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**SCIENTIFIC AND METHODOLOGICAL APPROACHES TO THE
CLASSIFICATION OF LAND AFFECTED BY MILITARY
ACTIONS IN UKRAINE**

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Abstract. *The focus is placed on the necessity of classifying lands and land parcels affected by military actions in Ukraine and establishing restrictions on their use. The study identifies the fragmented nature of legal regulation and the absence of a comprehensive approach to determining the legal regime of lands impacted by warfare. A synthesis of scientific literature on land classification has served as the foundation for developing the theoretical framework of a classifier for war-affected lands.*

The historical experience of managing war-affected lands is analyzed through the examples of the French Republic and the Federal Republic of Germany, which rely on

scientific approaches to classifying damaged territories and guiding their recovery. The importance of establishing a classification system for lands affected by military actions is emphasized as a critical component in designing effective strategies for their rehabilitation.

A classification system for war-affected lands is proposed, comprising five main categories: physically disturbed lands, littered lands, contaminated lands, mined lands, and lands with mixed contamination and debris. A detailed structure of the classifier is presented, describing the types and subtypes of affected lands, classification levels based on damage severity, the complexity of reclamation, and restrictions on future land use. The proposed classifier structure takes into account all relevant criteria and contributes to the development of effective measures for land restoration.

***Key words:** classification of damaged lands, war-damaged land classifier, military actions, land resources, land reclamation, contaminated lands, mined areas, land use restrictions, littered lands, land restoration, post-war recovery, land condition assessment, land resource management.*

Problem Statement. The full-scale military invasion of Ukraine by the Russian Federation has led to significant changes in the structure of the country's land resources, causing substantial damage to agricultural land, forests, water bodies, and other natural assets. As a result of physical destruction, chemical and technogenic contamination, landmines, and infrastructure disruption, a large portion of land has become unsuitable for its original intended use. At the same time, the absence of a unified classification system for damaged and degraded lands complicates the development of sound strategies for their restoration, the determination of their legal status, the assessment of damage, and the establishment of future land use restrictions.

Existing methodologies for assessing land damage remain fragmented and fail to reflect the complex nature of war-related degradation, which varies based on the duration, intensity of hostilities, and regional characteristics. Moreover, the lack of integration between land accounting data, monitoring tools, cadastral systems, and

spatial analytics prevents systematic planning of land reclamation efforts. Inadequate legal and regulatory frameworks, as well as procedural inconsistencies across different levels of government, create additional barriers for land management authorities and land users.

In the context of post-war recovery, the need for a comprehensive classification system for disturbed lands becomes increasingly urgent. Such a system should account for the nature and degree of damage – from physical and chemical degradation to explosive and mixed impacts. A classification of this kind would serve as an effective tool for informed decision-making regarding: 1) prioritization of restoration efforts; 2) planning of land reclamation activities in compliance with environmental and land management standards; 3) assessment of environmental and public health risks. Furthermore, it would support the restoration of productive land use in alignment with the principles of sustainable development.

Review of Recent Research and Publications. Issues related to land classification, land management approaches, legal status, and use under special conditions have been addressed in the works of numerous scholars, including D. Dobryak, D. Babmindra, O. Kanash, I. Rozumnyi, Y. Dorosh, Sh. Ibatullin, O. Dorosh, A. Barvinskyi, I. Kupriyanchyk, among others.

A significant contribution to the development of a scientifically grounded land classification system for environmentally safe use of agricultural land is evident in the research of D. Dobryak, O. Kanash, D. Babmindra and I. Rozumnyi. These scholars have proposed a multi-level typology of land that takes into account natural and climatic conditions, soil characteristics, agro-industrial potential, and economic factors. Their work emphasizes the role of land classification in spatial planning, agroecological zoning, and the justification of land's designated use. The authors have also developed methodological approaches for assessing land suitability for agricultural production and for the scientific support of land management planning [1].

