

The sustainability of financing for the demining process in Ukraine's territory

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Abstract. The article considers the possibility of integrating demining efforts with economic recovery and sustainable development initiatives. For this purpose innovative financial models such as Outcomes-Based Financing, Outcome-Based Public-Private Partnerships and Sustainability-Linked Bonds are proposed that can provide sustainable financing beyond traditional humanitarian aid. The potential to attract diverse sources of capital and to overcome funding gaps is demonstrated by these mechanisms, with demining transformed from a costly humanitarian operation into a strategic investment. Specific recommendations are provided for creating a favourable regulatory environment, prioritizing economically significant work, and strengthening international coordination. The main conclusion is that the transformation of approaches to financing is deemed essential for ensuring Ukraine's comprehensive post-war recovery and prosperity.

1 Introduction

The challenges associated with demining in Ukraine are analyzed in this article, which is estimated to be the most heavily mined country in the world. The large-scale contamination with explosive remnants of war, covering approximately 174,000 km² (almost 30% of the country's territory), is identified as a direct consequence of the full-scale invasion. Tragic human losses are not only caused, particularly among children, but vast agricultural lands are rendered unproductive, and economic recovery as well as food security are critically hampered. According to international experts, a cost of US\$34.6 billion is estimated for complete demining over the next decade by Ukraine's economy, with urgent updates to approaches to financing this process being required. The widespread contamination of Ukraine's territory with explosive remnants of war (ERW) is one of the most acute consequences of Russia's full-scale invasion. Ukraine is now the most heavily mined country in the world, with around 100 million people in more than 60 countries and territories living under the threat of landmines and ERW. Human casualties are rising: in 2024, the number of people injured and killed by EOD increased by 22 percent, representing over 1,000 additional

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victims compared to 2023. It is noteworthy that about 85 percent of landmine victims worldwide are civilians, and more than half of them are children [1].

Scientific publications address this issue from various angles, encompassing general challenges, technical and economic aspects, as well as specific financing mechanisms and their economic impact. International experts and organizations are actively seeking new financing models to complement traditional donor assistance. They emphasize the need to attract private capital through instruments such as social bonds and impact investments. These authors stress that financing mine clearance can be attractive to investors because it contributes to humanitarian missions and opens up opportunities for economic development.

Experts [2] from the United Nations Development Programme (UNDP) in their report “Enhancing Mine Action Finance in Ukraine” propose specific solutions, including Sustainability-Linked Bonds and Public-Private Partnerships.

Kryvtun and Naniwska draw attention to factors that influence the speed and cost of demining, emphasizing the need for a systematic approach that combines investment with effective process management [3]. Research linking demining with economic recovery occupies a special place. The author [4] argues that the restoration of economic activity and the growth of capitalization of enterprises in the agro-industrial sector are impossible without clearing the territories. This publication emphasizes that financial support for demining is a necessary condition for business recovery and development.

The publications analyzed indicate that financing demining is a complex, interdisciplinary problem that requires a comprehensive approach. Researchers focus both on general problems and their impact on the economy, as well as on specific financing mechanisms.

2 Methodology

The development of specific financial models and instruments for the effective mobilization, allocation and use of funds in accordance with humanitarian demining priorities is a relevant issue for research. Models such as Outcomes-Based Financing (OBF), Outcome-Based Public-Private Partnerships (OB-PPPs), Sustainability-Linked Bonds (SLBs), Cost reimbursement schemes for farmers with donor support, Corporate Social Responsibility (CSR) and Crowdfunding are considered. These models connect financing to specific results – demining – which makes investments more transparent and attractive.

3 Discussion and Results

Mine action is identified as one of the key factors in ensuring lasting peace, strengthening security, and stimulating development. The threat of mines makes it impossible to access agricultural land, undermines food security, deprives children of their right to attend educational institutions, hinders the creation of new jobs, and complicates the return of internally displaced persons and refugees to their homes [1].

In today's world, mine action is not only important for humanitarian reasons, but also for social and economic reasons, as it is a prerequisite for rebuilding critical infrastructure, stabilizing local communities, and implementing government programs for the reintegration of territories. The contamination of Ukrainian territory with explosive remnants of war (ERW) has reached unprecedented levels and is one of the leading threats to national security, socio-economic development, and post-war recovery. As of April 2023, approximately 174,000 km², or 29-30 percent of the country's territory, was considered potentially mined. Some sources gave an even higher estimate of up to 40 percent. According to the State Emergency Service of Ukraine, in January 2023, the scale of the mine hazard covered about

30 percent of the country's territory. Thanks to the coordinated actions of state bodies and international partners, the area of potentially dangerous land was reduced from 156,000 km² to 139,000 km² in 2024, which is larger than the area of Greece. Despite the progress achieved, Ukraine remains the country with the world's widespread scale of ERW contamination [5, 6].

