

## Challenges and advances in the assessment of damaged agricultural land using remote sensing

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### ABSTRACT

**Background.** Wartime hostilities have resulted in large areas of Ukrainian land becoming temporarily inaccessible, damaged, or mined, thereby challenging the validity of conventional land valuation approaches, notably the Normative Monetary Valuation (NMV). The current NMV framework is ill-suited for current realities, as it does not incorporate factors such as physical destruction, cratering, and the extent of soil degradation resulting from military operations and the use of missile weaponry. Consequently, an investigation into the relevance and effectiveness of the NMV under martial law is crucial for taxation and for planning the country's reconstruction.

**The purpose** of the study is to identify challenges in the assessment of damaged land, to substantiate the methodology for its operational monitoring and classification based on remote sensing (RS) data, and to develop practical recommendations for improving the mechanisms of NM through the introduction of a correction coefficient. **The object** of the study is the system of Normative Monetary Valuation of land in Ukraine under martial law. **The subject** is the relevance, effectiveness and challenges of using NMV of land under martial law, as well as ways to improve it.

**Methods.** This study employs a comprehensive approach, including: a systematic and comparative analysis of the legal and regulatory framework, cartographic modeling, and spatial and statistical data analysis. The key methods were geographic information technologies (GIS) and analysis of satellite images (Planet Labs, Google Earth) for the identification, vectorization and spatial assessment of the affected areas.

**Results.** It was confirmed that remote sensing is the most effective tool for a large-scale and safe damage assessment, enabling to record craters. During the study, a classification of missiles was developed according to the degree of damage done to the ground. Four main levels of damage were established (Low, Medium, High, and Critical), which correlate with the crater's diameter and depth, as well as with the approximate percentage of soil productivity loss. The introduction of the “Land Suitability Coefficient” (LSC) as a mandatory corrective amendment to the current NMV formula was proposed and justified. It has been established that the LSC should incorporate both the area of damage and the coefficient of destruction intensity (D), obtained on the basis of the classification of remote sensing. Improving the NMV model by incorporating the LSC ensures increased objectivity of the assessment and its compliance with the actual ecological condition of the land, which is necessary for fair land taxation and compensation calculation.

**Conclusions.** The findings of the study demonstrate the critical need to reform land valuation relations in wartime through the integration of geospatial data. The proposed approach based on remote sensing and the implementation of the LSC is a practical solution that allows authorities and cadastral services to promptly account for losses and fairly regulate financial relations in the field management, thereby contributing to effective planning of the recovery of the agricultural sector.

**Keywords:** Normative Monetary Valuation, agricultural land, martial law, land suitability coefficient, geoinformation technologies, remote sensing, assessment of damaged lands, Degree of damage.

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## **Introduction**

The Russian full-scale invasion of Ukraine, which began on February 24, 2022, has caused widespread destruction, significant casualties, and a serious impact on the country's economy [1]. The destruction of infrastructure, reduced production, massive population displacement, and instability of the financial system have significantly affected all areas of economic activity, including land relations. As a result of the hostilities, a significant part of the land has been damaged or temporarily lost to use, which complicates the process of its assessment and management [2].

Under martial law, new challenges arise for local authorities, in particular regarding budget filling, land management and taxation. The Normative Monetary Valuation of land plays an important legal role in the formation of tax revenues. However, its effective application in modern conditions requires addressing several challenges. Changes in legislation, a decrease in economic activity and the destruction of the land fund call into question the relevance of the current valuation methodology, which requires a substantiated analysis and development of new approaches [3].

Research into the relevance and effectiveness of the use of NMV under martial law is extremely important regarding the formation of a substantiated state policy in the land management sector, fair taxation and planning for the reconstruction of the country.

**The relevance of the research** topic is important given the large-scale and unprecedented consequences of the military aggression of the Russian Federation, which has led to catastrophic damage to a significant portion of the agricultural land fund of Ukraine. Traditional methods of land assessment and Normative Monetary Valuation (NMV) have proven to be unadapted to new reality, since they: 1) do not take into account physical damage to the soil (shell damage, mine and explosive contamination, soil degradation from chemicals), which dramatically reduces its productivity and usability; 2) are unable to provide prompt, objective and large-scale monitoring of damage over large areas, which complicates fair taxation, compensation to owners and planning of recovery work.

In this context, remote sensing (RS), in combination with geographic information systems (GIS), becomes the only effective tool for: the rapid identification and vectorization of affected areas, the objective classification of damage levels, the integration of current data on the land condition into the state accounting system and the methodology of the NMV (for example, through the calculation of a new corrective suitability coefficient).

Thus, this research is vital for ensuring econo-

mic justice (fair taxation and compensation), the effective management of land resources and laying a scientific and methodological foundation for the post-war reconstruction of the country's agricultural sector.

The **purpose** of the study is to identify challenges in the valuation and classification of agricultural land damaged as a result of military aggression, to substantiate the methodology of its monitoring and assessment based on remote sensing (RS) data, and to develop recommendations for improving the NMV system to ensure its compliance with current realities, proposing a new "land suitability coefficient".

**Object of the study:** the processes of valuating, monitoring and assessing the condition of agricultural land that have been damaged (through destruction, pollution, mining) as a result of military aggression on the territory of Ukraine.

**Subject of the study:** methods and technologies of remote sensing (RS), their relevance and effectiveness for rapid detection, spatial assessment and classification of the damage levels of agricultural land.

To achieve this aim, the following objectives must be met:

- To analyze the current state and the legal and regulatory challenges of damaged/destroyed agricultural land assessment under martial law.
- To investigate the use of remote sensing methods to monitor changes in land condition.
- To identify the challenges that arise when applying NMV under martial law.
- To develop recommendations for improving the NMV system taking into account modern challenges.
- To investigate the impact of various weapon types on the land and assess the resulting levels of destruction.
- To propose an alternative coefficient for improving the NMV methodology.

### **Analysis of recent research and publications.**

When covering the issues of normative monetary valuation (NMV) under martial law, it is extremely important to integrate scientific data on the actual degradation of land resources. Analysis of the study [4], devoted to assessing the impact of the consequences of military actions on soils, serves as a necessary basis for understanding the relevance and error of NMV in combat zones. The authors emphasize the unique value of Ukrainian soils (over 60% are chernozems) and the scale of damage caused by military conflicts. The impact of aggression is multifactorial and causes long-term degradation of soil cover and reduced fertility, which directly affects the real value of land, which should be reflected by the NMV.

Critical to understanding the relevance of the

Normative Monetary Valuation (NMV) is the analysis of methodologies that use the NMV as a baseline indicator for calculating damage. The presented study [5] focuses on this issue, identifying and justifying areas for improving the methodology for assessing damage caused by armed aggression to the land resources and soils. The study [6] is devoted to the analysis and scientific challenges of the NMV methodology for land plots in Ukraine, particularly in the context of the Unified Methodology approved by the Resolution of the Cabinet of Ministers of Ukraine No. 1147 of November 3, 2021. This methodology aims to simplify existing methods and ensure the valuation of land of all categories and forms of ownership. This study highlights the need for scientific substantiation and improvement of approaches to NMV.