Y. Dorosh, Sh. Ibatullin, O. Dorosh, and A. Barvinskyi, within the framework of scientific research, conducted an analysis of the current classification of types of designated use for agricultural lands with the aim of improving it. The researchers

proposed a four-level classification structure that enables differentiation between land tenure forms and actual land use. The approach incorporates the principles of systematization, complexity, hierarchy, as well as the requirements of automated cadastral systems and international recommendations. The implementation of this approach is expected to improve the accuracy of land accounting and contribute to more efficient land resource management [2, 3]. In a related study focused on the classification of designated land use types for residential and public development, the same group of scholars analyzed the existing classification and proposed an enhanced four-level structure based on Article 38 of the Land Code of Ukraine. Taking into account the consequences of military operations, the authors substantiated the relevance of introducing a subcategory for "technogenically contaminated lands due to hostilities", which are temporarily unsuitable for their designated use. Following decontamination and reclamation, such lands may regain their potential for restoration to their original functional purpose. [4, 5, 6].

I. Kupriyanchyk, H. Kolisnyk, R. Kharytonenko, D. Melnyk, and M. Bratinova, in their study, proposed an approach to classifying land-use restrictions for areas damaged as a result of military actions through the use of geographic information systems (GIS). The researchers identified 12 groups of spatial data that are critical for assessing the condition of affected territories, including mined areas, forests, radiation-contaminated zones, and infrastructure. They proposed a three-tier restriction system: complete prohibition, partial restriction, and conditional suitability for use. [7].

Given the existing scientific developments on the classification of land and land parcels, as well as the use of modern GIS technologies, the need for new approaches becomes particularly urgent in the context of post-war transformation of Ukraine's land resources. The extensive damage to territories calls for a scientifically grounded classification of disturbed lands that takes into account the types of impact, degree of degradation, complexity of reclamation, and land-use restrictions [8]. Integration of such a classification with the State Land Cadastre is a key condition for its effective implementation. It is also advisable to incorporate international experience, in which similar classification approaches were used after the end of hostilities to support the

monitoring and inventory of disturbed lands for the purpose of their effective restoration.

The aim of the study is to substantiate and develop scientific and methodological approaches to the classification of lands disturbed as a result of military actions in Ukraine, taking into account the types of damage, the degree of impact, the complexity of reclamation, and the necessary land-use restrictions.

Materials and Methods. The study employed an interdisciplinary set of methods combining legal, geoinformation, structural-analytical, and predictive approaches to assess lands disturbed by military actions. The following methodologies were applied: the monographic method, structural-logical modeling, classification method, analytical method, and predictive approach. The monographic method was used to review scientific publications, legal and regulatory documents, and international experience related to the classification of disturbed lands. The analytical method enabled the systematization of land damage types, identification of their characteristic features, and assessment of their impact on the prospects for future land use. The classification method was applied to develop a multi-level structure for classifying lands disturbed by warfare, considering the type of disturbance, degree of damage, complexity of reclamation, and legal restrictions. The structural-logical modeling method was used to visualize relationships between damage characteristics and to construct a logical-semantic classification framework. The predictive approach allowed for the evaluation of potential implementation scenarios for the proposed classification system in spatial planning, land restoration, and its integration with the State Land Cadastre.

Results and Discussion. An analysis of existing governmental methodologies (2022) for assessing damage and identifying lands disturbed by military actions in Ukraine has revealed their limitations. These documents fail to adequately cover the full typological diversity of damage that has occurred at various stages of the war (2014–2024), and they do not account for the dynamic nature of military operations [9]. This creates obstacles for conducting a comprehensive inventory, monitoring, and accounting of war-affected lands, and complicates the establishment of an effective system for their restoration. Therefore, there is an urgent need to develop more detailed

methodological approaches that go beyond the mere documentation of damage and allow for the identification of its nature, scale, associated risks, and the potential for land rehabilitation.