Comparative data show that Ukrainian indicators significantly exceed the scale of mine contamination in other countries that have experienced prolonged wars. In Bosnia and Herzegovina, approximately 1,125 km², or 2.2–2.4 percent of the country's territory, remained dangerous between 2013 and 2024 [7]. Even in Cambodia, which was considered one of the most mine-affected regions in the world, the figure was around 715 km² [8].

A significant part of Ukraine's agricultural land, which is strategically important for the economy, is not being used due to the threat of mines and other consequences of the war. It is estimated that about 3,000 km² of land remains excluded from agricultural production, which is about one-fifth of agricultural land [9].

Mine contamination poses not only economic but also humanitarian and environmental risks. The most affected are the frontline and de-occupied regions: Chernihiv, Sumy, Kharkiv, Donetsk, Dnipropetrovsk, Mykolaiv, Kherson, and Odesa regions. More than 2.8 million people live here, which is a significant proportion of the 5.4 million citizens who need comprehensive assistance within the framework of mine action programs. The highest density of ERW is recorded in areas adjacent to the line of contact, where the mine hazard blocks land use and makes infrastructure restoration impossible, which increases the relevance of humanitarian demining [5].

Demining is a long-term and capital-intensive process, the implementation of which is only possible with widespread investments. Its duration depends on the extent of contamination, types of ERW, and natural conditions, which is why in many countries this process takes decades.

International experience shows that the demining process is exceptionally long. In a number of countries affected by military conflicts at the end of the 20th century, work on the disposal of explosive objects is still ongoing. A significant number of states that have undertaken international obligations to clear their territories of mines are unable to meet their deadlines due to the widespread contamination. Even in countries where hostilities ended more than half a century ago, explosive remnants continue to pose a serious threat to the population and hinder sustainable development.

The cost of humanitarian demining depends on the degree of contamination and can range from \$0.3 to \$200 per square meter. The total cost of demining in Ukraine could reach \$30 billion, with an average cost of \$2–8 per square meter [10]. The cost of the work is increasing due to the need to involve qualified specialists, use robotic systems, drones, and other modern technologies, as well as conduct information campaigns for the population. Given the widespread nature of the task, mine action in Ukraine requires long-term financing strategies, innovative technological solutions, and broad international support. In view of the above, international aid and state budgets allocated for Ukraine's recovery should consider demining as an essential, mandatory investment rather than a separate area of humanitarian activity. This approach will make it possible to unlock broader financial resources for demining by integrating it into the overall strategy for the country's recovery. The economic impact of UXO contamination in Ukraine is significant and multifaceted. Table 1 shows an estimate of the annual economic influence of mine contamination in Ukraine.

Table 1. Estimated annual economic impact of mine contamination in Ukraine (potential before and after demining)

Indicators	Value (annual)	Explanation
Loss of GDP	US\$11.2 billion [11]	Equivalent to approximately 5.6 percent of Ukraine's GDP in 2021. In the most affected areas, the impact exceeds 20 percent of regional GDP
Export reduction	US\$8.9 billion [11]	Before the war, agriculture accounted for 41 percent of Ukraine's exports.
Decrease in regional tax revenues	US\$1.1 billion [11]	Approximately 31 percent
Total contaminated area	139,000 km ² (potentially) [5]	Estimates vary from 30 percent to 40 percent of Ukraine's territory [6]
Inaccessible agricultural land	6 million hectares (60,000 km ²) [9]	Approximately one-fifth of all agricultural land [9]
Potential restoration	80 percent of contaminated areas to productive use within 10 years [11]	-

The economic cost of inaction far exceeds the investment in demining. Annual GDP losses are estimated at US\$11.2 billion, and export losses at US\$8.9 billion due to contamination [11]. The total cost of demining is US\$34.6 billion [12]. This means that in just 3-4 years, the economic losses from inaction will equal or exceed the total investment in demining. This situation highlights the critical opportunity cost. The cost-benefit analysis of demining agricultural land in Ukraine is presented in Table 2.

