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STRATEGIC MANAGEMENT OF HUMANITARIAN DEMINING PROJECTS IN UKRAINE: ECONOMIC LOSSES AND SOCIAL RISKS

ABSTRACT

Mine contamination of Ukraine's territories is one of the key factors constraining the country's socio-economic recovery, limiting the efficient use of natural resources, and posing significant risks to public safety. According to estimates by the Ministry of Defense of Ukraine, as of the end of 2024, the area potentially contaminated with explosive remnants of war amounts to approximately 139 thousand km², which corresponds to about 25–29% of the country's territory. Such a scale of mine contamination results in substantial economic losses, which, according to certain estimates, exceed USD 17 billion in 2025 and continue to grow.

The methodological framework of the study is based on the principles of strategic management, project management, and risk management. The research employs methods of system, structural, and comparative analysis, expert evaluation techniques, as well as multi-criteria analysis tools to substantiate the prioritization of managerial decisions. The information base is formed from data provided by international organizations, public institutions, and analytical reports on the scale of mine contamination and its associated socio-economic losses.

The study substantiates an integrated risk-oriented approach to the strategic management of humanitarian demining, combining the principles of multi-criteria optimization and project management. A formalized model for prioritizing territories has been developed, based on the weighted aggregation of normalized indicators of economic losses, social risks, infrastructure significance, and environmental impact, while also taking into account resource constraints in the planning process. The results of the model testing confirm its applicability for ranking territories and improving the validity of managerial decision-making in the field of my action.

The practical significance of the results lies in the possibility of applying the proposed approach to optimize resource allocation, form portfolios of humanitarian demining projects, and enhance the effectiveness of strategic management. The implementation of the proposed solutions will contribute to accelerating the recovery of affected territories, reducing social risks, and ensuring the sustainability of regional socio-economic development.

Keywords: multi-criteria optimization, humanitarian demining, economic losses, mine contamination, post-war recovery, territorial prioritization, mine action, risk-oriented approach, project management, strategic management, social risks, managerial decision-making

JEL Classification: H56, O18, Q34, D81, F52

INTRODUCTION

Large-scale contamination of Ukraine's territory with explosive remnants of war is one of the key consequences of the full-scale war, creating long-term constraints on socio-economic development and public safety. Significant areas of agricultural land, infrastructure facilities, and settlements remain potentially hazardous for use, which slows down the recovery of economic activity, complicates the return of the population, and hinders post-war reconstruction processes. The relevance of this study is determined by substantial economic losses, social risks, and institutional constraints in the field of

humanitarian demining. Under conditions of limited resources and high uncertainty in the security environment, improving the efficiency of demining management requires the enhancement of approaches to strategic planning, coordination, and prioritization of territories subject to clearance.

A review of the scientific literature indicates that existing studies are primarily focused on the technical aspects of humanitarian demining or on general assessments of economic losses caused by mine contamination. At the same time, insufficient attention has been paid to the integration of strategic management and project management in the field of humanitarian demining, as well as to the careful consideration of economic, social, and security risks in managerial decision-making. This highlights a research gap related to the development of integrated risk-oriented and multi-criteria approaches to managing demining processes. The study addresses the impact of integrating economic, social, and security risks on the formation of humanitarian demining priorities, as well as identifies strategic and project management tools that enhance the effectiveness of planning and implementing demining programs in conditions of limited resources.

LITERATURE REVIEW

The issue of humanitarian demining, its economic consequences, and associated social risks has become a subject of active research in both national and international academic literature. Ukrainian scholars such as Yu. Rohozian, K. Serebriak, Ye. Akhromkin and others consider humanitarian demining as a necessary precondition for restoring the economic potential of affected regions and ensuring sustainable development (Rohozian et al., 2024). These studies primarily focus on the financial costs of demining, institutional mechanisms for its organization, and its overall impact on the economic security of territories. At the same time, the works of V. Ustymenko and O. Trehub examine the economic and legal nature of mine action, with particular emphasis on regulatory frameworks, while issues related to the management of project implementation efficiency remain secondary (Ustymenko et al., 2023). Research by T. Hutsul, K. Myronchuk, V. Tkach, and M. Khobzei explores approaches to prioritizing demining territories based on economic feasibility and social significance; however, these approaches are largely theoretical and insufficiently integrated into strategic management systems (Hutsul et al., 2023). Technical aspects of detecting explosive hazards are addressed in the studies of I. Mentus, V. Yasko, and I. Saprykin, where the focus is mainly on technological solutions, while managerial and socio-economic implications are considered to a limited extent (Mentus et al., 2024).

Additional scholarly interest is found in studies examining the experience of humanitarian demining in post-conflict countries, where various models of risk management and program organization have been developed. In particular, research on Bosnia and Herzegovina highlights that the demining process is closely linked to land rights and spatial recovery, and that the persistence of mine contamination directly affects access to resources and the restoration of economic activity (Landmines and Land Rights in Bosnia and Herzegovina, 2010). The World Bank notes that even in the long term, the effectiveness of recovery depends on the alignment of institutional reforms, international assistance, and demining programs (Bosnia and Herzegovina: From Post-Conflict Reconstruction to EU Integration, 2012), indicating a systemic dependence of demining outcomes on the quality of governance. In Cambodia, economic studies by Harris demonstrate that demining expenditures significantly influence the recovery of agricultural production and land productivity, establishing a direct relationship between investment in demining and regional economic growth (Harris, 2020). At the same time, it is emphasized that without stable funding and long-term planning, the effects of demining remain fragmented and unsustainable. The experience of Angola, summarized in international mine action reviews, indicates a strong dependence of demining effectiveness on external financial support and the level of technical capacity of programs (Explosive remnants of war and mines other than anti-personnel mines, 2005). In this context, the application of innovative technologies, including remote sensing and unmanned systems, improves the accuracy of identifying hazardous areas, but does not eliminate institutional constraints.

In Colombia, studies by Macías Montoya and Corcione Nieto show that humanitarian demining has not only a technical but also a socio-behavioral dimension, as the perception of risks by deminers and local populations influences the effectiveness of operations (Macías Montoya & Corcione Nieto, 2020). Furthermore, Llanes emphasizes the indirect social consequences of conflict-related programs, including increased vulnerability of local communities during territorial transformation processes (Llanes, 2022). This underscores the necessity of incorporating social and behavioral factors into risk management systems. Contemporary technological approaches to humanitarian demining are reflected in the concept of "Demining 4.0," where Bechtel et al. substantiate the integration of digital platforms, robotic systems, and geospatial technologies as a basis for improving the efficiency of demining operations (Bechtel et al., 2021). However, the authors also highlight the gap between technological capabilities and the managerial readiness of countries to implement them, which limits the practical impact of innovations.

Comprehensive international reports by UNMAS confirm that the effectiveness of humanitarian demining largely depends on the standardization of procedures, risk management practices, and coordination between international and national actors (UNMAS). In this context, GICHD emphasizes the importance of integrating demining into the Sustainable Development Goals, allowing it to be considered as part of broader post-conflict recovery processes (GICHD). Moreover, global assessments of mine contamination impacts indicate its long-term effects on territorial development, including restrictions on population mobility, reduced investment attractiveness, and degradation of land resources (Explosive remnants of war and mines other than anti-personnel mines, 2005). This confirms that humanitarian demining should be regarded not only as a technical process but also as an instrument of economic and social reconstruction.

Thus, the analysis of post-conflict country experiences allows for the identification of three key approaches to organizing humanitarian demining: the institutional-state approach, as in Bosnia and Herzegovina, the economic-investment approach, as observed in Cambodia and Angola, and the technological-innovative approach, as demonstrated in Colombia. At the same time, all these approaches reveal a common limitation, namely the absence of an integrated model that combines risk-oriented management, a project-based approach, and a comprehensive socio-economic assessment of impacts. This gap forms the scientific basis for further research aimed at developing integrated systems of strategic and project management in the field of humanitarian demining.