Determining the value of real estate is crucial for various tasks, including taxation, privatization, insurance, land registration and cadastral fees, land reorganization and urban transformation. As countries become more economically developed and the complexity of assessment grows, more accurate assessments become increasingly important.

The works [7-11] present the international experience of real estate valuation. The authors emphasize the crucial importance of accurate determination of precise value for various tasks and the need to use multi-criteria methods (for example, BWM) and GIS technologies to eliminate subjectivity and overcome the shortcomings of traditional valuation methods.

Studies [12-13] examine the valuation and assessment of land parcels, particularly within the agricultural sector. They also highlight the critical challenges of performing such assessments under wartime conditions, including land mining, occupation, physical damage to parcels, and the subsequent need for land conservation. Shepel I. justifies the need to improve land accounting practices through the creation of specialized sub-accounts for occupied territories and the development of new reporting forms [13]. The study [14] analyzes the challenges of rational management of disturbed lands using the case of Kryvyi Rih, focusing on degradation caused by anthropogenic factors (mining industry). In the research, a comprehensive approach to reclamation (biological and technical methods) and the need to integrate environmental, economic, and social aspects are justified.

The works [15,7] summarize the impact of military operations on soil degradation and the environment. The authors analyze the main factors affecting soil, water and Nature Reserve Fund (NRF), identifying mechanisms for nature protection. Identifies shortcomings of the current Methodology for assessing damage to the land resources [3]. State

that the existing legislative and methodological support does not reflect the content of the necessary recovery work [16]. The authors propose to use several existing standards for calculating damage, but argue for the urgent development of new regulatory and methodological documents and the implementation of legislative changes to realize comprehensive plans for territorial reconstruction. Emphasize the critical state of fertile soils (chernozems) as a result of the war and the need for legislative consolidation of legal methods for regulating reconstruction [17]. The authors argue for an integrated approach (including legislative, environmental, and economic aspects) and the involvement of international assistance for accelerated land reconstruction. Raise the issue of large-scale mining in Ukraine, the most heavily mined territory in the world [18]. The need to develop modern approaches to assessing the priority of humanitarian demining is emphasized in order to return the most promising areas to economic use as a priority [19] show how terrorism and conflicts affect land use, increasing the area of fallow land, increasing the distance to cultivated areas, and reducing the expected value of land. Examine the impact of the land market on the regional development in Ukraine [20]. They emphasize that unlocking the potential of the land market is a significant factor in attracting investment, improving infrastructure, and raising living standards, which is especially important in the context of recovery. The work [21] illustrates how land reform can be used to modernize the agricultural sector and create the prerequisites for autonomous industrial development, breaking the ties of oligarchies with the land.

Traditional methods of property valuation allow for direct comparison of legal, physical and market parameters, but each property is different. Therefore, an alternative method is needed to take these differences into account. While traditional valuation methods— including the comparative, income, and cost approaches— may be sufficient for single properties, they are largely inadequate for valuing multiple properties, a process commonly known as mass valuation

Currently, the Normative Monetary Valuation methodology is irrelevant due to the failure to take into account destruction, cratering and levels of destruction. The modern approach to land valuation does not show the real impact of military operations, only the damage caused by the use of missile weapons and the associated destruction of infrastructure. As a result, the existing methodology does not allow for an adequate assessment of the economic damage caused to the territories that have been destroyed.

Therefore, this methodology requires significant improvement and a wider range of factors, including the type of weapon, the power of the explo-

sion, crater parameters and the severity of the resulting damage.

### Methods

The main source of information in this study was the State Land Cadastre (SLC). An important component of the information infrastructure is geographic information systems (GIS), which allow integrating spatial and attribute data. In particular, digital maps, remote sensing data, satellite images and statistical indicators were used for the assessment. The public cadastral map of Ukraine [22] which provides open-access visualization of land plot boundaries, was also actively used. The integration of these tools allowed for accurate localization of plots and the consideration of specific features such as relief, soil type, and climatic conditions. This approach significantly enhances the quality and objectivity of the Normative Monetary Valuation.

The existing methodology for analyzing land value does not take into account specific case studies of military operations, in particular, destruction caused by the use of missile weapons. The new ap-

proach will allow taking into account both direct damage to the surface layers of the soil and indirect consequences caused by the destruction of infrastructure, and changes in the operational characteristics of the land. This methodology analyzes the type of weapon used, its impact and the approximate parameters of the craters that appeared as a result of explosions. Particular attention is paid to the classification of missiles by the damage levels, which allows for a more accurate use of the scale of destruction at the sites of their use. Calculations are performed considering the specific technical characteristics of the missiles and the land use conditions of the damaged territory. Taking into account situational consequences allows for an accurate adjustment of the land price assessment in accordance with the level of destruction. In addition, the affected area of land plots will be calculated using remote sensing data. This approach will help determine the objective price of the land.

In the standard methodology for conducting the Normative Monetary Valuation (NMV) [23], the value is calculated using the following formula:

$$NMV = A \times N_{cri} \times K_{m1} \times K_{m2} \times K_{m3} \times K_{m4} \times K_{lu} \times K_{su} \times K_{idx}, \quad (1)$$

where:

NMV – Normative Monetary Valuation of the land parcel.

A – Area of the land plot, in square meters.

$N_{cri}$  – Normative Capitalized Rent Income per unit of area.

$K_{m1}$  – Coefficient for location within the influence zone of major cities.

$K_{m2}$  – Coefficient for the resort and recreational value of the settlement.

$K_{m3}$  – Coefficient for location within radiation contamination zones.

$K_{m4}$  – Coefficient for location-specific zonal factors.

$K_{lu}$  – Coefficient for the designated land use of the plot (according to the State Land Cadastre).

$K_{su}$  – Coefficient for specific use features within the primary land category

$K_{idx}$  – Cumulative Indexation Coefficient, representing the product of annual indexation coefficients from the approval date of the  $N_{cri}$  to the valuation date.

Another coefficient – “Land suitability coefficient” (LSC) – was developed - It will be calculated according to the formula:

$$LSC = 1 - (S_{urazh} / S_{total}) \times D, \quad (2)$$

where

$S_{total}$  – total area of the land plot,

$S_{damaged}$  – area of the affected part of the plot;

$D$  – damage coefficient, which reflects the intensity of destruction.

This indicator reflects the retained suitability of the territory after damage. If the damaged area of the plot is zero, i.e.  $S_{(damage)}=0$ , LSC takes the value of 1, it indicates the full suitability of the site. Conversely, in cases of severe destruction, when  $S_{(damage)}$  and the coefficient  $D$  are high, LSC can significantly decrease, reflecting a significant deterioration in the characteristics of the land. The proposed formula is indicative and can be adapted to specific damage conditions.