Table 2. Cost-benefit analysis of agricultural land demining in Ukraine (estimates per hectare)

Indicators	Cost/benefit estimate
Cost of non-technical survey (NTS)	~US\$6 per hectare [9]
Cost of detecting explosives	>\$3,000 per hectare [9]
Cost of mechanized demining/clearing	up to \$30,000 per hectare [9]
Total estimated cost of demining agricultural fields	\$10-15 billion [9] (Does not include costs of agrochemical recultivation, infrastructure, new equipment, and insurance mechanisms)
Economic benefit (multiplier)	4+ USD return on every USD invested [9] (Includes GDP growth, job creation, and the return of people to communities)
Total cost of demining Ukraine	34.6 billion USD [12]
Time to return on investment	<3.5 years [11] (if funding needs are fully met)

This is a compelling argument for rapid and significant investment in demining, not only as a humanitarian imperative, but also as a financially responsible strategy for economic recovery. Delaying demining will lead to cumulative economic losses, making overall recovery more expensive and protracted.

The demining of agricultural land has the most direct and immediate economic benefits. Many sources repeatedly emphasize the serious impact on Ukraine's agricultural sector, its pre-war role as a global food supplier, and the direct economic losses from uncultivated land

[5]. Unlike other sectors, agriculture cannot be easily relocated from affected areas to unaffected ones [11].

To bridge the significant funding gap in Ukraine's demining and ensure sustainable recovery, a shift from traditional humanitarian aid to innovative financing mechanisms is needed. OBF involves paying funds only for independently verified results, rather than for resources spent [2]. Payment is made for each hectare of land cleared of explosive hazards, for the restoration of social and economic activity in the area, or for the return of internally displaced persons to their homes. This approach encourages flexible and adaptive work performance, as contractors are free to choose the most effective methods to achieve their goals. OBF minimizes risks as payment is made only for the successful achievement of agreed results. This model is particularly attractive to impact investors and development institutions seeking measurable social and economic benefits from their investments.

The introduction of OBF will promote greater national accountability, as payments will be linked to objectively measured, publicly verified results. This will encourage closer cooperation between government agencies and service providers and increase overall accountability. Even the successful experience of UNMAS in Afghanistan, Sudan, Iraq, and Palestine, where the results were cleared land, restored houses, and the return of the population, proves its effectiveness and can serve as a basis for developing OBF criteria in Ukraine.

In Ukraine, where the need for demining is enormous and resources are limited, the OBF model has significant potential. Instead of paying for the number of days worked or the amount of equipment used, funding can be tied to indicators such as:

- the number of hectares of verified cleared land;
- restoration of access to critical infrastructure (e.g., power grids, gas pipelines);
- return of agricultural land to use;
- creation of jobs in restored areas.

To implement OBF model, it is necessary to develop clear, measurable, and independently verified targets. In addition, it is important to create a “Results Fund” that can accumulate funds from various donors and distribute them on a competitive basis among the most effective performers.

OB-PPPs are agreements between the government and the private sector for the joint implementation of projects. In the context of demining, this may include the transfer of ownership of contaminated land to a private investor after successful demining financed by that investor [2]. The amount of the government subsidy may be adjusted depending on the cost of the land and the cost of demining.

The private sector invests in land clearance for solar power plants, receiving compensation from the Ukrainian government through a share of solar energy sales (via a “special demining fee”) and performance-based payments. This offers more favourable terms for covering investor development costs than commercial loans [12].

PPPs offer mechanisms for self-sustaining demining through value creation. A model whereby the state transfers cleared land to a private investor for further use can stimulate both the demining process itself and the attraction of additional investment.

Another option is a model that involves private sector financing of demining, with costs subsequently recouped through profits from the project, such as the sale of solar energy generated on the cleared land. This approach transforms demining from a simple expense into an integral part of profitable investments, making it attractive for attracting significant amounts of private capital. This model creates synergy by aligning the financial interests of businesses with the national goal of land clearance and economic development.

The main challenge for implementing OB-PPPs for demining is not legal reform, but rather the development and promotion of specific projects that fit into this framework and

attract private interest. It also highlights the potential of green bonds and sustainable development bonds to finance these PPPs due to their alignment with the SDGs.

These are financial instruments (SLBs) where the interest rate or other financial characteristics are linked to the issuer's achievement of predetermined sustainability goals [2]. For demining, this could mean linking interest rates to the amount of land cleared or the restoration of agricultural productivity.

Ukrainian companies have actively refocused their CSR efforts on helping the army and affected citizens since the start of the full-scale invasion. CSR is now an integral part of doing business in Ukraine, with consumers favouring brands that support the Armed Forces and participate in volunteer activities. This creates an opportunity for businesses to invest in demining as part of their social license to operate and to gain competitive advantages.