AIMS AND OBJECTIVES

The purpose of this article is to substantiate the theoretical and methodological foundations of strategic management in humanitarian demining and to develop an integrated risk-oriented approach based on multi-criteria optimization, which provides for the formalization of territorial prioritization and managerial decision-making under resource constraints.

In view of this aim, the objectives of the study are to:

- analyze theoretical approaches to strategic project management under crisis conditions and identify their specific applications in the field of humanitarian demining;
- carry out a quantitative and structural assessment of economic losses caused by landmine contamination of Ukrainian territories, taking into account their impact on the agricultural sector, infrastructure, business, and investment activity;
- analyze the financial costs of humanitarian demining and substantiate directions for optimizing the financial support of mine action activities, considering limited resources and the need to attract international assistance;
- investigate social risks associated with mine hazards, including their impact on public safety, access to resources and services, as well as the socio-psychological condition of communities;
- substantiate the application of project-based and portfolio-based approaches within the humanitarian demining system, including the prioritization of projects, resource planning, scheduling, and risk management;
- develop an integrated risk-oriented approach to strategic management of humanitarian demining based on multicriteria optimization principles, incorporating project management guidelines;
- justify a system of strategic and project-level managerial decisions and their implementation mechanisms (including tools for planning, monitoring, and evaluating project effectiveness) with the aim of enhancing demining efficiency and ensuring socio-economic recovery of affected territories.

METHODS

The methodological framework of the study is based on the principles of strategic management, project management, risk management, and the economic assessment of the consequences of mine contamination. The study is grounded in a combination of qualitative analysis, expert evaluation, and multi-criteria analysis tools aimed at substantiating the prioritization of humanitarian demining under resource constraints.

The information base was formed using statistical and analytical materials from the United Nations Mine Action Service (UNMAS), Geneva International Centre for Humanitarian Demining (GICHD), and the World Bank, as well as aggregated estimates of the scale of mine contamination in Ukraine for the period 2022–2025. Data on potentially contaminated areas and economic losses (in USD) were compiled from open reports of international organizations and subsequently harmonized into a unified analytical database. To ensure comparability of indicators, values were converted into constant prices using the average annual exchange rate for the respective periods.

Within the multi-criteria approach to territorial prioritization, a system of criteria was developed, including the level of mine hazard, the economic value of land (agriculture and infrastructure), the social significance of territories (population density and access to critical facilities), as well as the cost and duration of demining operations. To ensure comparability of indicators, the min–max normalization method was applied, after which the integral assessment was calculated using a weighted additive model. The weights of the criteria were determined through expert evaluation involving specialists in humanitarian demining, including representatives of public authorities, mine action operators, and academic institutions. The selection of experts was based on professional experience (at least five years of practical or academic work in the fields of security, risk management, or humanitarian demining). The aggregation of expert judgments was carried out by calculating weighted averages, with the consistency of opinions assessed using Kendall's coefficient of concordance.

The method of systems analysis was applied to examine humanitarian demining as a complex socio-economic system involving interactions among public institutions, international organizations, mine action operators, and local communities. A process-based approach was used to decompose demining activities into key stages: planning, prioritization, implementation, monitoring, and evaluation of results. Graphical and analytical methods were employed to visualize the spatial distribution of risks, the structure of economic losses, and the outcomes of the multi-criteria analysis, enabling the interpretation of results in a form suitable for managerial decision-making in the field of humanitarian demining.

RESULTS

Under contemporary conditions, the management of complex socio-economic processes, such as humanitarian demining, requires the application of strategic management capable of accounting for economic losses, social risks, and institutional constraints. At the same time, the effective implementation of relevant measures is impossible without the use of project management approaches, which ensure the structuring of processes, clear planning of work stages, allocation of resources, and control over results. Effective planning, organization, and coordination of demining activities require a systemic and integrated approach that combines various methodological management concepts, risk assessment, and adaptive solutions aimed at minimizing the negative consequences of crisis phenomena.

An analysis of scientific sources indicates that several key approaches are distinguished within the field of strategic management of crisis processes, each addressing specific tasks: classical strategic planning enables the formulation of long-term goals and priorities; the systems approach ensures the coordination of all elements of the process; the risk-oriented approach focuses on identifying and minimizing negative impacts; the adaptive approach emphasizes the need for flexibility and rapid response to changes in external and internal conditions; and the project-based approach facilitates the implementation of strategic objectives through a system of interrelated projects and programs. To provide a clearer representation of the features of each approach, their characteristics are presented in Table 1.

Table 1. Theoretical and methodological approaches to strategic and project management under crisis conditions and their application in humanitarian demining.

Nº	Approach	Core idea and key concepts	Representatives	Application in Humanitarian Demining
1.	Classical Strategic	Involves systematic forecasting and planning of organizational activities, taking into account internal resources and external conditions; analysis of strategic opportunities and threats (SWOT, PEST); and definition of long-term goals and priorities. Ensures the development of structured managerial decisions that minimize economic losses and optimize the use of limited resources under crisis conditions.	H. Ansoff, M. Porter, K. Serebriak, Yu. Rohozyan	Development of long-term demining plans, identification of priority areas, and assessment of economic losses from contaminated land.
2.	Systems Approach	Considers an organization as an integrated system in which all components, human, technical, financial, legal, and social, are interconnected. The approach aims to optimize their interaction to achieve strategic goals, ensure stability, and adapt to environmental changes. In crisis conditions, it enables comprehensive process management and avoids fragmented decisions.	P. Checkland, V. Ustyenko, O. Trehub	Coordination of technical means, human resources, financing, and legal aspects of demining; ensuring the integrity of the management system.
3.	Risk-Oriented	Focuses on systematic identification, assessment, and management of potential threats. Involves analysis of the probability and impact of risks, development of mitigation and adaptation strategies, ensuring safety, and reducing social and economic losses. In humanitarian demining, it supports prioritization and resource allocation.	D. Hillson, I. Mentus	Systematization of incident probability data, assessment of social and economic impacts, and prioritization of territory clearance.

(continued on next page)

Table 1. Continued.

№	Approach	Core idea and key concepts	Representatives	Application in Humanitarian Demining
4.	Adaptive (Crisis)	Emphasizes flexibility and rapid response to dynamic changes in internal and external environments. Enables quick adjustment of strategic plans, redistribution of resources, and decision-making under uncertainty, which is critical in post-conflict or active combat conditions.	J. Kotter, T. Hutsul	Adjustment of demining plans in post-conflict regions and in areas of active hostilities, operational re-allocation of resources, and reprioritization.
5.	Project-Based (Project-Oriented)	Involves managing activities through a system of projects and programs with clearly defined objectives, timelines, resources, and performance indicators. Based on planning, monitoring, control, and risk management principles, enhance transparency and effectiveness. In crisis conditions, ensure flexibility and efficient resource utilization.	PMI, United Nations Mine Action Service, Geneva International Centre for Humanitarian Demining	Formation of demining project portfolios, prioritization of territories, planning of resources and timelines, risk management, and evaluation of project effectiveness.

The generalization of theoretical and methodological approaches to strategic management under crisis conditions indicates the necessity of integrating various conceptual frameworks to ensure the effective management of complex socio-economic processes, such as humanitarian demining. The classical strategic approach provides a clear formulation of long-term goals and priorities, taking into account limited resources and external threats, while the systems approach enables consideration of the demining process as an integrated set of interrelated elements requiring coordinated management. The risk-oriented approach facilitates the identification and minimization of potential threats through the assessment of the likelihood of adverse outcomes, whereas the adaptive (crisis) approach emphasizes the importance of flexibility and rapid response to dynamic changes in the external environment. At the same time, the project-based approach ensures the practical implementation of strategic decisions through the management of specific projects and programs, thereby enhancing the efficiency of resource utilization and the achievement of planned outcomes. Such a combination of conceptual approaches makes it possible to develop an effective system of strategic management capable of accounting for both economic and social dimensions in the implementation of humanitarian demining measures under crisis conditions and mine hazards.