A review of international experience shows that a systematic classification of disturbed areas is an essential component of their rehabilitation process. For example, after the First World War, the Ministry of Liberated Regions of the French Republic (France. Ministère des Régions libérées, 1917–1925) implemented a color-coded land classification system (blue, yellow, red zones), which reflected the level of damage and potential for land use. Blue zones allowed for economic use with minimal restrictions; yellow zones permitted partial use, contingent upon mandatory demining; and red zones were deemed completely unfit for habitation or agricultural activities due to high levels of danger. This experience may be adapted for use in the Ukrainian context, with appropriate modification of classification criteria to reflect national conditions [10, 11, 12].

Another example is the Green Belt (ger. Grünen Bandes) of the Federal Republic of Germany – a territory along the former inner border between West and East Germany (FRG and GDR), parts of which remain difficult to access due to uncleared landmines. Environmental protection restrictions were introduced on these lands, which facilitated the formation of a network of biotopes [13].

Incorporating similar approaches in Ukraine would enable not only the spatial zoning of war-affected lands but also the proposal of alternative functional uses aimed at ecological and recreational development. Within the framework of this study, a classification of disturbed lands is proposed, comprising **five** main groups: **physically disturbed lands, littered lands, contaminated lands, mined lands, and lands with mixed pollution and littering**. Physically disturbed lands refer to areas where military actions have altered the topography or soil structure. Littered lands are areas where remnants of warfare are concentrated, complicating or preventing agricultural or other land uses. Contaminated lands include areas affected by chemical, fuel, or toxic pollution. Mined lands are territories containing explosive devices, posing a threat to life and rendering safe land use impossible. Lands with mixed pollution and littering

are characterized by a combination of multiple types of damage, such as soil contamination by chemicals, the presence of unexploded ordnance, technogenic pollution, and altered geomorphology [14]. Such areas are the most challenging in terms of restoring them to their original functional designation and require an integrated approach to land reclamation.

Each classification group is further subdivided into relevant subgroups, enabling the formation of a hierarchical model for classifying disturbed lands. This model serves as a tool to ensure consistency and coherence in the collection and processing of cadastral information, enhance the accuracy of damage assessment and the justification of loss calculations, define land use restrictions, and support the development of land reclamation projects.

Physically disturbed lands are categorized into the following subgroups:

- damage caused by explosive ordnance (*craters from detonations, disrupted soil layers*);
- damage resulting from the construction of fortification structures (*trenches, dugouts, bunkers, entrenchments, etc.*).

Littered lands are classified into the following subgroups:

- former combat zones, *where remnants of munitions, destroyed military equipment, and remains of fortification structures are present*;
- areas of temporary military deployment outside permanent bases, often accompanied by *technogenic waste and debris*;
- anti-tank obstacles (*e.g. "dragon's teeth"*) *that act as barriers to agricultural land use*;
- destroyed settlements, *where land has lost its original function and acquired characteristics of technogenically impacted areas*.

Contaminated lands are categorized into the following subgroups:

- contamination from burned military equipment: *involves pollution of soils with toxic residues of fuel, lubricants, and heavy metals formed as a result of combustion or detonation of military vehicles*;

- contamination from munitions (*including cluster, high-explosive, and thermobaric munitions*): *caused by explosive residue, metal fragments, and detonation by-products that persist in the soil following use or explosion*;
- contamination from chemical weapons use: *refers to soil and water pollution by toxic combat substances that leave persistent chemical compounds hazardous to the environment and human health*.

Mined lands are subdivided into the following subgroups:

- Systematic mining: *refers to the deliberate and structured placement of minefields in accordance with military engineering standards, schemes, and instructions*;
- Chaotic (random) mining: *involves remote or automated deployment of mines without any orderly pattern or layout*;
- Mixed mining: *characteristic of areas subjected to prolonged and intensive hostilities, representing the most hazardous and difficult type for demining operations*.