The proposed land suitability coefficient LSC, which was calculated by formula 1, can be integrated into the formula for the normative and monetary valuation as an additional multiplier that reflects the real level of damage to the territory. Thus, standard regulatory and monetary parameters are combined with the damage assessment. This approach allows a more accurate reflection of the economic value of the land, particularly after a territory has sustained damage. If  $LSC=1$ , this means that no destruction was recorded on the land plot (i.e.,  $D$  is 0). On the other hand, if LSC is significantly less than 1, this indicates serious damage, which reduces the plot's assessed value. This approach provides a more comprehensive and objective assessment, taking into account the specifics of destructive actions, in particular the use of missile weaponry. The integration of this coefficient into the general formula will contribute to the ongoing calculation of compensation payments and the restoration of economic stability in the affected regions.

The proposed land suitability coefficient (LSC) allows us to take into account not only the area of the affected territory, but also the intensity of destruction, which is an important factor in determining the real value of the land.

The calculation of the land suitability coefficient according to formula 1 allows us to assess the level of land degradation depending on the area of damage and the type of weaponry used.

For example, in the case of precision strikes, when S (damage) is insignificant and the damage coefficient D has a low value, the overall suitability of the land remains high. However, in the case of large-scale destruction that covers a significant part of the territory (high value of S (damage)) and has a severe impact (high value of D), the LSC is significantly reduced, reflecting the loss of economic and business value of the land.

The use of LSC in the formula of regulatory and monetary assessment provides not only a more accurate calculation of the value of the land plot, but also creates a basis for developing mechanisms for compensating landowners and tenants for damages. Including this factor in the NMV allows for the establishment of a fair value of land for taxation, lease or sale, taking into account its actual condition after the damage. This is particularly relevant for agricul-

tural land, since even partial contamination or mining of land can significantly limit its use and affect productivity.

### Results

Over the course of almost 900 days, more than 4,500 missiles have been fired across the territory of Ukraine, excluding S-300/S-400 missiles [24]. In order to fully understand the damage caused by missile strikes to the ground, a possible classification of missiles was developed. Classification of missiles by the level of damage is an effective tool for assessing the identified impact of missile attacks on objects and the population. Using the indicative levels presented in the table, experts can calculate the scale of destruction by considering factors such as the power of the explosion, the parameters of the missile carriers, as well as local terrain characteristics. Such calculations not only allow documenting the consequences of the use of missile weapons, but also contribute to the formation of an objective evidence base for further analysis of the situation. It should be noted that the presented degrees of formation are approximate, they consider the variety of conditions of use and the design features of the missile. Table 1 below reflects the main categories of damage levels, which provide the basis for further research and subsequent legal analysis of the position.

Table 1

Levels of land damage

Level of damage	Diameter of the crater, m	Depth, m	Approximate % loss of soil productivity
Low	2-5	0,5-1,5	10-30% (local damage to the topsoil)
Medium	5-10	1,5-3	30-60% (deep destruction of the humus layer, partial salinization of the soil)
High	10-15	3-5	60-90% (significant mixing with mineral rocks, formation of unsuitable craters)
Critical	15+	5+	90-100% (complete destruction of the soil, possible release of toxic elements)

Based on the data from Table 1, an analysis was made of the main types of missiles that the Russian Federation uses on the territory of Ukraine, and the level of damage for each type was determined. The results are presented in Table 2.

The study of the types of damage relative to the used weapons showed significant differences in the scale and nature of the destruction. Analysis of missile strikes reveals that their immense power and the rapid propagation of their impact cause the most

Table 2

Example of damage rating assignment for some missiles

Rocket type	Degree of damage	Soil damage assessment (%)	Average soil damage (%)
Kh-22 Burya	High - Critical	70-100%	85
Kh-32	High	60-90%	75
Iskander-M (9M723)	High	60-90%	75
Kalibr 3M-14	Medium – High	40-70%	55
Kh-59	High	60-90%	75
Kh-69	High	60-90%	75

devastating consequences. Classification of missiles by the damage levels allows for the more accurate definition of the category of damage and enables us to calculate the approximate parameters of explosion craters. The use of modern calculation methods based on the latest scientific and technological achievements is key to an objective assessment. The obtained data provide an opportunity to form an evidentiary base for further investigation of war crimes and bring the perpetrators to justice. An independent examination that considers the specifics of different weapon types ensures the objectivity of judicial proceedings. The results of the study open up prospects for improving the methods of analyzing the consequences of rocket attacks. A comprehensive approach to damage assessment involves the integration of technical calculations, expert opinions and practical experience. Such research is important for rapid response in emergency situations.

The study was based on the analysis of high-spatial resolution satellite images and the use of open geospatial resources to identify, visualize, and spatially assess changes in areas affected by armed conflict. This approach allowed us to obtain an objective picture of the damage without physical access to the study area.

At the first stage, satellite images were selected from the Planet Labs platform [25], which, within the framework of the Education and Research Program, provided access to archival and daily images

with a spatial resolution of up to 3 meters. This enabled the authors to detect even minor damage that could have been overlooked when using medium-resolution images. However, due to the current military situation, the process of obtaining up-to-date satellite data was accompanied by several complications. In order to confirm the detected changes, an additional source was used - Google Earth [26], which contains a chronology of high-resolution panoramic images. The comparative analysis included a comparison of satellite images before and after the alleged damage.

Particular attention was paid to careful visual analysis, since some of the changes could be barely noticeable or mixed with natural or anthropogenic objects (e.g., plowing, harvesting, temporary structures). Therefore, only those areas where signs of damage were clearly recorded, as well as those where satellite images before and after the event were available for reliable comparison, were selected for further processing.

It also should be noted that the image processing required careful manual analysis of each case, as automatic geolocation of impacts is absent or inaccurate. As a result, identifying even individual instances of damage required sequential examination of time-lapse images, coordination with other sources, and synchronization of data for further vectorization within the GIS platform. Figure 1 shows the land plots that were damaged.