Transitioning from the analysis of theoretical approaches to strategic management, it is important to consider their practical implementation through the mechanism of humanitarian demining management. Such a mechanism includes interconnected elements that ensure the planning, coordination, and control of all processes from the subjects and objects of management to specific tools, methods, tasks, and resources. At the same time, it is advisable to consider this mechanism through the lens of project management, which involves the formation of demining portfolios and programs, the determination of their priorities, the management of timelines, resources, and risks, as well as continuous monitoring and evaluation of performance. This approach enables the integration of technical, organizational, and social aspects of activities, ensuring an effective response to crisis phenomena, minimization of economic losses, and reduction of social risks. The scheme of the structural organization of the strategic management and project management mechanism for humanitarian demining is presented below, illustrating the interconnections between key components and providing a visual representation of their functioning (Figure 1).

The mechanism of strategic management and project management in humanitarian demining clearly demonstrates the necessity of integrating various theoretical and methodological approaches to ensure the effective management of complex socio-economic processes under crisis conditions. The systemic structure of the mechanism, which includes subjects and objects of management, tasks, methods, tools, resources, and project portfolios, enables comprehensive planning, coordination, and control of all stages of the demining process (Boyko et al., 2025). The integration of classical, systems-based, risk-oriented, adaptive, and project-based approaches ensures the development of strategically grounded decisions, optimization of resource utilization, minimization of economic losses, reduction of social risks, and prompt adaptation to changes in both external and internal environments. The proposed model of the strategic management and project management mechanism serves as both a theoretical and practical foundation for enhancing the effectiveness of humanitarian demining in affected areas and contributes to ensuring public safety, sustainable infrastructure recovery, and the stability of socio-economic processes in regions with a high level of mine hazard.

Having considered the mechanism of strategic management and project management of humanitarian demining, which ensures the integration of management subjects and objects, methods, tools, tasks, and resources for effective planning, coordination, and control of operations, it becomes possible to proceed to the assessment of its practical implications in the socio-economic dimension. The systems-based and project-oriented approach makes it possible to identify priority areas of activity, plan portfolios of demining projects, and determine the sectors most significantly affected by mine hazards. This creates the basis for a systematic analysis of economic losses resulting from contamination by explosive devices and enables both quantitative and qualitative assessment of their impact on the agricultural sector, infrastructure, business activity, regional investment attractiveness, and overall socio-economic stability. Such an approach provides a

scientific and practical foundation for setting priorities in humanitarian demining, optimizing resource allocation, and ensuring effective project management in affected regions.

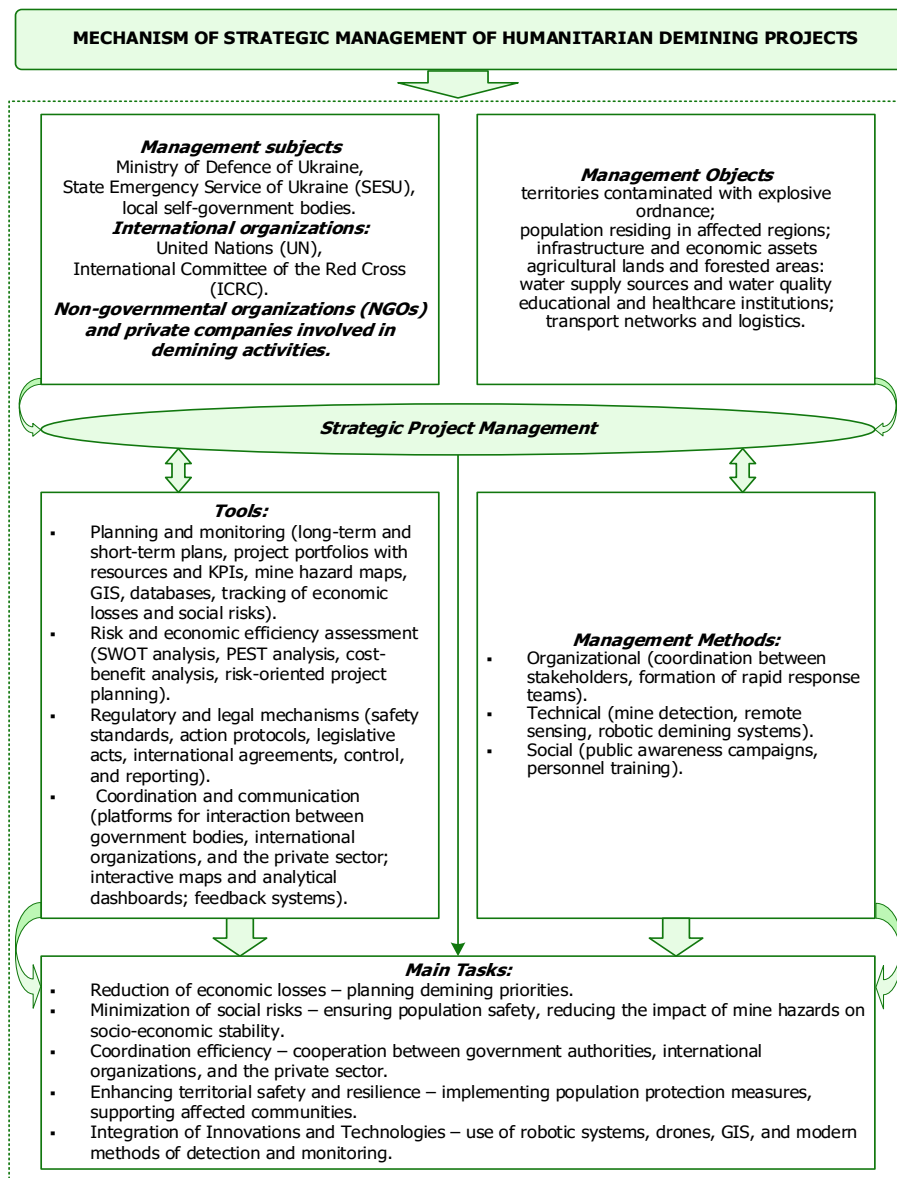


Figure 1. Mechanism of integrated strategic management and project management for humanitarian demining.

The contamination of Ukraine’s territory with explosive devices is a critical factor that significantly constrains the country’s economic recovery, public safety, and the functioning of key economic sectors. As a result of the full-scale armed conflict, territories where active hostilities took place or that were temporarily occupied have become heavily contaminated with mines, unexploded ordnance fragments, and other explosive remnants of war (ERW). This creates serious risks for the civilian population, agricultural production, infrastructure, and the investment attractiveness of regions.

According to the Ministry of Defence of Ukraine, as of the end of 2024, the area of land potentially contaminated with explosive devices amounted to approximately 139 thousand km², which remains one of the highest estimates globally in terms of the territorial scale of mine hazards (2024). This reduction compared to previous estimates is explained by the results of non-technical surveys and demining operations in de-occupied territories, where significant areas have been surveyed and cleared. Other sources provide somewhat broader estimates of potentially contaminated areas, as, according to Ukrainian civil protection authorities and expert non-governmental organizations, a total of 156–174 thousand km² required a detailed survey and subsequent clearance during certain periods of 2023–2024.

International charitable and humanitarian organizations also confirm the large-scale nature of the problem, estimating that approximately 25–29% of Ukraine’s territory may be contaminated with explosive devices, making Ukraine one of the most

mine-contaminated countries in the world as a result of the modern armed conflict. In particular, according to the international organization Humanity & Inclusion, Ukraine is currently among the countries with the highest levels of mine contamination globally, due to the widespread use of explosive weapons since the full-scale invasion in 2022. Experts from the organization estimate that about 29% of the country's territory may be contaminated with explosive devices, including mines and explosive remnants of war, which corresponds to approximately 174 thousand km². Such a level of contamination is comparable to global high-risk mine-affected zones and requires comprehensive and long-term humanitarian and technical measures to ensure safe clearance and the restoration of land use (2025).

