensive military aggression has exerted profound effects on Ukraine, encompassing its economic structure. Within the realm of engineering, the sectors of topographic-geodetic and land surveying have been markedly impacted by the war. This manuscript intends to scrutinize the ramifications of comprehensive Russian aggression on the operational status of surveying and geospatial activities in Ukraine.

It is pertinent to highlight that prevailing scholarly works have predominantly concentrated on analyzing the impact of military conflicts on land administration systems and the safeguarding of land ownership rights. The research contributions by Todorovski, Zevenbergen, and van der Molen, which include investigations into the integrity of cadastral records in post-conflict states of the former Yugoslavia [1-3], alongside Flower's examination of post-conflict land use in Sri Lanka [4], and Törhönen and Palmer's study on the land management system in post-conflict Cambodia [5], are notable. These studies underscore the academic focus on the post-conflict dynamics of land systems and ownership in countries such as Malawi, South Africa, Ethiopia, Ghana, Tanzania, Uganda, Liberia, and Rwanda, which have experienced military conflicts. In the context of the research, the studies of Ratkevičs, Celms, and Veliks [6], Martyn, Openko et al. [7], Medynska, Hunko, and Reznik [8] deserve attention. However, there exists a lacuna in scholarly inquiries into the direct economic impacts of military conflicts on the topographic-geodetic and land surveying sectors viewed as branches of the engineering profession.

The research problem centers on examining the extensive effects of Russian military aggression on Ukraine's topographic-geodetic and land surveying sectors, crucial components of the engineering field. It aims to explore the multifaceted challenges and significant economic losses these sectors have faced due to the conflict, including disruptions to service provision, regulatory changes, technological limitations, and the safety of professionals. Acknowledging a gap in existing literature, which has largely focused on land systems and ownership rights post-conflict, this study seeks to quantify the direct impacts of the war on these engineering discipline operational and economic structures.

## Materials and methods

To evaluate the repercussions of the extensive Russian military aggression on Ukraine's engineering surveying sector, this study employed an analytical approach centered on the examination

of publicly accessible data from the State Service of Ukraine for Geodesy, Cartography, and Cadaster. Specifically, the research utilized information available through the "Portal of electronic services of the State Land Cadaster", which provides monthly statistics concerning the provision of cadastral administrative services, including the registration of land plots, spanning from 2015 to the current period [9]. To approximate the detriments incurred by the topographic and geodetic sector, the study applied business analytics tools from the electronic platform for public procurement, SE "Prozorro", selecting the procurement of topographic surveying services during 2022 and 2023 as a key indicator [10].

Furthermore, this investigation entailed a thorough review of alterations in Ukraine's legal statutes pertinent to the adaptation of the land management system, land cadaster, topographical and geodetic activities, and land valuation under wartime conditions. This legal analysis was conducted utilizing official documents disseminated in the "Legislation of Ukraine" database managed by the Verkhovna Rada of Ukraine [11]. Through this multifaceted research methodology, the aim was to acquire an exhaustive insight into the challenges confronting the topography, geodetic, and land management sectors amidst the conflict in Ukraine, alongside envisaging the potential enduring impacts, and delineating strategies for adaptation and recuperation.

**Results and discussion**

The land surveying and topographic-geodetic sectors hold significant importance for Ukraine, as is the case for any European nation, due to their pivotal role in upholding land and real estate rights, facilitating the operational efficacy of corresponding real estate markets, spatial planning, public administration, and environmental conservation, as well as ensuring anthropogenic safety [12].

In the context of wartime, the surveying profession faces substantial challenges, given that these sectors are fundamentally oriented towards fostering economic growth, whereas military conflicts precipitate a marked decrease in the nation's economic activities. This situation underscores the necessity of acknowledging the difficulties encountered by these professionals amid military conflicts and devising strategies to ensure the uninterrupted provision of their critical services. Within the context of Ukraine's wartime economy, several critical challenges have been identified impacting the topographic-geodetic and land management sectors.