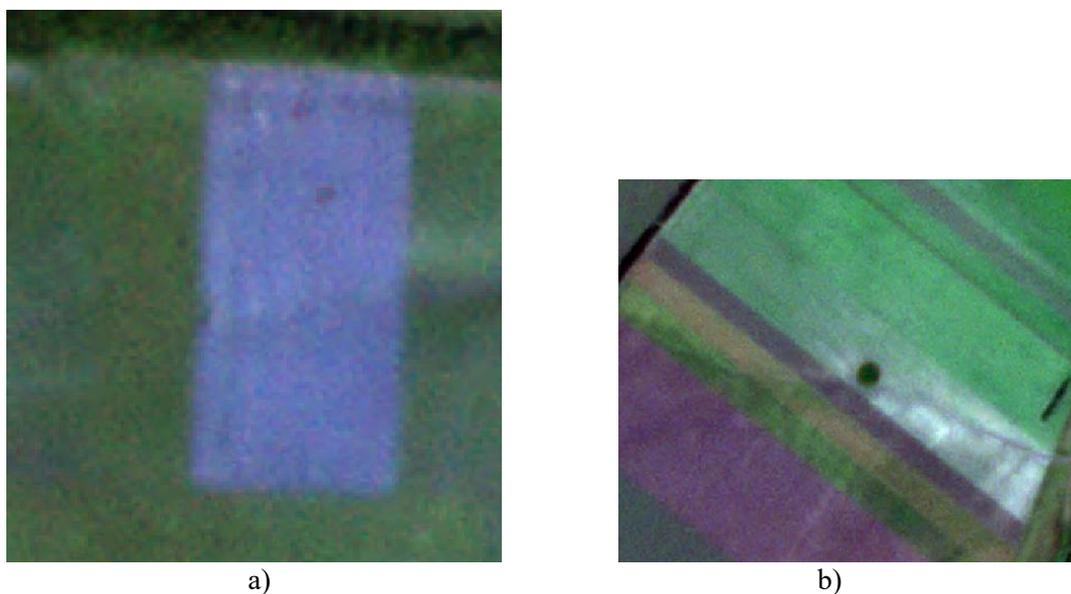


Fig. 1. Visualization of damage to land plots:  
a) Poltava region (08/28/2023); b) Dnipropetrovsk region (06/22/2023)

In order to clarify the boundaries of the affected land plots and ensure the spatial accuracy of the research results, open geodata from the Public Cadastral Map of Ukraine resource was used. The involvement of this resource made it possible to link the damage detected on satellite images with offi-

cially registered land plots, which made it possible to conduct further analysis at the legal and functional level.

This process also made it possible to assess whether the damage affected officially registered land tenures, and, accordingly, to determine the potential

legal, economic or environmental consequences.

However, several problems and limitations arose during the research. First of all, the Public Cadastral Map does not allow direct export of vector layers, so it was decided to digitize the boundaries of the affected areas manually. This process required considerable time and concentration, as the boundaries had to be reproduced based on coordinates and visual reference to satellite images. Particularly challenging were the cases where the boundaries of

cadastral areas had an unclear or fragmentary display on the map, which forced additional verification with adjacent areas or reference to archival sources.

Despite these difficulties, manual digitization provided high accuracy of spatial boundaries (Fig. 2), which is extremely important for subsequent stages of work - in particular, for building buffer zones, calculating affected areas, and assessing damage.

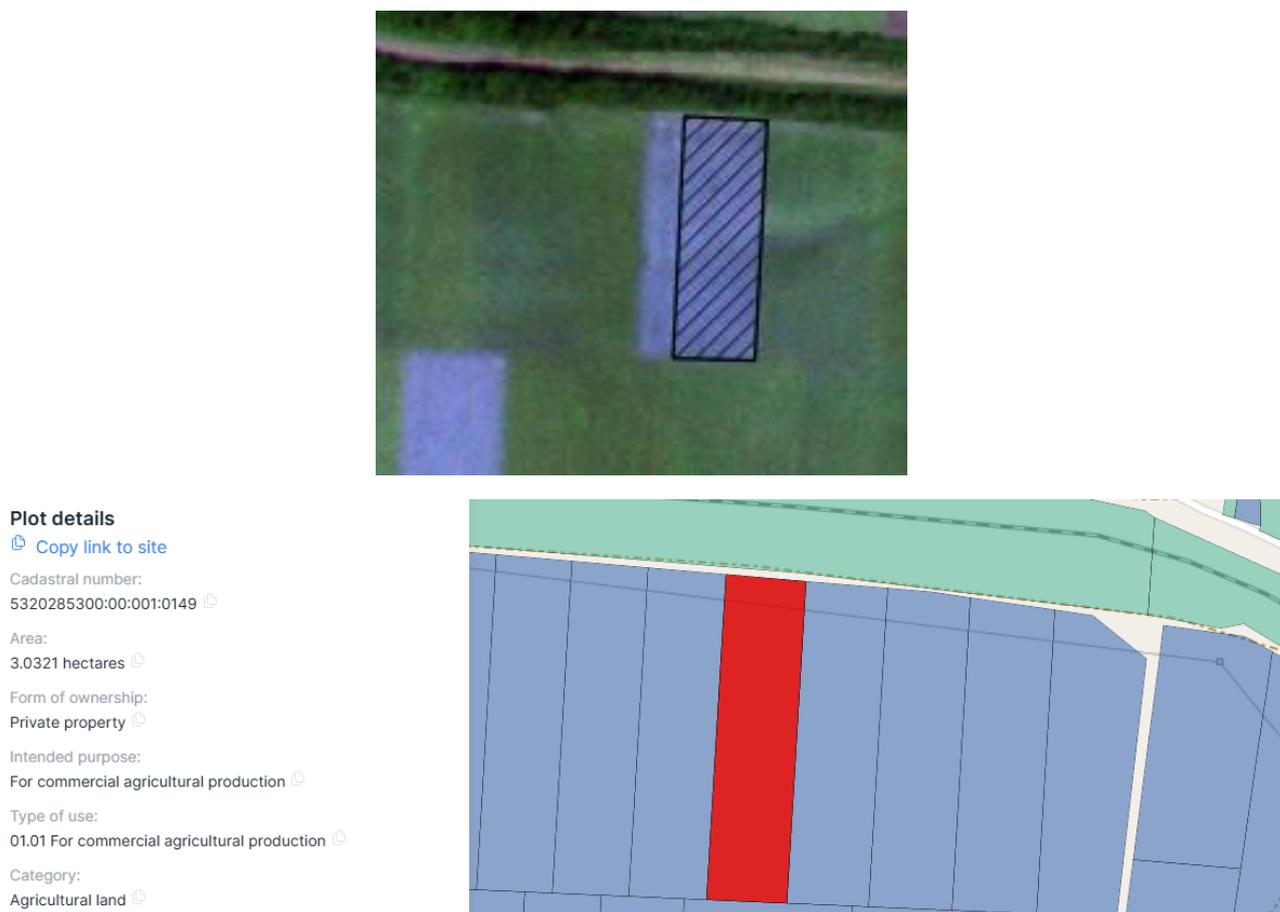


Fig. 2. Vectorized boundaries of land plots in Poltava region (08/28/2023)

The next stage of the study was the buffering of the impact areas (Fig. 3), which involves the creation of a spatial impact zone of a certain fixed width around each object. In the context of the analysis of the consequences of hostilities, the buffer zone is used to take into account not only the directly affected territories, but also adjacent areas that could potentially be affected by secondary impacts - for example, due to a shock wave, debris, fire or chemical contamination. In this study, an average buffer zone radius of 250 meters was used. This indicator is a compromise between the safety requirements proposed by international mine action standards and practical data from open sources on the impact zones of missile weaponry [27]. On average, this distance allows for covering territories that, according to open satellite materials, often have visual

signs of secondary damage, even if the immediate epicenter of the explosion is located outside the cadastral area.