Large-scale mine contamination creates not only direct threats to human life and health but also significant socio-economic constraints. Contaminated territories restrict the movement of people, limit access to basic services, reduce labor productivity, hinder the safe conduct of agricultural activities, and disrupt logistics and trade flows in affected regions. Particular attention is paid by Humanity & Inclusion to the humanitarian dimension of the problem: since the beginning of the conflict, more than 40 thousand civilian casualties caused by explosive devices have been recorded, including severe injuries, amputations, and fatalities. This underscores the critical need for the implementation of risk education programs and preventive measures, especially for children and other vulnerable population groups.

Moreover, a large proportion of residents returning to de-occupied territories face the "invisible threat" of mines and explosive remnants of war, which leads to long-term psychological and social consequences. The population remains under constant stress, experiences uncertainty about the future, and faces limited opportunities to resume economic activities, significantly slowing down the process of socio-economic recovery. For many communities and settlements, safety remains uncertain, as territories require both non-technical surveys to identify potential hazards and subsequent technical clearance operations before economic activities can be resumed or displaced persons can return.

As evidenced by the analytical data from Humanity & Inclusion, these findings are consistent with information provided by governmental authorities and confirm that nearly one-third of Ukraine's territory is affected by mine hazards. This highlights the importance of using such data in further research to assess economic losses, plan humanitarian demining activities, and develop strategic management decisions for the recovery of affected regions. The scale of mine contamination in Ukraine not only poses a direct threat to human life and health but also generates substantial socio-economic constraints. To fully understand the impact of explosive devices on the economy and livelihoods in affected regions, it is necessary to analyze the structure of economic losses resulting from territorial contamination (Botnarenko, 2025). Such analysis enables the systematization of both direct and indirect damages, identification of priority areas for humanitarian demining, and substantiation of effective managerial decisions aimed at restoring socio-economic activity in affected territories. The structure of economic losses caused by contamination with explosive devices in Ukraine is presented in Table 2.

Table 2. Structure of economic losses of Ukraine's economy since the beginning of the full-scale Russian invasion.

№	Type of loss	Cost subcategories	Mechanism of loss formation	Approximate level of impact	Potential consequences for the economy and society
1.	Direct losses in the agricultural sector	1. Land taken out of cultivation. 2. Reduced crop yields. 3. Limited access to agricultural machinery.	Mine-contaminated and explosive-laden arable and pasture lands become temporarily unsuitable for use.	Very high.	Reduced production volumes, loss of foreign exchange earnings, and a threat to food security.
2.	Infrastructure losses	1. Roads and bridges. 2. Energy facilities. 3. Communications and logistics hubs.	Destruction or restricted functioning of facilities, complications in transport, and supply.	High.	Disruptions in goods transportation, delays in resource delivery, and increased logistics costs.
3.	Demining costs	1. Procurement of specialized equipment. 2. Training and personnel preparation. 3. Financing operational activities.	Necessity of large-scale clearance for safe land use restoration.	Very high.	Significant burden on the state budget and international aid, delays in restoring economic activity.
4.	Business and industrial losses	1. Enterprise shutdowns. 2. Limited production cycles. 3. Job reductions.	Contaminated territories restrict access to production facilities and resources.	High.	Reduced company revenues, increased unemployment, decreased domestic GDP.
5.	Investment losses	1. Reduced attractiveness of regions for investors. 2. Delayed project implementation.	Increased investment risk due to hazardous areas.	Medium-high.	Limited foreign and domestic investment, slowed economic recovery.
6.	Socio-economic losses	1. Reduced household incomes. 2. Migration processes. 3. Psychological stress on residents.	Limited access to work, business, and social services; population anxiety.	High.	Increased unemployment, social instability, and reduced quality of life.
7.	Environmental losses	1. Soil degradation. 2. Environmental pollution. 3. Loss of biodiversity.	Explosions and remnants of ammunition damage soils, water, and forest resources.	Medium.	Reduced land productivity, deterioration of environmental conditions, and long-term costs for reclamation.

Mine contamination makes the safe use of land resources impossible, restricts access of agricultural producers to farmland, leads to crop losses and a corresponding decline in income, and negatively affects the level of tax revenues. According to estimates by the World Bank, annual losses in budget revenues in affected regions amount to approximately USD 1.1 billion, which corresponds to 9.2% of total regional tax revenues in 2021 (Ukraine, Rapid Damage and Needs Assessment, 2025). According to a study conducted by the Tony Blair Institute for Global Change (TBI) in cooperation with the Ministry of Economy of Ukraine, mine contamination of agricultural land results in annual losses to the Ukrainian economy exceeding USD 11 billion in terms of GDP reduction (Methodology for determining the amount of damage caused to land and soils as a result of emergencies and/or armed aggression and hostilities during the period of martial law, 2022). The inability to fully utilize agricultural land also leads to a decrease in agricultural exports by approximately USD 4.3 billion annually, while additional losses from idle land are estimated at up to USD 0.8 billion per year.

In addition to economic impacts, environmental losses are also significant. During the period from 24 February 2022 to 31 December 2024, the territorial and interregional bodies of the State Environmental Inspectorate of Ukraine recorded damages amounting to nearly UAH 20 billion due to soil contamination and over UAH 1,169 billion due to land degradation and pollution, indicating an extremely high level of environmental damage caused by the military aggression of the Russian Federation (Report on indirect financial losses of the economy resulting from Russia's military aggression against Ukraine up to the end of 2026, 2026). These quantitative indicators can be summarized to provide a clear representation of the scale of economic and environmental consequences of mine contamination (Figure 2), enabling comparison of losses across key impact areas.

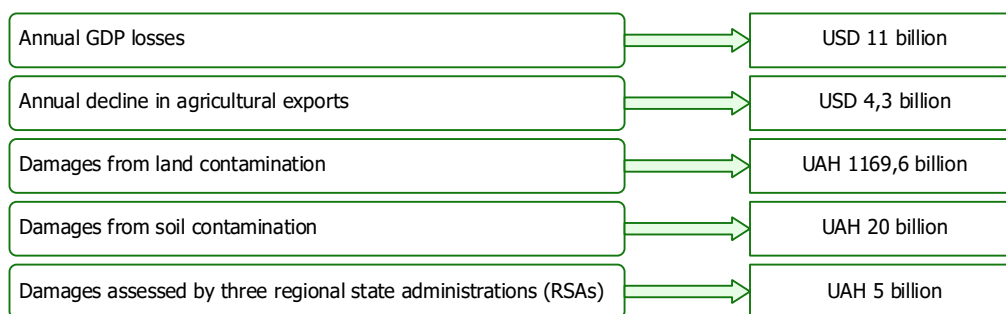


Figure 2. The main economic and environmental losses caused by mine contamination of Ukraine's territories. (Source: compiled by Report on indirect financial losses of the economy resulting from Russia's military aggression against Ukraine up to the end of 2026, 2026)

As observed, mine contamination of Ukraine's territories has the most significant impact on the country's GDP through its contraction, as well as on agricultural exports. Generalized macroeconomic assessments allow national economic losses to be interpreted as an integrated outcome not only of direct destruction but also of long-term constraints, among which mine contamination represents a key factor. According to estimates by the KSE Institute, Ukraine's total losses, including actual and projected reductions in revenue and value added, amount to approximately USD 1,7 trillion and USD 0,6 trillion, respectively. Such a scale of losses is largely indirectly driven by restricted access to production resources, including agricultural land and infrastructure facilities affected by mine hazards.

A comparison with earlier estimates, specifically USD 1,164 trillion in revenue losses and USD 385,7 billion in value-added losses as of July 2024, indicates a further increase in the overall scale of losses, partly reflecting the cumulative effect of mine contamination. The updated methodology and extension of the forecasting horizon to 2026 have enabled a more accurate consideration of the long-term economic consequences associated with the inability to fully utilize contaminated land. The structural distribution of losses confirms that mine contamination exerts an indirect impact across all key sectors of the economy. The largest losses are concentrated in trade (USD 696,3 billion), industry, construction, and services (USD 645,6 billion), as well as agriculture (USD 81,9 billion), which is directly linked to restricted access to land resources and production areas contaminated with explosive hazards. Significant losses in the energy sector (USD 75,3 billion) and transport (USD 60.2 billion) are also partially обусловлені risks associated with the safe operation of infrastructure in potentially mined areas (Report on the results of the performance audit on the topic. Humanitarian demining of agricultural land in Ukraine: restoring safety and agricultural production, 2025).