1. A significant reduction in the solvent demand for engineering land surveying and topographic-geodetic services arises as investment activities diminish due to wartime uncertainties and risks. This downturn is further exacerbated by the suspension of construction and development projects, alongside a comprehensive reallocation of state and local budgetary resources towards defense and crisis management efforts.
2. The feasibility of executing tasks, including those previously contracted, is severely compromised by concerns for the personal safety and lives of practitioners in areas temporarily under occupation, active conflict zones, or regions subjected to military impositions or the threat of explosive remnants.
3. The enactment of new regulatory frameworks and operational restrictions tailored to the wartime setting poses significant challenges, complicating or outright obstructing the operational capabilities of land surveying and geodetic engineering enterprises. This includes stringent procedures for field investigations, the cessation or curtailment of the IT systems integral to the State Land Cadaster and the State Register of Rights to Real Estate, among other bureaucratic hurdles.
4. The sector faces the temporary or permanent attrition of highly skilled professionals due to forced internal displacement or emigration, conscription into the armed forces, or career shifts prompted by economic volatility and the unfeasibility of securing stable employment within their field of expertise.
5. Technological limitations on operational practices emerge, encompassing restrictions or complete prohibitions on airspace usage for unmanned aerial vehicles (UAVs), difficulties in utilizing GNSS (Global Navigation Satellite System) equipment amidst electronic warfare activities, and additional constraints on accessing GNSS networks.

Concurrent with the Russian invasion, a significant cyber assault targeted the information technology systems of the Ukrainian government, leading to the immediate physical disconnection of servers that hosted critical state information resources, including registers and cadasters such as the State Land Cadaster and the State Register of Real Property Rights. Ensuring the physical security of data and equipment emerged as a paramount concern.

On February 25, 2022, a Russian cruise missile struck an apartment building on Valery Lobanovsky Avenue in Kyiv. Analyzing the missile trajectory suggests that the intended target might have been the data processing center of the SE State Land Cadaster Center, which holds approximately 4.6 petabytes of crucial data. This repository includes the State Land Cadaster information (encompassing plot registrations, land use limitations, administrative demarcations, cartographic foundations, etc.), scanned land management documents, scanned land title deeds issued prior to 2013, orthophoto maps, and remote sensing materials.

During the initial stages of the conflict, it became evident that land cadastral data and services maintain their critical importance even under wartime conditions. Such data are indispensable for the administration of public lands, the urgent allocation and restoration of infrastructure, the identification of plots for relocating enterprises away from conflict zones, and the construction of accommodations for displaced individuals. Consequently, despite the initial suspension of the State Land Cadaster IT system and the prevailing uncertainty regarding the resumption of its operations, efforts to develop alternative, decentralized, "semi-paper" systems for land rights registration commenced within the first weeks of the conflict. These systems were designed to operate independently of centralized data processing facilities.

The legislation enacted by Ukraine on May 12, 2022 (Law No. 2247-IX) facilitated a systematic adjustment of the country's land laws to the exigencies of martial law. This legislation introduced several pivotal reforms, such as the partial reinstatement of the State Land Cadaster operations (albeit without a public cadastral map and imposing specific requirements on state cadastral registrars), the permanent cessation of services in territories under temporary occupation or active conflict zones, and the streamlined allocation of state-owned lands for pressing needs without the need for electronic land auctions or approval processes.

In the wake of comprehensive anti-sabotage measures undertaken during the war early months, a legal framework was established from April to November 2022, introducing a mandatory protocol for conducting field geodetic surveys.

Effectively, from May 2022, the execution of land surveying engineering activities in Ukraine was legally permissible. However, practical implementation remained infeasible across approximately 21% of Ukraine's territory, either due to temporary occupation, ongoing hostilities, or the presence of unexploded ordnance, thereby posing significant risks to the personnel involved.

Over the past several decades, the utilization of Global Navigation Satellite System (GNSS) technology has become integral to surveyors for achieving precise measurements and positioning. However, the onset of military conflict has markedly impacted the civilian application of GNSS equipment and the execution of geodetic tasks in areas adjacent to the front lines and during missile and aerial bombardments. Radio electronic warfare (EW) capabilities have the potential to disrupt GNSS signals through the emission of radio frequency (RF) noise on frequencies identical to those used by GNSS signals, a practice commonly referred to as "jamming". Such interference can severely degrade the functionality of civilian GNSS receivers, leading to potential inaccuracies, delays, or the complete inability to ascertain location data.

Beyond jamming, EW operations may employ "spoofing" tactics, notably during engagements involving Russian strike drones. Spoofing entails the transmission of counterfeit GNSS signals, compelling the drone's GNSS receiver to compute erroneous positional information. The ramifications of jamming and spoofing for civil geodetic operations are substantial, as they can result in the collection of flawed data and the inaccurate determination of object locations.