This approach allows us to take into account the incompleteness of satellite data, as well as those areas that may have been affected, but do not have obvious visual changes in the images due to the resolution limitations or the atmospheric conditions during image acquisition. This corresponds to the approaches used in environmental expertise and engineering assessment of territories, where the consequences of explosions are assessed not only at the site of impact but also within their radius of spatial influence [26].

For automated calculation of the area of all buffer zones, the Raster Calculator in the QGIS 3.40.6 environment was used. Buffer polygons were

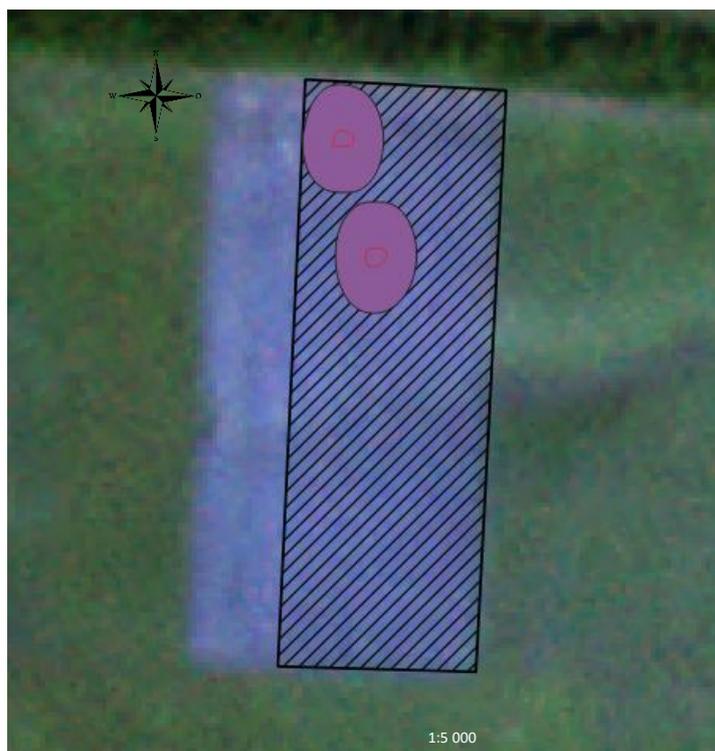


Fig. 3. Buffering of affected areas, using the example of Poltava region

previously converted to raster format, after which the total area of impact over the study area was determined using classification and taking into account the resolution of the layer. In cases where several buffers

overlapped the boundaries of one cadastral plot, the calculation was performed manually. This allowed us to avoid duplication of areas, especially in areas with a dense concentration of affected objects.

Table 3

Calculated areas of damage

Plot	Date of damage	Region	Settlement	Area affected, ha
1	04.06.2022	Odesa region	v. Protopopivka	0,032514
2	26.07.2022	Odesa region	v. Bilenke	0,076960
3	31.07.2022	Odesa region	v. Bilenke	0,002988
4	22.06.2023	Dnipropetrovsk region	v. Mykhailo-Zavodske	0,147724
5	27.06.2023	Poltava region	v. Sosnivka	0,503918
6	28.08.2023	Poltava region	v. Hoholove	0,021366
7	28.08.2023	Dnipropetrovsk region	v. Chervona Poliana	0,014286
8	13.06.2024	Mykolaiv region	v. Mishkovo-Pohorilove	0,071029
9	11.07.2024	Odesa region	v. Moldovanka	0,071162
10	19.07.2024	Sumy region	v. Sadove	0,024914

These data allow for an accurate assessment of the potential consequences of damage for each land tenure, taking into account the spread of the risk zone beyond the initial explosion.

Within this stage of the study, a full-scale assessment of ten land plots located within the territories affected by active hostilities was conducted. The main goal of the analysis was not only to perform a

basic calculation of the Normative Monetary Valuation (NMV), but also to take into account the impact of the actual degree of destruction of each plot on its economic value.

The calculation of NMV was carried out in accordance with the current Methodology approved by the Resolution of the Cabinet of Ministers of Ukraine No. 105 of 03.03.2021. The basic NMV

values for the studied plots ranged from ₴42,500 to ₴48,900 per hectare, which is typical for a region with an average level of fertility and moderate infrastructure accessibility.

In order to adapt the assessment results to the real conditions of martial law, a land suitability coefficient (LSC) was introduced - a numerical indicator reflecting the usability of a land plot after being damaged by hostilities (see Formula 1).

The calculation of the adjusted value of the NMV

was carried out according to formula 3:

$$NMV_{adj.} = NMV \times LSC, \quad (3)$$

where

*NMV* is the standard Normative Monetary Valuation, calculated according to the current Methodology; approved by the Resolution of the Cabinet of Ministers No. 105 of 03.03.2021;

*LSC* is the Land Suitability Coefficient of the land plot.

Table 4

Calculation of the suitability coefficient of a land plot

Region	Settlement	Total area (ha)	Area affected (ha)	Strike ratio	Kpz
Odesa region	v. Protopopivka	5,2	0,032514	0,75	0,995310
Odesa region	v. Bilenke	5,9	0,076960	0,75	0,990217
Odesa region	v. Bilenke	3,6	0,002988	0,85	0,999295
Dnipropetrovsk region	v. Mykhailo-Zavodske	7,4	0,147724	0,85	0,983032
Poltava region	v. Sosnivka	30	0,503918	0,85	0,985722
Poltava region	v. Hoholove	3	0,021366	0,55	0,996083
Dnipropetrovsk region	v. Chervona Poliana	5,2	0,014286	0,55	0,998489
Mykolaiv region	v. Mishkovo-Pohorilove	15,7	0,071029	0,75	0,996607
Odesa region	v. Moldovanka	11,5	0,071162	0,75	0,995359
Sumy region	v. Sadove	4,2	0,024914	0,75	0,995551

In the absence of official technical documentation that would certify the current state of the studied areas (since the assessment was not ordered by an authorized state institution), the source of information was open Internet resources. In particular, for spatial analytics, the Public Cadastral Map of Ukraine, Google Earth, interactive satellite images, as well as photo documentation of territories available through open data sources were used.

Based on the analysis of these materials, a scale of destruction was formed, which included the damage coefficient of the land plot ranging from 0.50 to 0.85, corresponding to an estimated loss of 15% to 50% of the land's productive value. The application of the Land Suitability Coefficient to each plot reflects the individual level of its suitability after the military impact.

It should be noted that due to the lack of technical documentation based on field surveys and land condition survey reports, the authors cannot guarantee the absolute reliability of the results obtained. All calculations were made solely on the basis of publicly available information, which does not guarantee accuracy in accordance with state standards for land valuation. At the same time, in the opinion of the authors, the used sources are sufficiently substantiated for conditional modeling of the

situation and formulation of objective conclusions within the framework of this scientific research.