The developed structure for classifying war-affected lands provides a conceptual foundation for creating a specialized classification system with practical applications in land accounting, information-analytical support for decision-making, and the planning of restoration and rehabilitation measures for damaged territories. The proposed classification can be integrated into the State Land Cadastre system, enabling its practical use in the development of land management documentation, the assessment of environmental and economic damage, the identification of legal land use restrictions, and the prioritization of reclamation activities. Its hierarchical structure includes relevant categories and subcategories, allowing for a more detailed consideration of the nature of damage and the most appropriate strategies for reintegration. Of particular practical value is the inclusion of a distinct group – complex contamination and littering of land – which captures the most critical cases of combined types of damage. A generalized conceptual diagram of the classification of war-damaged lands is presented in Figure 1, illustrating the main categories, subcategories, and their interrelationships.

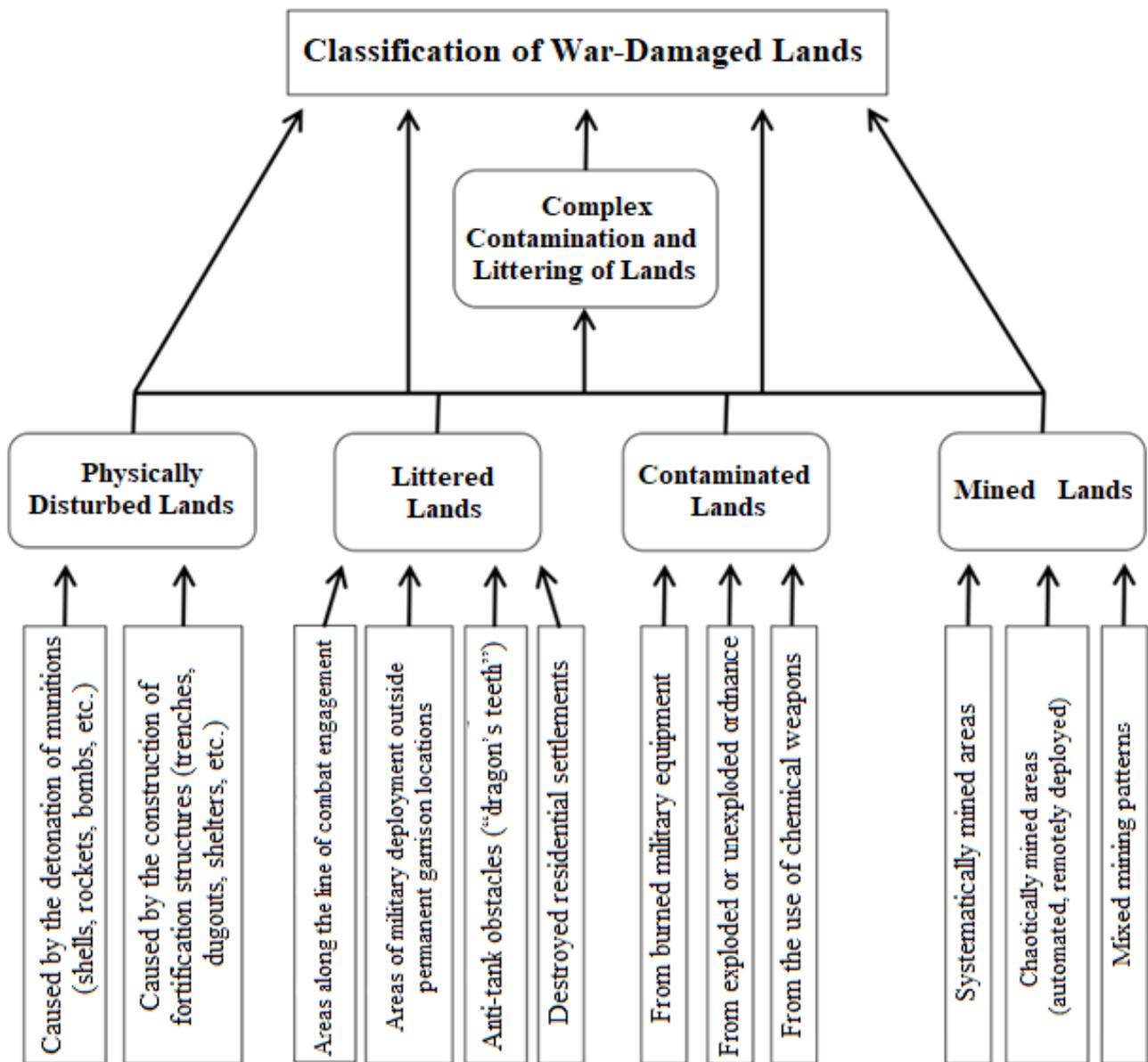


Figure 1 – Conceptual and Logical Diagram of the Classification of War-Damaged Lands

Developed by the authors

The proposed classification system for war-damaged land not only identifies the types of damage but also accounts for the degree of disturbance, which is critical for selecting appropriate reclamation approaches. This approach allows for the detailed categorization of damaged areas based on the intensity of impact, the complexity of restoration, and the need to impose use restrictions. Within each group of disturbed land, degradation classes have been introduced to complement the hierarchical structure of the classifier. This methodology enables the assessment of land suitability

for reclamation, estimation of recovery timelines, and justification for temporary or permanent land use restrictions.

This level of detail underscores the need to develop a specialized classifier for disturbed land, which would not only systematize the types and degrees of damage but also enable a standardized and unified description. The construction of such a classifier should be based on a multi-level structure that allows for the systematic and consistent grouping of information by origin, nature, as well as the degree and scale of territorial damage. The structure of the classifier for war-damaged land must support integration into the State Land Cadastre and facilitate its use in spatial planning, the design of restoration measures, legal regulation of land-use regimes, and the assessment of damage extent. In this context, the following structural logic of the classifier is proposed, which includes key elements required for comprehensive management of damaged land parcels: **type of disturbed land, subtype, degradation class, reclamation potential, and land-use restrictions** [14].