In light of the aforementioned alterations to the execution of land surveying and topographic-geodetic operations under wartime conditions, it is imperative to evaluate the impact of the conflict on these industries from both economic and human dimensions.

Given that a significant portion of surveying activities in Ukraine, akin to many European nations (approximately 80%) [12], pertains to the demarcation of boundaries and the cadastral registration of land plots, an assessment of the geodetic industry's land-related losses due to the conflict has been conducted using the metric of land plot registration numbers.

A comparative analysis of the applications for land plot registration within the State Land Cadastre between 2021 (2.012 million applications) and 2022 (653 thousand applications) indicates a substantial decrease in activity, with the land management sector experiencing an approximate 67.5% reduction in its pre-conflict revenue streams as a direct consequence of the war. The trend of industry development during the conflict, as highlighted in the analysis, is vividly depicted in Fig. 1.

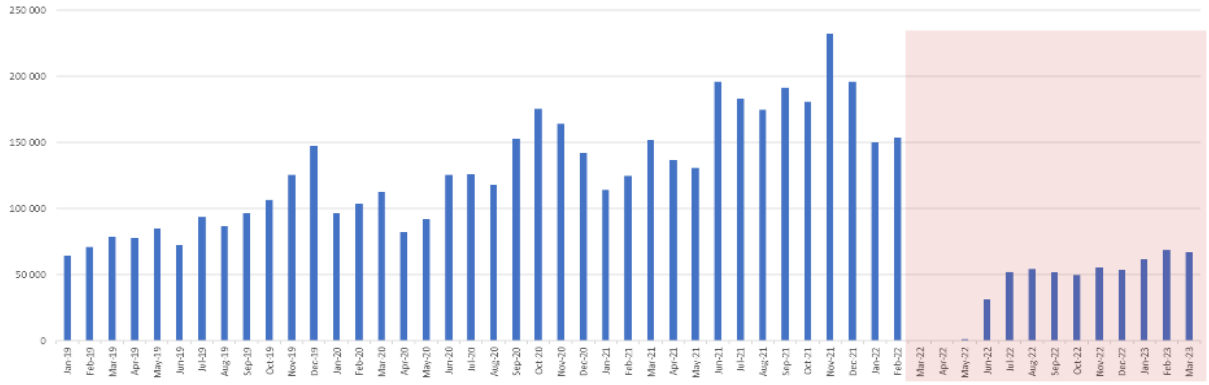


Fig. 1. **Number of monthly applications for registration of land plots in the State Land Cadaster of Ukraine for the period from January 2019 to March 2023 (data from the State Service of Ukraine for Geodesy, Cartography and Cadaster)**

Preliminary assessments conducted by the professional associations of land surveying engineers in Ukraine indicate that the pre-conflict annual market volume for land surveying was estimated between UAH 4.3 and 4.6 billion (approximately EUR 130 to 138 million). Consequently, the land surveying sector in Ukraine incurred an estimated revenue loss of around UAH 3 billion (about EUR 90 million) due to the conflict in 2022.

It is estimated that 15-20% of this revenue decline is attributable to the territories that are either temporarily occupied or have been liberated, where land surveying activities have been halted or face significant operational challenges. For instance, the Kharkiv region, a pre-conflict leader in land management and planning efforts, had initiated pilot projects for developing comprehensive plans for the territorial development of two communities in 2021, with approval expected in March 2022. However, these plans were disrupted by the onset of Russian aggression.

An additional decrease of 10-15% in industry revenue in 2022 is linked to the cessation of state and local community funding for land surveying activities, including reductions in state budget allocations for land reform (UAH 139 million) and state-wide topographical, geodetic, and cartographic works (UAH 32 million), among others. These funds were reallocated to defense and crisis management needs. It was not until March 2023 that the Cabinet of Ministers of Ukraine reinstated the possibility of conducting public procurements for land surveying works using budgetary resources [10].

Following the complete suspension of land management operations from March to May 2022 due to the cessation of activities by the State Land Cadaster, the industry has been experiencing a gradual recovery. As of the first half of 2023, the sector has achieved only 60-65% of the pre-conflict average monthly performance indicators.