The final results of the analysis of ten plots showed that the average decrease in NMV as a result of the application of the LSC was about 34%, which indicates a significant loss of economic suitability and investment attractiveness of agricultural land in the affected areas.

Based on the comparative analysis (Table 5), it can be concluded that the average level of losses in the economic value of agricultural land in the combat zone is approximately 34%. This indicates a significant degradation of the economic potential of the territories, which must be taken into account when forming tax policy, providing compensation, and planning recovery measures.

Thus, the proposed approach to taking into account the destruction coefficient is an effective tool for modifying the current methodology of normative monetary valuation, ensuring adaptation to martial law conditions and supporting a fair approach to the reconstruction of the agricultural sector.

### Conclusions

The existing Normative Monetary Valuation (NMV) methodology for land has proven to be ill-adapted to the realities of martial law, as it does not take into account the destruction, cratering, and var-

Comparison of land tax reductions after adjusting the NMV methodology

Region	Settlement	NGO, UAH	Tax, UAH	NGOSkor, UAH	Tax, UAH	Difference, UAH
Odesa region	v. Protopopivk	848 440	101 813	844 461	101 335	477
Odesa region	v. Bilenke	505 731	60 688	500 783	60 094	594
Odesa region	v. Bilenke	308 582	37 030	308 364	37 004	26
Dnipropetrovsk region	v. Mykhailo-Zavodske	450 789	54 095	443 140	53 177	918
Poltava region	v. Sosnivka	2 425 045	291 005	2 390 421	286 850	4 155
Poltava region	v. Hoholeve	202 087	24 250	201 295	24 155	95
Dnipropetrovsk region	v. Chervona Poliana	303 500	36 420	303 041	36 365	55
Mykolaiv region	v. Mishkovo-Pohorilove	885 849	106 302	882 843	105 941	361
Odesa region	v. Moldovanka	985 747	118 290	981 172	117 741	549
Sumy region	v. Sadovo	235 930	28 312	234 880	281 86	126

ying levels of soil degradation caused by hostilities and missile strikes. This leads to an inadequate assessment of economic damage and complicates fair taxation and compensation for damages.

Remote sensing of the Earth (RS), in particular the use of high-resolution satellite imagery (Planet Labs, Google Earth), is a key and most effective tool for identifying, visualizing, and spatially assessing affected areas. This approach allows for an objective picture of damage without physical access to dangerous areas.

The study developed a classification of missiles by the level of damage they cause to the ground. As a result, four main damage levels have been established (Low, Medium, High, Critical), which correlate with the diameter and depth of the crater, as well as with the approximate percentage of soil productivity loss (for example, for the Kh-22 Buria missile, the average soil damage is estimated at 85%).

Furthermore, a Land Suitability Coefficient (LSC) was proposed. The calculation of the LSC takes into account the area of the affected part of the site (S damage) and the damage coefficient (D), which reflects the intensity of destruction (depending on the type of weapon). The integration of the LSC into the NMV formula provides a more accurate calculation of the cost of the site, taking into account both the area of damage and the intensity of destruction.

The proposed model allows to increase the accuracy of the assessment, to ensure fair tax assessment, and facilitates a reasonable determination of losses for agricultural lands. The results of the study are important for improving the efficiency of land management and establishing a scientific and methodological basis for the post-war reconstruction of the territories.

#### Bibliography

1. Stakhiv, I., Zatserkovnyi, V., De Donatis, M., Pastushenko, T., Hordiichuk, S., & Malik, T. (2025). *Spatial analysis of the flooded land area of the Kherson Region Nature Reserve using remote sensing data. Visnyk Taras Shevchenko National University of Kyiv. Geology*, (2), 1–14. DOI: <https://doi.org/10.17721/1728-2713.109.14>
2. Войтюк, Д., & Єрмолаєва, Т. (2023). *Наслідки впливу військових дій на стан навколишнього природного середовища. Grail of Science*, 28, 122–129. DOI <https://doi.org/10.36074/grail-of-science.09.06.2023.19>
3. Trofimenko P., Minzhener A., Zatserkovnyi V., Stakhiv I., Kobylinska S. (2024). *Cartographic and analytical assessment of land price formation depending on the physical and geographical conditions of the territory under military aggression in Ukraine. Visnyk of V. N. Karazin Kharkiv National University, series "Geology. Geography. Ecology"*, (61), 259–271. DOI: <https://doi.org/10.26565/2410-7360-2024-61-21>
4. Сакун А. О., Кутковий Д. О. (2025). *Оцінка впливу наслідків військових дій на ґрунти. Екологічні науки. 1* (58), 350–353. DOI <https://doi.org/10.32846/2306-9716/2025.eco.1-58.56>
5. Кучер, А. (2022). *Методика оцінювання збитків, завданих збройною агресією земельному фонду та ґрунтам: проблеми та напрями вдосконалення. Journal of Innovations and Sustainability*, 6(2), 1–9 DOI: [10.51599/is.2022.06.02.10](https://doi.org/10.51599/is.2022.06.02.10)
6. Вольська, А. (2022). *Наукові проблеми методики Нормативної грошової оцінки земельних ділянок в Україні. Naukovi Perspektivi*. DOI: [https://doi.org/10.52058/2708-7530-2022-3\(21\)-131-144](https://doi.org/10.52058/2708-7530-2022-3(21)-131-144)
7. Ayalke, Z., and Sisman, A. (2022). *Nominal Land Valuation with Best-Worst Method Using Geographic Information System: A Case of Atakum, Samsun. ISPRS International Journal of Geo-Information*, 11(4), 213. DOI: <https://doi.org/10.3390/ijgi11040213>