A separate category consists of additional expenditures directly related to addressing the consequences of mine contamination. The most substantial among these are demining costs (USD 24,6 billion), reflecting the scale of efforts required to restore safe land use. These also include expenditures related to housing reconstruction (USD 26.8 billion), debris removal and demolition of destroyed infrastructure (USD 13 billion), and social support for the population (USD 7.5 billion), all of which impose additional fiscal pressure under conditions of limited access to safe territories. Therefore, mine

contamination acts as a cross-sectoral factor that amplifies both direct and indirect economic losses, affecting production, investment activity, logistics, and overall social stability.

Alongside economic losses, social risks associated with mine contamination require significant attention, including threats to life and health, restricted access to territories and resources, and psychological consequences for communities. Simultaneously, the shortage of qualified personnel for humanitarian demining limits the speed and effectiveness of clearing territories, further intensifying the socio-economic pressure on affected regions and complicating the restoration of safe land use.

The main social risks related to mine contamination in Ukraine can be highlighted as follows:

1. Threats to life and health – mine-contaminated territories create a direct risk of injuries and fatalities among civilians. According to Humanity & Inclusion, since the start of the full-scale invasion, over 40,000 civilians have been injured, including severe injuries, amputations, and deaths. Children, elderly people, internally displaced persons, and agricultural workers are particularly vulnerable.
2. Restrictions on mobility and access to services – contaminated areas limit people’s movement, complicating access to medical, educational, and social services. Damaged infrastructure and risk of explosions also hinder the transportation of goods and humanitarian aid, further exacerbating social problems in affected regions.
3. Psychological and social consequences – the persistent threat of mines and explosive remnants of war causes high levels of stress, anxiety, and uncertainty about the future, especially for those returning to de-occupied areas. This affects communities’ readiness to resume economic activities, reduces social integration, and increases psychological pressure on vulnerable groups.
4. Impact on socio-economic activity – contaminated territories directly restrict economic activity by lowering labor productivity, temporarily taking land out of cultivation, and limiting business processes. This leads to rising unemployment, reduced household incomes, and delayed or canceled investment projects, creating additional social tensions and slowing the economic recovery of affected regions.
5. Shortage of qualified demining personnel – a limited number of certified specialists slows humanitarian demining, prolonging the mine threat and amplifying socio-economic consequences. This creates a cyclical effect: hazardous areas restrict economic and social activity, which, in turn, reduces opportunities for training and attracting additional specialists, complicating the restoration of safe land use and stable community life.

The presented overview of social risks not only systematizes the key problems related to mine contamination but also emphasizes the interconnection between population safety, community psychological well-being, and regional economic activity. For a clear representation of these interdependencies and the degree of impact of each factor, it is advisable to present social risks in a structured diagram (Figure 3).

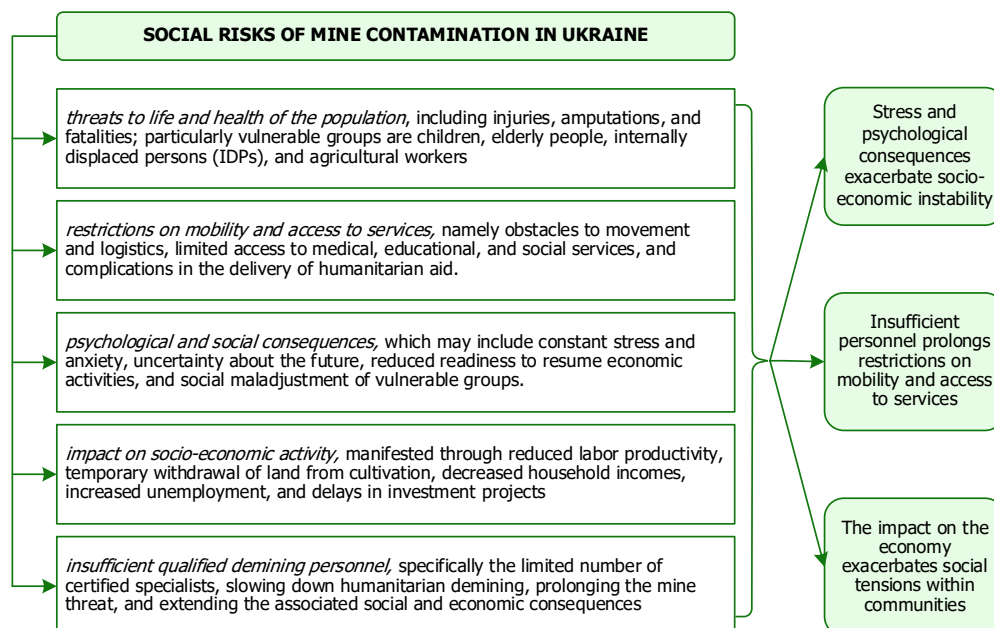


Figure 3. Social risks of mine-contaminated areas in Ukraine and their interconnections.

The social risks associated with mine contamination in Ukraine are complex and interconnected, as they combine immediate threats to human life and health with long-term consequences for the socio-economic development of communities. Restricted access to the safe use of land, infrastructure, and essential services creates persistent barriers to restoring normal living conditions, intensifies migration processes, and contributes to rising social tensions. In this context, it is important to note that, according to estimates by the Ministry of Defence of Ukraine, the pace of humanitarian demining increased by nearly 50% in the first half of 2025 compared to 2024. However, despite this positive trend, demining activities remain significantly constrained by a range of systemic factors, including the large scale of mine contamination, limited funding, insufficient technical capacity, a shortage of qualified personnel, challenging security conditions, inadequate levels of non-technical land survey, weak coordination among mine action stakeholders, and the presence of bureaucratic barriers.

At the same time, the institutional and operational capacity of mine action in Ukraine continues to expand. A wide range of actors are currently involved, including the State Emergency Service, the National Police, the Ministry of Defence of Ukraine, and non-governmental organizations. In total, 112 certified mine action operators are active, of which 8 are foreign entities. More than 9,000 specialists are engaged in demining operations, supported by 278 units of mechanized equipment and over 13,000 metal detectors, indicating a gradual increase in operational capacity. The growing number of operators has contributed to the development of a competitive environment in the demining services market, which, in turn, has led to a significant reduction in the cost of operations. However, cost estimates remain highly variable: according to different sources, the cost of demining one hectare of agricultural land in 2025 ranges from UAH 31,000 to UAH 62,000, which complicates the planning of both public and donor-funded resources. The institutional strengthening of mine action is also reflected in the state's strategic documents. In 2024, the National Mine Action Strategy until 2033 and a tripartite operational plan for 2024–2026 were approved, envisaging the clearance of at least 70% of potentially contaminated territories by 2033. In addition, the Ukraine Demining Cluster was established, bringing together more than 60 international and national companies and focusing on the long-term restoration of land for economic use by 2040.

Financing of mine action is implemented through a mixed model that combines domestic and international resources. Particular emphasis is placed on international support for demining efforts: total partner contributions to humanitarian demining in Ukraine reached USD 1.5 billion in 2025, including additional commitments of USD 80 million announced at the Mine Action Conference with the participation of representatives from 57 countries and leading international organizations, including the European Union and the United Nations. At the same time, efforts are underway to implement the digital platform GRIT, which supports planning, prioritization, and monitoring of humanitarian demining activities, serving as an important tool for strategic management and improving operational efficiency. The State Budget of Ukraine for 2026 allocates approximately UAH 2 billion to compensate for costs associated with the humanitarian demining of agricultural land. Additionally, in 2025, an international Demining Coalition was established, uniting over 50 countries and mobilizing approximately USD 1.2 billion in financial, technical, and expert assistance. An important direction for increasing the effectiveness of mine action is technological modernization. Unmanned technologies, elements of artificial intelligence, and geographic information systems are being actively implemented for mapping contaminated areas. The use of drones, thermal imaging technologies, and automated image processing enables the creation of density maps of explosive hazards and the prioritization of demining zones, significantly improving the accuracy of managerial decision-making (Report on indirect financial losses of the economy resulting from Russia's military aggression against Ukraine up to the end of 2026, 2026).