An ancillary evaluation of the war effects on the topographical and geodetic sector can be derived through the analysis of public procurement volumes for topographical surveying services, utilizing the business analytics capabilities of the State Enterprise "Prozorro" [10] (refer to Table 1).

From this analysis, it is deducible that the conflict has precipitated a 70% reduction in the volume of public procurements for topographical surveying services. Concurrently, the monetary value of contracts executed in this domain witnessed a decline from UAH 104.6 million to UAH 45.8 million, marking a 67% decrease.

In the context of formulating a strategy for the revitalization of the engineering surveying and topographic-geodetic industries in Ukraine, it is pivotal to note that anticipations are primarily tied to post-conflict recovery endeavors. The following initiatives are deemed crucial for the rejuvenation of these sectors:

Table 1

**Analysis of public procurement of topographic surveying services in 2021 and 2022 according to the data of SE "Prozorro"**

| Year | 2021 | 2022 |
|---|---|---|
| Number of procurements | 2 402 | 713 |
| Number of lots | 2 415 | 715 |
| Expected cost, UAH | 338 509 141.20 | 102 140 379.41 |
| Initial value of contracts, UAH | 142 506 915.36 | 46 916 633.54 |
| Current value of contracts, UAH | 140 565 900.78 | 45 765 035.92 |

1. Surveying engineers are instrumental in evaluating and documenting the war-induced damages to buildings, infrastructure, and natural resources. Their proficiency in geospatial data gathering and analysis, alongside land valuation and enhancement, enables the production of detailed maps and reports elucidating the destruction wrought by the conflict. Such documentation is vital for pinpointing severely impacted locales, thereby optimizing the allocation of reconstruction resources. Furthermore, precise damage assessments are integral for formulating compensatory claims against the aggressor, developing governmental compensation programs for the aggrieved, and supporting international rehabilitation projects aimed at revitalizing war-torn communities.
2. The preliminary action plan for Ukraine's post-war recuperation and advancement, unveiled in Lugano in July 2022, envisages the re-mapping of Ukraine's territory and the establishment of a National Spatial Data Infrastructure (NSDI). The availability of updated cartographic data is indispensable for the post-conflict reconstruction and territorial development [8]. The deployment of Geographic Information Systems (GIS), encompassing land surveillance, will facilitate informed decision-making by governmental and local self-governing entities, satisfying societal demands for geographic information and fostering integration into global and European geospatial data infrastructures. The anticipated productive employment of geospatial data is projected to contribute up to 1% annually to GDP growth, with the project budget preliminarily estimated at UAH 3.3 billion (110 million USD).
3. The identification of territories impacted by military activities, along with land restoration efforts, is increasingly critical. Integrating data on areas contaminated with explosive remnants (exceeding 21% of Ukraine's territory) into the State Land Cadaster and ensuring effective data exchange with the Information Management System for Mine Action (IMSMA) is essential for implementing fiscal policies and exempting hazardous properties from taxation. Post-demining land reclamation, soil restoration, and the exploration of alternative uses for long-term contaminated lands constitute key aspects of recovery initiatives.
4. 4. The conflict has inflicted damages on Ukraine amounting to hundreds of billions of euros, yet the projected annual funding for reconstruction in the ensuing post-war period is estimated at 15-20 billion euros. Depending on the reconstruction modalities, topographic and geodetic support for construction projects is expected to represent 0.3 to 1.2% of the total estimated costs. The State Budget of Ukraine for 2023 allocates 23 billion UAH for reconstruction efforts, of which 120-200 million UAH will be dedicated to topographical and geodetic support.

## Conclusions

The study conclusively demonstrates that the Russian military aggression has precipitated profound and multifaceted impacts on Ukraine's topographic-geodetic and land surveying sectors. Key findings reveal an approximate 67.5% reduction in the land management sector pre-war revenue streams due to a significant decrease in the demand for engineering surveying services. This downturn is attributed to wartime uncertainties, leading to the suspension of construction projects and a comprehensive reallocation of budgetary resources towards defense efforts. Furthermore, the war has resulted in a 70% reduction in the volume of public procurements for topographical surveying services, with the monetary

value of contracts executed in this domain witnessing a 67% decline, from UAH 104.6 million to UAH 45.8 million.