The type of disturbed land defines the general nature of the damage inflicted on a given area. Each type is assigned a specific code and designation, for example: 01 – Physically disturbed land; 02 – Littered land; 03 – Contaminated land; 04 – Mined land; 05 – Land with mixed types of disturbance.

The subtype of disturbed land specifies the source and particular nature of the disturbance within each general type. Each subtype is also assigned a unique code and designation. For example, within the type 03 – Contaminated land: 03.1 – From burned-out military equipment; 03.2 – From munitions; 03.3 – From the use of chemical weapons.

Class of disturbed land by degree of impact reflects the intensity and depth of the damage, which determines the complexity of rehabilitation. This classifier parameter defines the level of physical, chemical, or technogenic disturbance of the land parcel, directly influencing the choice of restoration measures, the timeframe for reclamation, legal restrictions, and the potential for future use of the area. Four levels are provided, each with a corresponding code and title: I – Minor degree of disturbance;

II – Moderate degree of disturbance; III – Significant degree of disturbance; IV – Critical degree of disturbance

Class I – Minor Degree of Disturbance includes disturbances to the topsoil layer or minor littering that do not lead to a critical change in the functional condition of the land. These areas may be suitable for limited or temporary use without large-scale intervention. The following areas are classified under Class I: Localized explosions without the formation of deep craters; Scattered debris or small amounts of technical waste; Temporary military encampments without deep soil penetration. Reclamation for Class I lands can typically be carried out in the shortest timeframe (up to 1 year), and in some cases, recovery may occur through natural regeneration or surface-level cleanup.

Class II – Moderate Degree of Disturbance includes lands that have undergone moderate physical or chemical disruption. These areas may contain explosion craters, residual contamination, or localized minefields. Soil fertility is partially lost, and restoration requires professional intervention. Typical examples of Class II territories include: Locations of military checkpoints and earthen fortifications; Areas with partial and identifiable mine placement; Sites with limited contamination from munitions. Reclamation of Class II lands involves standard decontamination procedures, pollution assessment, and controlled reintegration into land use. The estimated recovery period ranges from 1 to 5 years.