8. Yalpir, Ş., & Ünel, F. B. (2022). Multivariate statistical analysis application to determine factors affecting the parcel value to be used mass real estate valuation approaches. *International Journal of Engineering and Geosciences*, 7(1), 32-42. DOI: <https://doi.org/10.26833/ijeg.862563>
9. Bencure, J. C., Tripathi, N. K., Miyazaki, H., Ninsawat, S., & Kim, S. M. (2022). Factors affecting decision-making in land valuation process using AHP: a case in the Philippines. *International Journal of Housing Markets and Analysis*, 15(1), 188-202. DOI: <https://doi.org/10.1108/IJHMA-11-2020-0136>
10. Mete, M. O., & Yomralioglu, T. (2021). Implementation of serverless cloud GIS platform for land valuation. *International Journal of Digital Earth*, 14(7), 836-850. DOI: <https://doi.org/10.1080/17538947.2021.1889056>
11. Son, N. P., Van Manh, L., Thuy, N. T., Vu, T. N., Hanh, N. T., & Linh, L. P. (2020). Factors that affect land values and the development of land value maps for strengthening policy making in Vietnam: the case study of non-agricultural land in Quang Ninh province, Vietnam. *EQA-International Journal of Environmental Quality*, 36, 23-35. DOI: <https://doi.org/10.6092/issn.2281-4485/9771/>
12. Мустеца І. (2025). Оцінка та облік земельних ділянок в умовах воєнного часу. Фінансово-кредитні системи: перспективи розвитку. 2(17). 132-142. DOI: <https://doi.org/10.26565/2786-4995-2025-2-11>
13. Шепель, І. (2025). Удосконалення обліку земельних ресурсів у сільському господарстві: проблеми, виклики та шляхи вирішення. *Науковий вісник Ужгородського національного університету Серія: Міжнародні економічні відносини та світове господарство*, 179-186 DOI: <https://doi.org/10.32782/2413-9971/2025-54-28>
14. Перегудов, В. В., Березан, С. Ю., & Паламар, А. Ю. (2025). Аналіз досліджень і шляхів раціонального використання порушених земель на прикладі міста Кривого Рогу. *Науковий вісник будівництва*, (112), 233-240. DOI: <https://doi.org/10.33042/2311-7257.2025.112.1.28>
15. Kucher, A. (2022). Методика оцінювання збитків, завданих збройною агресією земельному фонду та ґрунтам: проблеми та напрями вдосконалення. *Journal of Innovations and Sustainability*, 6(2), 1-23.
16. Третьяк, А. М., Третьяк, В. М., Капінос, Н. О., Гетьманчик, І. П., & Третьяк, Р. (2022). Землепорядкування та оцінка нанесеної шкоди землекористуванню на територіях, що зазнали військових дій в Україні. DOI: <https://doi.org/10.32702/2306-6792.2022.11-12.3>
17. Покальчук, М. Ю., Марачук, А. В., & Шулєпова, О. О. (2024). Правове забезпечення заходів повоєнного відновлення земельних ресурсів України. Аналітичне-порівняльне правознавство ДВНЗ «УжНУ» – Ужгород, №6, 455-461. <https://dspace.uzhnu.edu.ua/jspui/handle/lib/71147>
18. Беспалько, Р., Гуцул, Т., Казімір, І., & Мирончук, К. (2023). Сучасні підходи до оцінювання черговості гуманітарного розмінування територій. *Технічні науки та технології*, 1 (31), 146–157. DOI: [https://doi.org/10.25140/2411-5363-2023-1\(31\)-146-157](https://doi.org/10.25140/2411-5363-2023-1(31)-146-157)
19. Adelaja, A., & George, J. (2019). Terrorism and land use in agriculture: The case of Boko Haram in Nigeria. *Land Use Policy*, 88, 104116. DOI: <https://doi.org/10.1016/j.landusepol.2019.104116>
20. Дугієнко, Н., & Ланг, В. (2023). Вплив ринку землі на регіональний розвиток України. *Економіка та суспільство*, (56). DOI: <https://doi.org/10.32782/2524-0072/2023-56-72>
21. Saleth, R. M. (1991). Land reform under military: Agrarian reform in Peru, 1969-78. *Economic and Political Weekly*, PE85-PE92. <https://www.jstor.org/stable/41498500>
22. Публічна кадастрова карта України. Публічна кадастрова карта України. Режим доступу: <https://kadaстрова-karta.com/> (дата звернення: 07.03.2025).
23. Постанова Кабінету Міністрів України “Про затвердження “Методики нормативної грошової оцінки земельних ділянок” №1147. (2021). Київ. Режим доступу: <https://zakon.rada.gov.ua/laws/show/1147-2021-%D0%BF#Text> (дата звернення: 05.05.2025).
24. Marsh, N. (2023). Responding to needs: military aid to Ukraine during the first year after the 2022 invasion. *Defense & Security Analysis*, 39(3), 329–352. DOI: <https://doi.org/10.1080/14751798.2023.2235121>
25. Planet Explorer. Режим доступу: <https://www.planet.com/explorer/> (дата звернення: 05.03.2025).
26. Google Earth. Режим доступу: <https://earth.google.com/web/> (дата звернення: 01.05.2025).
27. IMAS. (2020) *International Mine Action Standards*. КММС – Übersicht. Режим доступу: <https://www.mineactionstandards.org/standards/> (дата звернення: 12.05.2025).

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### References

1. Stakhiv, I., Zatserkovnyi, V., De Donatis, M., Pastushenko, T., Hordiichuk, S., & Malik, T. (2025). Spatial analysis of the flooded land area of the Kherson Region Nature Reserve using remote sensing data. *Visnyk Taras Shevchenko National University of Kyiv. Geology*, (2), 1–14. DOI: <https://doi.org/10.17721/1728-2713.109.14>
2. Voytyuk, D., & Yermolaeva, T. (2023). Consequences of the impact of military actions on the state of the natural environment. *Grail of Science*, 28, 122-129. DOI: <https://doi.org/10.36074/grail-of-science.09.06.2023.19> [in Ukrainian]
3. Trofimenko P., Minzhener A., Zatserkovnyi V., Stakhiv I., Kobylinska S. (2024). Cartographic and analytical assessment of land price formation depending on the physical and geographical conditions of the territory under military