Overall, mine action in Ukraine is evolving into a comprehensive system that integrates institutional, financial, technological, and organizational components. The adoption of strategic documents, expansion of operational capacity, strengthening of international partnerships, and implementation of innovative technologies create a foundation for the gradual reduction of social risks associated with mine contamination. However, the scale of the remaining challenge requires substantial resources: according to estimates, the full clearance of potentially contaminated territories in Ukraine will require approximately USD 24.6 billion (excluding maritime areas), highlighting the long-term nature of the problem and the need for continued coordination between the state and international partners.

Given the scale of economic losses, social risks, and the limited resources in humanitarian demining, the development and implementation of effective strategic management solutions and project-based approaches becomes particularly important. Such solutions should be grounded in the principles of systematization, prioritization, risk-oriented planning, interagency coordination, and project management, ensuring resource optimization, effective work planning, execution control, and acceleration of territory clearance processes. Table 3 presents the main strategic management decisions and project activities in the field of humanitarian demining in Ukraine.

The presented strategic management decisions provide a comprehensive framework for enhancing the effectiveness of humanitarian demining in Ukraine, as they cover institutional, personnel, technological, financial, and social aspects, while ensuring project-based implementation of all key initiatives. Their implementation will contribute not only to accelerating the clearance of territories from explosive hazards but also to creating conditions for sustainable socio-economic recovery of affected regions, increasing population safety, and integrating Ukraine into the international humanitarian demining system.

Table 3. Strategic management decisions and project activities to enhance the effectiveness of humanitarian demining in Ukraine.

№	Strategic management direction	Content of the management decision	Expected socio-economic and managerial effects
1.	Institutional support	Establishment of a unified national coordination center for mine action; harmonization of the legal framework with international standards (IMAS); clear division of powers among authorities; implementation of unified management procedures; project-based planning of the center's activities and coordination programs.	Reduction of institutional fragmentation; faster decision-making; alignment of actions among all stakeholders; shorter implementation time for demining programs.
2.	Development of human resources	Expansion of training, retraining, and certification system for deminers; creation of specialized training centers; implementation of international training standards; incentives for specialist recruitment (including veterans); project-based training, simulations, and certification programs.	Increased number of qualified operators; improved quality and safety of operations; reduced duration of land clearance.
3.	Technological modernization	Integration of innovative technologies: unmanned systems, robotic complexes, remote sensing systems, GIS platforms; digitalization of survey and monitoring processes; project-based implementation of technology upgrades.	Increased demining productivity; reduced risks to personnel; higher accuracy in identifying hazardous areas; cost optimization.
4.	Financial support	Development of long-term financing programs; creation of dedicated demining funds; mobilization of international technical and financial assistance; use of public-private partnership mechanisms; project-based budgeting and resource control.	Ensures stability of financial flows; reduces budgetary burden; increases scale and speed of operations.
5.	Information and analytical support	Creation of a unified digital database of contaminated areas; integration of geoinformation systems; use of analytical tools for risk forecasting and work planning; project-based analytical dashboards and monitoring platforms.	Improved rationale for management decisions; transparency and control of processes; effective resource planning.
6.	International cooperation	Expansion of partnerships with international organizations (UNDP, HALO Trust, MAG, etc.); participation in international programs; access to foreign technologies and expertise; project-based involvement of partners in specific demining programs.	Enhanced technical and expert capacity; access to innovations; accelerated integration into global mine action standards.
7.	Prioritization of territories	Definition of prioritization criteria (population density, economic significance, agricultural potential, critical infrastructure); application of a risk-oriented approach; project-based planning of work sequence.	Maximization of socio-economic impact from demining; rapid recovery of key economic sectors; increased population safety.
8.	Social policy and risk education	Conducting awareness campaigns on mine safety; implementation of educational programs in schools and communities; support for affected individuals (rehabilitation, social assistance); project-based communication and training activities.	Reduction of injuries and fatalities; increased public awareness; social stabilization of affected areas.
9.	Integration with economic recovery	Coordination of demining with infrastructure reconstruction programs, agricultural sector development, and investment policy; inclusion of demining in regional development strategies; project-based coordination with recovery initiatives.	Accelerated economic recovery; return of land to productive use; increased investment attractiveness of regions.

In the context of identified economic losses, social risks, and institutional limitations in humanitarian demining, there is a need to deepen the theoretical and methodological foundation of strategic management by developing an integrated scientific and project-based approach capable of ensuring the substantiation and effectiveness of management decisions. Given the multidimensional consequences of mine contamination, it is advisable to apply an integrated risk-oriented approach based on multi-criteria optimization, which allows synthesizing economic, social, infrastructural, and environmental parameters into a unified decision-making and project planning system.

The theoretical and methodological basis of the proposed approach is founded on a combination of principles from systems analysis, risk management, multi-criteria decision-making, and project management. This involves hierarchical decomposition of the management object, formation of project blocks, and subsequent integration of assessment results in the form of aggregated priority indicators. Within this approach, the process of strategic management of humanitarian demining should be implemented through a sequence of interconnected stages, including project planning, monitoring, and evaluation of results (Figure 4).

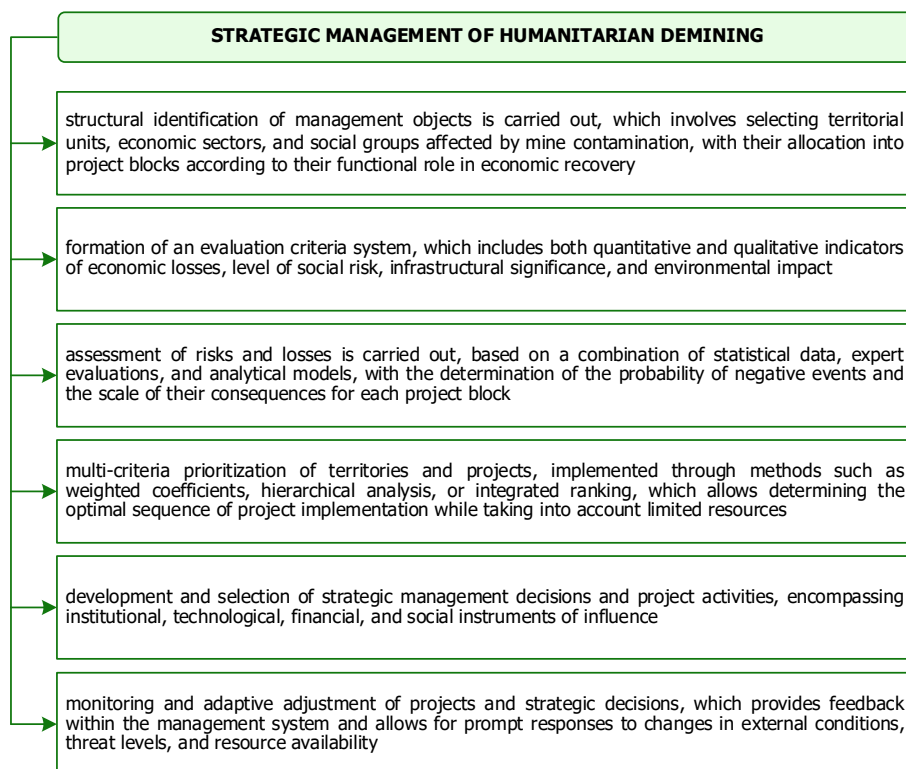


Figure 4. Stages of strategic management of humanitarian demining.