Class III – Significant Degree of Disturbance includes areas that have experienced substantial soil structure disruption, deep contamination, or systematic mining. Such lands are unsuitable for use without long-term, intensive reclamation. Examples of Class III territories: Heavily mined areas with unknown mine placement patterns; Lands contaminated by heavy metals, fuel and lubricants, or toxic agents; Destroyed industrial or military sites with pollutant releases into the soil; Concentrations of burnt military equipment and exploded munitions. Rehabilitation of Class III areas requires comprehensive technical and ecological interventions, including deep decontamination and, in many cases, reassignment of land use categories. The estimated restoration period may be up to 20 years.

Class IV – Critical Degree of Disturbance encompasses territories that have undergone severe degradation of the soil cover and have lost their natural soil functions. These areas are characterized by contamination levels that are technically challenging or economically impractical to remediate under current conditions. Continued use of the land for its original purpose is unsafe or entirely unfeasible. Such critical degradation may result from: Widespread use of chemical weapons or toxic substances; Contamination by explosive materials; Irreversible soil erosion or complete loss of the fertile layer; Minefields with unstable or undocumented mining patterns. Rehabilitation of Class IV lands requires long-term environmental monitoring, and in most cases, only partial ecological restoration is possible. These territories are subject to containment measures, with extended or permanent conservation status. Estimated recovery time exceeds 20 years, if feasible at all.

Reclamation potential reflects the capacity of a land plot for ecological and functional restoration, depending on the nature of the damage, depth of degradation, type of contamination, and the technical feasibility of carrying out reclamation measures. Conducting reclamation allows for the projection of timeframes for the return of land to its intended use, with approximate implementation periods for corresponding measures as follows: fully restorable – up to 5 years, partially restorable – up to 10 years, difficult to restore – up to 20 years, minimally restorable – more than 20 years.

Use Restrictions establish the necessary temporary or permanent prohibitions on specific types of activities depending on the damage class and associated hazards of the land. This classification parameter determines the permitted or prohibited uses of land affected by military actions. Restrictions may be either temporary or permanent, depending on the nature and severity of the damage, presence of hazardous substances or explosive materials, level of contamination, or technogenic instability of the area. Such restrictions play a critical role in protecting public health and safety, preventing secondary contamination or ecological disasters, defining the legal regime for land use, prioritizing recovery efforts, and supporting spatial planning, zoning, and regional development strategies. Depending on the type of activity, restrictions may include

bans on crop cultivation or livestock grazing. In the context of construction, restrictions may prohibit any building (residential, industrial, or infrastructure-related), as well as deep drilling, excavation, or habitation on hazardous sites. Thus, a sample structure of the classification system for war-affected lands is illustrated in Figure 2, which demonstrates the hierarchical layout of the model, including coded identifiers, classification levels, projected restoration timelines, and anticipated land use restrictions.

Type of Disturbed Land		Subtype of Disturbed Land		Class of Disturbed Land by Degree of Damage		Reclamation Feasibility	Restrictions on Use
<i>code</i>	<i>name</i>	<i>code</i>	<i>name</i>	<i>code</i>	<i>name</i>		
01	Physically Disturbed Lands	01.1	From explosions of ammunition (shells, rockets, bombs, etc.)	01.1.1	Class I (minor degree of damage)	Fully operational by 5 years	
				01.1.2	Class II (moderate degree of damage)	Limited capacity up to 10 years	
				01.1.3	Class III (significant degree of damage)	Hardly capable of 20 years of age	
				01.1.4	Class IV (critical degree of damage)	Extremely limited capacity for more than 20 years	

Figure 2 – Structure of the Classification System for War-Affected Lands: Example of Physically Damaged Lands

Developed by the authors

The classification structure for war-affected lands developed within this study is based on the synthesis of up-to-date information regarding the spatial distribution, nature, and origin of land damage. The classifier’s structure enables a systematic organization of restoration activities, both in terms of methodological planning and temporal progression—from the identification of affected areas to the selection of

optimal reclamation approaches. The system is designed to align with the current normative framework of land designation within the State Land Cadastre.