- aggression in Ukraine. *Visnyk of V. N. Karazin Kharkiv National University, series "Geology. Geography. Ecology"*, (61), 259-271. DOI: <https://doi.org/10.26565/2410-7360-2024-61-21>
4. Sakun A. O., Kutkovy D. O. (2025). Assessment of the impact of military actions on soils. *Ecological Sciences. 1* (58), 350-353. DOI: <https://doi.org/10.32846/2306-9716/2025.eco.1-58.56>. [in Ukrainian]
  5. Kucher, A. (2022). Methodology for assessing damage caused by armed aggression to land and soil: problems and areas for improvement. *Journal of Innovations and Sustainability*, 6(2), 1-9 DOI: <https://doi.org/10.51599/is.2022.06.02.10> [in Ukrainian]
  6. Volska, A. (2022). Scientific problems of the methodology of Normative monetary valuation of land plots in Ukraine. *Naukovi Perspektivi*. DOI: [https://doi.org/10.52058/2708-7530-2022-3\(21\)-131-144](https://doi.org/10.52058/2708-7530-2022-3(21)-131-144). [in Ukrainian]
  7. Ayalke, Z., and Sisman, A. (2022). Nominal Land Valuation with Best-Worst Method Using Geographic Information System: A Case of Atakum, Samsun. *ISPRS International Journal of Geo-Information*, 11(4), 213. DOI: <https://doi.org/10.3390/ijgi11040213>
  8. Yalpir, Ş., & Ünel, F. B. (2022). Multivariate statistical analysis application to determine factors affecting the parcel value to be used mass real estate valuation approaches. *International Journal of Engineering and Geosciences*, 7(1), 32-42. DOI: <https://doi.org/10.26833/ijeg.862563>
  9. Bencure, J. C., Tripathi, N. K., Miyazaki, H., Ninsawat, S., & Kim, S. M. (2022). Factors affecting decision-making in land valuation process using AHP: a case in the Philippines. *International Journal of Housing Markets and Analysis*, 15(1), 188-202. DOI: <https://doi.org/10.1108/IJHMA-11-2020-0136>
  10. Mete, M. O., & Yomralioglu, T. (2021). Implementation of serverless cloud GIS platform for land valuation. *International Journal of Digital Earth*, 14(7), 836-850. DOI: <https://doi.org/10.1080/17538947.2021.1889056>
  11. Son, N. P., Van Manh, L., Thuy, N. T., Vu, T. N., Hanh, N. T., & Linh, L. P. (2020). Factors that affect land values and the development of land value maps for strengthening policy making in Vietnam: the case study of non-agricultural land in Quang Ninh province, Vietnam. *EQA-International Journal of Environmental Quality*, 36, 23-35. DOI: <https://doi.org/10.6092/issn.2281-4485/9771/>
  12. Musteca, I. (2025). Valuation and accounting of land plots in wartime conditions. *Financial and credit systems: development prospects*. 2(17). 132-142. DOI: <https://doi.org/10.26565/2786-4995-2025-2-11> [in Ukrainian]
  13. Shepel, I. (2025). Improving land resource accounting in agriculture: problems, challenges and solutions. *Scientific Bulletin of Uzhhorod National University Series: International Economic Relations and the World Economy*, 179-186 DOI: <https://doi.org/10.32782/2413-9971/2025-54-28> [in Ukrainian]
  14. Peregodov, V. V., Berezan, E. Yu., & Palamar, A. Yu. (2025). Analysis of research and ways of rational use of disturbed lands on the example of the city of Kryvyi Rih. *Scientific Bulletin of Construction*, (112), 233-240. DOI: <https://doi.org/10.33042/2311-7257.2025.112.1.28> [in Ukrainian]
  15. Kucher, A. (2022). Methodology for assessing damages and losses caused by the armed aggression to the land fund and soils: problems and directions of improvement. *Journal of Innovations and Sustainability*, 6(2), 1-23. [in Ukrainian]
  16. Tretiak, A., Tretiak, V., Kapinos, N., Hetmanchyk, I., Tretiak, R. (2022). Land planning and assessment of damage to land use in territories affected by military action in Ukraine. DOI: <https://doi.org/10.32702/2306-6792.2022.11-12.3> [in Ukrainian]
  17. Pokalchuk, M., Marachuk, A., Shulepova, O. (2024). Legal support for post-war reconstruction measures of land resources of Ukraine. *Analytical and Comparative Jurisprudence*. (n.d.). SHEI "UzhNU", 6, 455-461. <https://dspace.uzhnu.edu.ua/jspui/handle/lib/71147> [in Ukrainian]
  18. Bepalko, R., Hutsul, T., Kazimir, I., & Myronchuk, K. (2023). Modern approaches to assessing the priority of humanitarian demining. *Technical sciences and technologies*, 1 (31), 146-157. DOI: [https://doi.org/10.25140/2411-5363-2023-1\(31\)-146-157](https://doi.org/10.25140/2411-5363-2023-1(31)-146-157)
  19. Adelaja, A., & George, J. (2019). Terrorism and land use in agriculture: The case of Boko Haram in Nigeria. *Land Use Policy*, 88, 104116. DOI: <https://doi.org/10.1016/j.landusepol.2019.104116>
  20. Duhiienko, N., Lang, V. (2023). Impact of the land market on the regional development of Ukraine, (56). DOI: <https://doi.org/10.32782/2524-0072/2023-56-72>. [in Ukrainian]
  21. Saleth, R. M. (1991). Land reform under military: Agrarian reform in Peru, 1969-78. *Economic and Political Weekly*, PE85-PE92. <https://www.jstor.org/stable/41498500>
  22. Public Cadastral Map of Ukraine. Available at: <https://kadastruva-karta.com/> (retrieved: 07.03.2025). [in Ukrainian]
  23. Cabinet of Ministers of Ukraine. (2021). On approval of the Methodology for normative monetary evaluation of land plots. (Decree No. 1147). Kyiv. Available at: <https://zakon.rada.gov.ua/laws/show/1147-2021-%D0%BF#Text> (retrieved: 05.05.2025). [in Ukrainian]
  24. Marsh, N. (2023). Responding to needs: military aid to Ukraine during the first year after the 2022 invasion. *Defense & Security Analysis*, 39(3), 329-352. DOI: <https://doi.org/10.1080/14751798.2023.2235121>
  25. Planet Explorer. Retrieved from: <https://www.planet.com/explorer/> (retrieved: 05.03.2025).
  26. Google Earth. Retrieved from: <https://earth.google.com/web/> (retrieved: 01.05.2025).
  27. IMAS. (2020) International Mine Action Standards. KMMCS – Übersicht. Retrieved from: <https://www.mineactionstandards.org/standards/> (retrieved: 12.05.2025).

## Проблеми та шляхи удосконалення обліку пошкоджених сільськогосподарських угідь методами ДЗЗ

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Земельні відносини завжди відігравали ключову роль у розвитку економіки України, особливо в аграрному секторі. Одним із основних інструментів регулювання цих відносин є нормативно-грошова оцінка земель (НГО), яка використовується при оподаткуванні, передачі земельних ділянок у власність чи користування, а також у процесах планування територій. Проте, в умовах воєнного стану, спричиненого повномасштабною збройною агресією, система НГО зазнала значних викликів. Руйнування інфраструктури, мінування територій, часткова або повна недоступність земель для використання, зміна функціонального призначення ділянок – усе це потребує переосмислення існуючих підходів до оцінки земельних ресурсів. У роботі розглянуто проблему актуалізації методики нормативної грошової оцінки земель в умовах воєнного стану. Автором запропоновано новий підхід до розрахунку НГО, який включає альтернативну поправку, що враховує не тільки економічні показники, а й екологічні характеристики та рівень придатності земель. У роботі використано методи аналізу законодавства, математичного моделювання та геоінформаційних технологій. Удосконалено модель розрахунку НГО, що забезпечує підвищення точності оцінки земельних ділянок на 12–15% шляхом включення альтернативної поправки з урахуванням екологічного стану і функціонального призначення земель. Апробація моделі здійснена на прикладі земельних ділянок Харківського району. Результати підтвердили підвищення точності оцінки та її відповідність сучасним умовам використання земель. Результати дослідження можуть бути використані органами місцевого самоврядування, державними установами та під час оновлення кадастрових баз даних для підвищення ефективності земельної політики. Уперше запропоновано включення комплексного екологічного коефіцієнта до формули НГО, що дозволяє більш об'єктивно враховувати природні фактори у процесі оцінки земель.

**Ключові слова:** нормативна грошова оцінка, сільськогосподарські угіддя, воєнний стан, коефіцієнт придатності земельної ділянки, геоінформаційні технології, ДЗЗ, облік пошкоджених земель, ступінь ураження.

**Внесок авторів:** всі автори зробили рівний внесок у цю роботу

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