The revitalization strategy for Ukraine's topographic-geodetic and land surveying industries post-war is predicated on reconstructing the sector infrastructure and enhancing the workforce capabilities, in light of the altered conditions of the post-war landscape. With an estimated revenue loss of around UAH 3 billion (approximately EUR 90 million) due to the conflict in 2022, the focus shifts towards evaluating war-induced damages, prioritizing reconstruction initiatives, and investing in advanced technologies. The State Budget of Ukraine for 2023 allocates 23 billion UAH for reconstruction efforts, of which 120-200 million UAH will be dedicated to topographical and geodetic support, underscoring the critical role of surveying engineers in documenting damages and facilitating recovery.

The recovery strategy emphasizes the importance of developing policies aimed at retaining current professionals and recruiting new talents, coupled with the collaboration with international organizations for the exchange of expertise. This approach is aimed not only at replenishing the industry's human resources but also at integrating Ukraine's topographic-geodetic and land surveying sectors into the European Union engineering services market. The findings highlight the urgent need for a cohesive and well-informed response to address the challenges faced by these sectors, ensuring their long-term viability and contribution to Ukraine's post-war reconstruction and development.

**Author contributions**

Conceptualization, A.M.; methodology, A.M. and L.H.; validation, L.H. and L.K; formal analysis, investigation, A.M., L.H., N.M. and L.K.; data curation, L.H., A.M. an A.P.; writing – original draft preparation, L.H.; writing – review and editing, A.M. and A.P.; visualization, N.M., L.K.; project administration, L.H.; funding acquisition, A.P. All authors have read and agreed to the published version of the manuscript.

**References**

[1] Todorovski D., Zevenbergen J., van der Molen P. "Conflict and post-conflict land administration–the case of Kosovo." Survey review 48.350, 2016, pp. 316-328.
[2] Todorovski D. "Characteristics of post-conflict Land Administration with focus on the status of land records in such environment." FIG Peer Review Journal (2011).
[3] van der Molen P., Lemmen C. "Land administration in post-conflict areas." Symposium on Land Administration in Post Conflict Areas. Geneva, Switzerland: UN-HABITAT and FIG Commission. Vol. 7. 2004.
[4] Flower B.C.R., et al. "Securing tenure for conflict-affected populations: A case study of land titling and fit-for-purpose land administration in post-conflict Sri Lanka." Land Use Policy 125, 2023, 106438.
[5] Törhönen M. P., Palmer D. "Land Administration in Post Conflict Cambodia." Proceedings of a Symposium held by FIG Commission. Vol. 7. 2004.
[6] Ratkevičs A., Celms A., Veliks A. Virsmas uzmērīšana pielietojot bezpilota lidaparātu ar lāzerskanēšanas iekārtu (Surface measurement using an unmanned aerial vehicle with a laser scanner). Latvijas Universitātes 75. zinātniskā conference, Rīga, Latvijas Universitāte 2017. 265-266 lpp. (In Latvian).
[7] Martyn A., Openko I., Ievsiukov T., Shevchenko O., Ripenko A. Accuracy of geodetic surveys in cadastral registration of real estate: value of land as determining factor. Engineering for Rural Development, 2019, pp. 1818-1825.
[8] Medynska N., Hunko L., Reznik N. Approaches to Land Zoning on the Basis of Sustainable Territory Development. In: Alareeni, B., Hamdan, A. (eds) Explore Business, Technology Opportunities and Challenges After the Covid-19 Pandemic. ICBT 2022. Lecture Notes in Networks and Systems, vol 495. Springer, Cham. 2023, DOI: 10.1007/978-3-031-08954-1_67.
[9] Portal of electronic services of the State Land Cadaster of Ukraine [online] [31.10.2023]. Available at: https://e.land.gov.ua/statistics/
[10] Applied business analytics tools from the electronic platform for public procurement, SE "Prozorro" [online] [31.10.2023]. Available at: https://bi.prozorro.org/hub/stream/aaec8d41-5201-43ab-809f-3063750dfafd

[11] "Legislation of Ukraine" database managed by the Verkhovna Rada of Ukraine [online] [31.10.2023]. Available at: https://zakon.rada.gov.ua/laws/main/

[12] CLGE 2008, "European requirements for cadastral surveyor activities", The European Cadastral Surveyor, Tech. Report, 2008. [online] [31.10.2023]. Available at: https://www.clge.eu/wp-content/uploads/2008/04/european_requirements_for_cadastral_surveyor_activity.pdf