To formalize the proposed integrated risk-oriented approach, a multi-criteria prioritization model for humanitarian demining areas has been developed, based on the principles of weighted aggregation of economic, social, infrastructural, and environmental indicators. Let a set of territorial units be defined as $T = \{t_1, t_2, \dots, t_n\}$ for each territory t_i , a vector of criteria x_{ij} where $j=1, \dots, m$, is constructed, representing:

- x_{i1} - the level of economic losses;
- x_{i2} - the level of social risk to the population;
- x_{i3} - the significance of infrastructure objects;
- x_{i4} - the environmental impact of mine contamination.

The integral priority index of territory is defined as:

$$P_i = \sum_{j=1}^m w_j * x_{ij}^*$$

$$\sum_{j=1}^m w_j = 1, w_j \geq 0,$$

where: P_i is the aggregated priority index of demining for territory; w_j are the weights of the criteria; x_{ij}^* are the normalized values of the original indicators.

Normalization is performed using the min–max approach:

$$x_{ij}^* = \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)}$$

which ensures the transformation of heterogeneous indicators into a unified scale and the correctness of their subsequent aggregation. The determination of weights w_j may be carried out using expert evaluation or the Analytic Hierarchy Process (AHP), allowing for consideration of the relative importance of criteria in decision-making.

The formalized prioritization problem can be represented as a maximization problem:

$$\max P_i, i = 1, \dots, n,$$

subject to resource constraints:

$$\sum_{n=1}^n C_i * y_i \leq B, y_i \in \{0,1\},$$

where: C_i is the cost of demining territory t_i ; B is the available budget; y_i is a binary variable indicating whether the territory is included in the priority demining plan.

The proposed model enables formalized multi-criteria prioritization of humanitarian demining areas under resource constraints, ensuring a balance between economic efficiency, social relevance, and managerial justification of decision-making. To validate the applicability of the developed model, an illustrative test was conducted on a hypothetical set of territorial units $t_1 - t_4$, characterized by different levels of economic losses, social risk, infrastructural significance, and environmental impact. The input indicators were normalized in advance using the min-max method and expressed as dimensionless values (Table 4).

Table 4. Normalized values of evaluation criteria and input data for testing the multi-criteria prioritization model of humanitarian demining areas.

Territory	Economic losses	Social risk	Infrastructure significance	Environmental impact
t_1	0.90	0.80	0.70	0.60
t_2	0.60	0.90	0.80	0.70
t_3	0.70	0.50	0.60	0.90
t_4	0.40	0.60	0.50	0.40

The weights of the criteria were determined based on an expert approach, taking into account the relative importance of the influencing factors:

$$w = \{0,35, 0,30, 0,20, 0,15\}$$

The integral priority indices were calculated using a weighted additive model:

$$P_1 = 0,79$$

$$P_2 = 0,76$$

$$P_3 = 0,68$$

$$P_4 = 0,47$$

The obtained values allow for the ranking of territories according to the priority level of humanitarian demining:

$$t_1 > t_2 > t_3 > t_4.$$

The results of the illustrative validation confirm the applicability of the proposed model for the formalized ranking of territories within a multi-criteria environment. In particular, the model ensures the integration of economic, social, infrastructural, and environmental parameters into a unified evaluation framework, which enhances the justification of managerial decision-making in the field of humanitarian demining under resource constraints.

The advantage of the proposed approach lies in its integrative, adaptive, and project-oriented nature, which allows for consideration of the dynamics of mine hazards, territorial heterogeneity in development, and the need to balance economic efficiency, social safety, and practical project implementation. The application of multi-criteria procedures enhances the objectivity and transparency of decision-making, which is critically important for international coordination, the mobilization of financial and technical assistance, and the management of complex demining projects.

The proposed scientific-methodological approach serves as an instrumental foundation for the formation and implementation of strategic management decisions and humanitarian demining projects, ensuring logical coherence, justification, and prioritization. Risk-oriented assessment determines the appropriateness of prioritizing territories and projects, multi-criteria analysis supports the optimization of resource allocation, and adaptive monitoring enhances the effectiveness of institutional and technological transformations. Together, this forms a comprehensive model of strategic management for humanitarian demining with a project-based component, aimed at minimizing losses, reducing social risks, and ensuring the sustainable development of affected territories.

Based on the conducted analysis, the key directions for improving the system of strategic and project management of humanitarian demining in Ukraine have been identified:

1. Comprehensive territorial analysis considering economic, social, and environmental risks – a systematic assessment of the level of mine contamination, identification of priority demining zones, and forecasting potential consequences. This includes mapping, evaluation of infrastructure conditions, and determination of priorities in agriculture, industry, and the social sector.
2. Establishment of a training and certification system for specialists – practical training in the use of modern technologies, robotic systems, unmanned aerial vehicles (UAVs), risk assessment methodologies, and strategic demining planning. Certification ensures high personnel qualification and enhances work safety.
3. Implementation of robotic and UAV systems – increases operational safety, reduces demining timeframes, enables risk assessment in hard-to-reach and hazardous areas, allows precise mapping, and accelerates work completion.
4. Stable and effective financing – creation of mechanisms for mobilizing national and international resources, optimizing the use of available financial assets, and introducing a transparent expenditure control system.
5. Use of geographic information systems and digital databases – continuous monitoring of contaminated areas, analysis of risk dynamics, evaluation of the effectiveness of implemented measures, precise forecasting, and resource optimization.
6. Enhancement of international cooperation and application of international standards (ISO, IMAS) – attracting additional resources and best practices, unifying approaches, and improving the safety and effectiveness of demining programs.
7. Development of adaptive work plans – rapid response to changes in the political, social, and economic environment, with adjustments to priorities and resources according to evolving risk dynamics.
8. Communication system with local communities and investors – informing the population about risks, involving them in planning and oversight, and engaging external partners and investors to support projects.
9. Performance evaluation based on KPIs – determining the effectiveness of demining activities, analyzing resource expenditure, comparing actual results with planned objectives, enhancing transparency, and improving operational processes.

A special role in ensuring the effectiveness of humanitarian demining is played by state-targeted programs, which enable systematic and stable funding of demining activities. Such programs provide for the allocation of dedicated budgetary funds for demining operations, technology updates, training and certification of specialists, as well as social support for affected communities. Utilizing state-targeted programs allows for optimizing resource allocation, ensuring transparency in financing, and guaranteeing continuity of operations even under conditions of limited financial and material resources. Furthermore, integrating these programs with international initiatives creates synergy, increases the scale and effectiveness of demining projects, and contributes to the more efficient restoration of affected areas (Khudoliy & Voitsekhivska, 2015).

An important aspect of humanitarian demining is the creation of safe passages through engineering obstacles, which ensures secure access to populated areas, infrastructure facilities, and strategically important territories. This work requires the use of specialized technologies, including mechanized systems, remote detectors, and robotic platforms, which reduce risks for personnel and enable effective identification of safe movement routes. Planning such passages should be based on a multi-criteria assessment of risks and prioritization of zones, which increases the accuracy of operations and reduces the time required for demining tasks.

At the same time, establishing passages through engineering barriers is a key element in supporting the economic and social activity of affected regions. Restoring safe access to agricultural lands, industrial facilities, transport routes, and social infrastructure accelerates economic recovery, ensures the normal functioning of communities, and improves population mobility. Additionally, these measures provide a foundation for strategic planning of further humanitarian demining operations, facilitate integration with infrastructure recovery programs, and increase the efficiency of using both state and international resources.

In the future, further research may focus on improving methodologies for assessing the economic, social, and environmental consequences of mine contamination, particularly through the integration of big data, remote sensing, and geographic information systems. An important direction is the development of multi-criteria prioritization models for territories, taking into account risk dynamics, resource availability, and potential impacts on local communities, which would allow for optimized resource allocation and increased effectiveness of humanitarian demining operations. Special attention should be given to studying the socio-psychological aspects of mine contamination's impact on the population and behavioral

factors that may affect the safety and efficiency of demining activities. It is also advisable to examine the effectiveness of state-targeted programs and international initiatives in terms of financing and coordination of demining efforts, as well as the adaptation of advanced technologies and international standards to Ukrainian conditions to ensure sustainable recovery of affected territories.