A key advantage of implementing such a classification system lies in its potential to:

- Systematize the accounting of war-damaged lands;
- Quantify the extent of damage and losses;
- Develop targeted reclamation and recovery measures;
- Establish appropriate use restrictions based on risk levels or ecological pressure;
- Ensure spatial accuracy and partial public transparency of information for both governmental authorities and civil society.

Thus, the introduction of this classification framework for war-affected lands facilitates greater transparency in planning processes, enhances inter-agency coordination, and lays the foundation for a long-term recovery policy for territories impacted by military actions.

Conclusions and Recommendations. The proposed approach to the classification of war-affected lands in Ukraine is grounded in a structured system that integrates a model for identifying types of damage with a multi-level classifier for characterizing individual land parcels. The study substantiates the relevance of such a systemic model, which enables detailed categorization of territories based on type and subtype of disturbance, degree of damage, potential for land reclamation, and applicable land use restrictions.

The developed semantic-logic classification scheme allows the division of disturbed lands into five main groups: physically disturbed, littered, contaminated, mined, and those with mixed types of damage. This hierarchical structure is further refined into subgroups, forming the basis for systematic data recording, damage assessment, loss estimation, and planning of land restoration measures.

The classification structure, demonstrated using the example of physically disturbed lands, defines the internal logic for describing each specific case of land degradation. It includes five essential components: type, subtype, damage severity

class, reclamation capacity, and land use restrictions. These elements enable a flexible and unified accounting model that takes into account the intensity of damage, potential for rehabilitation, and legal frameworks for land use.

Applying this classification approach to war-affected lands creates a foundation for integrating classification data into the State Land Cadastre, developing digital maps, prioritizing restoration areas, and designing technical frameworks for attracting international aid and supporting post-war recovery processes.

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НАУКОВО-МЕТОДИЧНІ ПІДХОДИ ДО КЛАСИФІКАЦІЇ ЗЕМЕЛЬ, ПОРУШЕНИХ УНАСЛІДОК ВОЄННИХ ДІЙ НА ТЕРИТОРІЇ УКРАЇНИ

Анотація. Акцентовано увагу на необхідності класифікації земель та земельних ділянок, які зазнали негативного впливу воєнних дій на території України, та встановленні обмежень у їх використанні. Виявлено фрагментарність нормативно-правового регулювання та відсутність цілісного підходу до визначення правового режиму земельних ділянок, що зазнали негативного впливу внаслідок воєнних дій. Узагальнення наукових праць з питань класифікації земель стало основою для формування теоретичних засад класифікатора порушених унаслідок воєнних дій земель.

Проаналізовано історичний досвід використання земель, що зазнали негативного впливу воєнних дій, на прикладі Французької Республіки та Федеративної Республіки Німеччини, які спираються на наукові підходи до класифікації порушених територій та їх відновлення. Підкреслено значущість

створення класифікації порушених земель унаслідок воєнних дій, як ключового елемента у формуванні підходів до їх відновлення.

Сформовано класифікацію порушених унаслідок воєнних дій земель, що охоплює п'ять основних груп: фізично порушені землі; засмічені землі; забруднені землі; заміновані землі; змішане забруднення та засмічення земель. Розроблено структуру класифікатора, яка деталізує види порушених земель, їх підвиди, класи за ступенем порушення, рівнем складності рекультивації та обмеженнями щодо подальшого використання. Запропоновано структуру класифікатора порушених земель внаслідок воєнних дій, що враховує всі зазначені критерії та сприяє розробці ефективних заходів з їх відновлення.

Ключові слова: *класифікація порушених земель, класифікатор порушених земель, воєнні дії, земельні ресурси, рекультивація земель, забруднені землі, заміновані території, обмеження у використанні земель, засмічені землі, відновлення земель, повоєнна відбудова, оцінка стану земель, управління земельними ресурсами.*