Targeted crowdfunding for specific, high-impact projects. Crowdfunding initiatives play an important role in demonstrating the public's willingness to support demining efforts. Such campaigns raise funds for specific, visible projects that have a significant impact. For example, these funds can be used to purchase specialized, expensive equipment, such as demining machines, which help speed up the clearance of explosive hazards from areas.

Diversified funding streams reduce the risk of a single point of failure and promote broader accountability. Reliance solely on traditional official development assistance has proven insufficient [11]. Combining large-scale innovative financing (OBF, OB-PPPs, SLBs) with smaller, targeted flows such as farmer compensation, CSR, and crowdfunding creates a more resilient and sustainable financing ecosystem.

International partners play a crucial role in helping Ukraine overcome the challenge of demining. The United States, for example, has provided significant funding and assistance, including training for deminers and support for non-governmental organizations to return land to productive use. The United Kingdom has also allocated significant funds, including £8.6 million to the HALO Trust, and extended the HALO Trust contract for 2025-2026, providing an additional £4.3 million [6]. Canada has provided US\$2.37 million to support the operation of 12 remotely controlled demining systems provided to the State Emergency Service of Ukraine in 2023, including technical support, training, and spare parts [13].

UNDP supports coordination, strategy development, technical assistance, and the provision of modern equipment. They transferred six remotely controlled demining machines and a full set of spare parts to the State Emergency Service of Ukraine (SES), which was funded by the governments of Croatia, France, the Netherlands, and Sweden. The Netherlands has pledged over €54 million for mine action in Ukraine, much of which is implemented through UNDP projects. France also supports humanitarian demining by providing advanced technological solutions [14].

A multifaceted funding strategy ensures that demining efforts are not entirely dependent on the political will or budget cycles of a few large donors. It also promotes greater national and civic responsibility by involving a variety of stakeholders, from international investors to local citizens and businesses (Table 3).

Table 3. Comparative analysis of innovative financing models for demining*

Model	Mechanism/ Description	Main source of financing	Key advantages	Key challenges/ Consideratio ns	Relevance for Ukraine
OBF	Payments for independently verified results (cleared land, restoration of economic	Impact investors, developmen t finance institutions (DFIs), and	Results- oriented, risk reduction for donors, attraction of	Need for working capital, complex structuring, and reliable	Ability to measure results (cleared hectares, GDP

	activity) rather than for resources invested	bilateral donors.	new capital, and increased accountability	verification systems.	recovery), alignment with national priorities
OB-PPPs	An agreement between the government and the private sector, where a private investor finances demining in exchange for land ownership rights or a share of revenues (e.g., from solar energy)	Private sector, commercial banks, infrastructure investors	Attracting significant private capital, creating self-sustaining models, and integrating demining with economic development (e.g., solar energy).	Complex structure, regulatory barriers, need for clear compensation mechanisms	Existing legal framework for PPPs (Law No. 7508), high potential for solar energy, urgent need for demining of agricultural land
SLBs	Financial instruments where the interest rate or other terms are linked to the achievement of sustainable development goals (e.g., amount of land cleared, restoration of agricultural productivity)	ESG investors, pension funds, insurance companies, mutual funds	Access to a large pool of ESG capital, increased transparency and accountability, and alignment with national sustainable development goals	Need for reliable metrics and verification, market conditions, and complexity of issuance	Ukraine's experience with issuing SLBs (Ukrenergo), alignment of PPPs with SDGs, and significant potential for green recovery
Cost reimbursement schemes for farmers with donor support	Donors compensate farmers for part of the costs of demining their land	Bilateral donors, international organizations	Direct support for agriculture, rapid return of land to productive use, stimulation of the private demining market	Limited scale, need for ongoing donor funding, risk of misuse	Urgent need for demining of agricultural land, the existing state compensation program
CSR	Companies' investments in demining as part of their social commitments	National and international corporations	Improved company reputation, involvement of local resources, and use of business expertise	Limited funding, dependence on voluntary initiatives, and need for transparency	High level of CSR among Ukrainian companies, priority given to supporting the Armed Forces and victims

Crowdfunding	Fundraising from a wide range of individual donors for specific demining projects	Private individuals, small organizations, diaspora	High public involvement, rapid response to local needs, and transparency in the use of funds	Limited scale, instability of funding, need for constant promotion	Experience of successful crowdfunding campaigns for Ukraine (e.g., for demining equipment)
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* constructed by the authors

Creating a robust private demining market. Small and medium-sized farms cannot afford demining, while government services are focused on demining cities and municipal infrastructure. Stimulating the private market is vital. One idea is to create a model, supported by donors, to reimburse part of the costs paid by local farmers for demining. This would allow Ukrainian demining operators to gain experience, train staff, and improve their skills by providing market services to Ukrainian farmers [5].