DISCUSSION

The obtained results confirm that humanitarian demining in Ukraine should be considered not merely as a technical process, but as a complex socio-economic system requiring the integration of strategic and project management approaches. Unlike most previous studies, which predominantly adopt sectoral or technological perspectives, this study proposes a comprehensive model that integrates the assessment of economic losses, social risks, and multi-criteria prioritization of territories.

A comparison of the results with approaches developed by international organizations and recent academic studies reveals both similarities and differences. In particular, the approach of the Geneva International Centre for Humanitarian Demining is primarily based on the standardization of procedures (IMAS), quality management, and coordination among mine action stakeholders. However, it places less emphasis on the economic feasibility and social effects of territorial prioritization. The approach proposed in this study extends this framework by integrating economic, social, and infrastructural criteria into a unified decision-making system.

Similarly, to the multi-criteria evaluation model presented in Camacho-Sanchez et al., this study employs weighted aggregation of indicators for ranking territories. However, unlike that approach, which mainly focuses on technical hazard parameters, the proposed model significantly expands the set of criteria by incorporating social risks and economic losses, thereby enhancing the practical relevance of the results for post-conflict recovery processes. The findings are also consistent with the conclusions of Prem et al., who demonstrate the substantial impact of mine contamination on economic activity and population mobility.

At the same time, the aforementioned studies predominantly rely on macroeconomic analysis, whereas this research focuses on the micro-level of managerial decision-making through the mechanism of territorial prioritization and the formation of demining project portfolios. Thus, the scientific novelty of the proposed approach lies in the integration of strategic management and project management principles; the incorporation of economic, social, infrastructural, and environmental criteria; the formalization of decision-making through a multi-criteria model; and the consideration of resource constraints in the form of an optimization problem. Particular attention should be given to the identified interdependence between human resource capacity and the pace of demining operations. The results indicate that a shortage of qualified operators creates a cyclical mechanism that slows down territorial recovery, a phenomenon that has only been partially addressed in previous research. At the same time, the results of the study are subject to certain limitations. The use of aggregated statistical data on contaminated areas and economic losses may introduce estimation errors. Given the diversity of data sources (government institutions, international organizations, and expert assessments), the possible deviation range in estimating the extent of mine contamination is approximately 10–20%, which correspondingly affects the calculation of economic losses. Furthermore, the application of expert-based weighting of criteria may introduce a degree of subjectivity, which, despite consistency checks, does not entirely eliminate the influence of individual expert judgments.

In addition, the dynamic nature of the security environment and changes in frontline conditions may rapidly alter territorial priorities, necessitating continuous data updates and model adaptation. Limitations are also associated with incomplete information regarding the actual condition of territories, particularly in active combat zones or recently de-occupied areas, which may affect the accuracy of normalization procedures and ranking results. Despite these constraints, the proposed approach demonstrates a high level of practical applicability, as it provides a structured framework for managerial decision-making in the field of humanitarian demining under conditions of uncertainty and limited resources.

CONCLUSIONS

The results of the study indicate that mine contamination in Ukraine constitutes a systemic factor that comprehensively affects economic development, social security, and the functioning of infrastructure. It has been demonstrated that its consequences manifest both in the form of direct losses, such as the withdrawal of land from economic use, a decline in production volumes, and restrictions on the operation of infrastructure facilities, and in the form of indirect effects, including reduced investment attractiveness, increased social tensions, and limited population mobility.

The study substantiates the feasibility of applying an integrated approach to the strategic management of humanitarian demining, combining risk-oriented analysis, project management principles, and multi-criteria optimization. This approach enables the systematic consideration of economic, social, infrastructural, and environmental factors in managerial decision-making and enhances their validity under conditions of uncertainty and limited resources.

Within the research framework, a formalized multi-criteria prioritization model for humanitarian demining areas has been developed. The model is based on the weighted aggregation of normalized indicators and allows for the integration of heterogeneous criteria into a single priority index. The results of the model's validation confirm its suitability for practical application in ranking territories under resource constraints and determining the optimal sequence of demining operations.

It has been established that the effectiveness of humanitarian demining is determined by the interaction of institutional, human resource, financial, and technological factors. In particular, a shortage of qualified specialists has been identified as a critical constraint that slows down the pace of territory clearance and, consequently, delays the socio-economic recovery of affected regions.

The practical significance of the obtained results lies in the applicability of the proposed approach for substantiating territorial prioritization, optimizing the allocation of financial and technical resources, forming portfolios of humanitarian demining projects, and improving the effectiveness of managerial decision-making in mine action. The application of the multi-criteria model contributes to increased transparency in planning processes, enhanced coordination among stakeholders, and accelerated recovery of affected territories.

Future research should focus on improving methods for assessing the economic and social impacts of mine contamination through the use of geographic information systems, big data, and remote sensing technologies. Further development of multi-criteria optimization models that account for the dynamic nature of the security environment is also warranted, along with deeper investigation into the socio-behavioral aspects of risk that influence the effectiveness of humanitarian demining.

ADDITIONAL INFORMATION

AUTHOR CONTRIBUTIONS

All authors have contributed equally.

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CONFLICT OF INTEREST

The Authors declare that there is no conflict of interest.

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СТРАТЕГІЧНИЙ МЕНЕДЖМЕНТ ПРОЄКТІВ ГУМАНІТАРНОГО РОЗМІНУВАННЯ В УКРАЇНІ: ЕКОНОМІЧНІ ВТРАТИ ТА СОЦІАЛЬНІ РИЗИКИ

Мінне забруднення територій України є одним із ключових факторів, що стримують соціально-економічне відновлення держави, обмежують ефективне використання природних ресурсів і формують суттєві ризики для безпеки населення. За оцінками Міністерства оборони України, станом на кінець 2024 р. площа потенційно забруднених вибухонебезпечними предметами територій становить близько 139 тис. км², що відповідає приблизно 25–29% території країни. Такий масштаб мінної небезпеки зумовлює значні економічні втрати, які, за окремими оцінками, перевищують 17 млрд дол. США у 2025 р. та мають тенденцію до зростання.

Методологічну основу дослідження становлять положення стратегічного менеджменту, проєктного управління та ризик-менеджменту. У роботі використано методи системного, структурного та порівняльного аналізу, експертного оцінювання, а також інструменти багатокритеріального аналізу для обґрунтування пріоритетності управлінських рішень. Інформаційну базу сформовано на основі даних міжнародних організацій, державних інституцій та аналітичних звітів щодо масштабів мінного забруднення й пов'язаних соціально-економічних втрат.

У дослідженні обґрунтовано інтегрований ризик-орієнтований підхід до стратегічного управління гуманітарним розмінуванням, що поєднує принципи багатокритеріальної оптимізації та проєктного менеджменту. Розроблено формалізовану модель пріоритезації територій, яка базується на основі зваженого узагальнення показників економічних втрат, соціальних ризиків, функціональної ролі інфраструктури та екологічного впливу, а також ураховує ресурсні обмеження в процесі планування. Результати апробації моделі підтверджують її придатність для ранжування територій і підвищення обґрунтованості управлінських рішень у царині протимінної діяльності.

Практичне значення отриманих результатів полягає в можливості застосування запропонованого підходу для оптимізації розподілу ресурсів, формування проєктів гуманітарного розмінування та підвищення ефективності стратегічного управління. Реалізація запропонованих рішень сприятиме прискоренню відновлення постраждалих територій, зниженню соціальних ризиків і забезпеченню стійкості соціально-економічного розвитку регіонів.

Ключові слова: багатокритеріальна оптимізація, гуманітарне розмінування, економічні втрати, мінне забруднення, післявоєнне відновлення, пріоритезація територій, протимінна діяльність, ризик-орієнтований підхід, управління проєктами, стратегічний менеджмент, соціальні ризики, управлінські рішення

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