Introduction of innovations and technologies. The scale and complexity of mine contamination in Ukraine require the intensive introduction of innovative technologies. The lack of systematic and centralized efforts to introduce innovative technologies, including unmanned aerial vehicles, the use of satellite imagery, artificial intelligence, and data collection and analysis systems, is a recognized problem [15]. Advanced methods such as remotely controlled demining machines, drones, and artificial intelligence can significantly improve the efficiency and safety of operations. For example, HALO Ukraine is transforming the approach to land preparation and clearance by using advanced survey methods and the targeted deployment of remotely operated vehicles.

Priorities based on economic and social impact. Strategic prioritization of demining should be based on maximum economic and social impact. This includes:

- agricultural land – as agriculture is the lifeblood of Ukraine’s rural economy and contamination results in billions of dollars in lost exports and GDP, prioritising the clearance of agricultural land is critical.
- critical infrastructure – demining bridges, power lines, and power plants is important for restoring essential services and economic activity.
- return of IDPs and refugees – ensuring the safe return of people to their homes and communities is a humanitarian and social imperative that contributes to the restoration of human capital.
- industrial facilities and investment sites – demining areas designated for the restoration of production or the attraction of new investment will accelerate reconstruction and create new jobs.

A comprehensive review of the legislative and regulatory framework for mine action is necessary to support innovative financing and the functioning of the demining market. Further reforms should ensure [15]:

- stimulation of demand for domestic mine action products and accessible certification processes.
- expansion of the existing capabilities of the mine action quality management system.
- alignment of planning and task allocation with the capabilities and offerings of mine action operators.

Despite the focus on economic recovery, the humanitarian aspect of demining and victim assistance remains critically important. This includes [15]:

- supporting and accompanying persons affected by ERW, including comprehensive medical support and monitoring;
- providing systems for the reintegration of affected persons into society;

- conducting educational campaigns on the risks of ERW for the population, especially children, to prevent accidents.

4 Conclusion

Based on the analysis, the following key recommendations are proposed for the sustainability of financing and acceleration of mine clearance in Ukraine:

- active implementation of OBF: create mechanisms that allow donors and investors to pay for actual demining results (e.g., cleared hectares, restored agricultural productivity, population return). This will increase attractiveness for impact investors and ensure more efficient use of funds.
- develop and scale up OB-PPPs: focus on models that combine demining with the development of renewable energy (e.g., solar power plants) or agriculture. Use mechanisms for transferring land or a share of the income from cleared areas to stimulate private investment in demining.
- issue SLBs for mine action: use the experience of Ukrenergo to issue sovereign or corporate SLBs, where interest rates will be linked to progress in demining and economic recovery.
- demining critical infrastructure and populated areas: ensure the safety of energy, transport, and residential areas to restore basic services and return the population.
- widespread implementation of advanced technologies: systematically invest in mechanized demining, the use of drones, satellite imagery, and artificial intelligence to increase the speed, efficiency, and safety of operations.
- building national capacity: continuing to train and equip Ukrainian deminers (both military and civilian) and developing domestic production of demining equipment.
- review and update the National Mine Action Strategy: ensure that the strategy reflects innovative financing models and economic recovery priorities, and includes clear coordination mechanisms between all stakeholders.
- increase transparency and accountability: implement robust systems for monitoring and verifying progress in demining and the use of funds, which is critical for attracting and retaining investors.
- stimulate the private demining market: create favourable conditions for private companies providing demining services, including public procurement, compensation mechanisms, and access to financing.
- encourage corporate social responsibility (CSR): actively engage Ukrainian and international companies in financing and implementing demining projects as part of their CSR initiatives.
- support crowdfunding initiatives: promote the development of targeted crowdfunding campaigns for specific projects or equipment purchases, leveraging the potential of public support.
- continuation and expansion of international assistance: ensure stable and sufficient support from international donors and organizations that play a key role in financing, technical assistance, and capacity building.
- coordination of efforts: strengthen coordination between all international and national mine action actors to avoid duplication of efforts and ensure maximum effectiveness.

Implementing these recommendations will enable Ukraine not only to overcome the enormous challenge of mine contamination, but also to transform it into a driving force for sustainable economic recovery and prosperity in the post-war period.

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