***Електронний журнал «Ефективна економіка» включено до переліку наукових фахових видань України з питань економіки (Категорія «Б», Наказ Міністерства освіти і науки України № 975 від 11.07.2019). Спеціальності – 051, 071, 072, 073, 075, 076, 292. Ефективна економіка. 2025. № 10.***

**DOI: http://doi.org/10.32702/2307-2105.2025.10.6**

**УДК 504.06:628.4:351.777(477)**

*I. Kupriianchyk,*

*Doctor of Economic Sciences, Professor, Professor of the Department of Land Management, National University of Life and Environmental Sciences of Ukraine*

*ORCID ID: https://orcid.org/0000-0003-1348-2128*

# CREATING A SAFE SPACE IN THE FIELD OF WASTE MANAGEMENT IN THE CONTEXT OF MODERN CHALLENGES

*І. Купріянчик,*

*д. е. н., професор, професор кафедри управління земельними ресурсами, Національний університет біоресурсів та природокористування України*

# ФОРМУВАННЯ БЕЗПЕКОВОГО ПРОСТОРУ У СФЕРІ ПОВОДЖЕННЯ З ВІДХОДАМИ В КОНТЕКСТІ СУЧАСНИХ ВИКЛИКІВ

*The article examines the issue of environmental safety in the context of managing various waste streams, including military waste, which has become particularly relevant in the context of armed aggression against Ukraine. The author justifies the need to move from a fragmented and technology-oriented approach to a systematic and spatially integrated waste management model that*

*would take into account the multi-level structure of risks and the interconnection between their sources, infrastructure facilities and technological processes.*

*The study is based on an analysis of the legal, institutional and infrastructural framework for waste management, as well as public participation in the formulation of environmental safety policy. The scientific novelty of the work lies in the development of methodological principles for the formation of a 'safety space' that integrates environmental risks at three levels: waste flows, infrastructure facilities and technological operations. This approach allows for the structuring of risks, the identification of their endogenous and exogenous factors, and the creation of conditions for their effective management during wartime and post-war periods. The article outlines the methodological principles for the formation of a security space, which involves the identification of environmental risks at three levels: waste flows, infrastructure facilities, and technological operations. Particular attention is paid to military waste as a separate type of hazardous waste that requires specific approaches to classification, neutralisation, and remediation. A structured risk assessment model has been developed, taking into account endogenous and exogenous factors, which allows for increasing the effectiveness of environmental policy in conditions of martial law.*

*The proposed recommendations are aimed at strengthening the role of regional management, developing logistics infrastructure, complying with environmental standards, and establishing a system of monitoring and public control. The article also substantiates the integration of environmental safety principles into the processes of land restoration, land use planning, and the location of landfills and waste treatment and disposal facilities, taking into account logistical, social, and economic factors. The results obtained are of practical importance for improving the waste management system in transitional and post-conflict periods.*

*У статті розглядається питання екологічної безпеки в контексті управління різними потоками відходів, включаючи військові відходи, що стало особливо актуальним в умовах збройної агресії проти України. Автор обґрунтовує необхідність переходу від фрагментарного та технологічно орієнтованого підходу до системної та просторово інтегрованої моделі управління відходами, яка враховувала б багаторівневу структуру ризиків та взаємозв'язок між джерелами їх виникнення, інфраструктурними об'єктами і технологічними процесами.*

*Дослідження базується на аналізі стану правового, інституційного та інфраструктурного забезпечення сфери поводження з відходами, а також участі громадськості у формуванні політики безпеки довкілля. Наукова новизна роботи полягає у розробленні методологічних засад формування «простору безпеки», який інтегрує екологічні ризики за трьома рівнями: потоки відходів, об'єкти інфраструктури та технологічні операції. Такий підхід дозволяє здійснити структуризацію ризиків, визначити їх ендогенні та екзогенні чинники, а також створити передумови для ефективного управління ними у воєнний і післявоєнний періоди. У статті окреслено методологічні засади формування простору безпеки, що передбачає виявлення екологічних ризиків на трьох рівнях: за потоками відходів, об'єктами інфраструктури та технологічними операціями. Особливу увагу приділено військовим відходам як окремому виду небезпечних залишків, що вимагають специфічних підходів до класифікації, нейтралізації та ремедіації. Розроблено структуровану модель оцінки ризиків з урахуванням ендогенних та екзогенних факторів, що дозволяє підвищити ефективність екологічної політики в умовах воєнного стану. Запропоновані рекомендації спрямовані на посилення ролі регіонального управління, розвиток логістичної інфраструктури, дотримання екологічних стандартів та формування системи моніторингу та громадського контролю. У статті також обґрунтована інтеграція принципів екологічної безпеки у процеси відновлення територій, планування землекористування, розміщення полігонів, об'єктів з*

*переробки та знешкодження відходів з урахуванням логістичних, соціальних та економічних факторів. Отримані результати мають практичне значення для вдосконалення системи поводження з відходами в перехідний та постконфліктний періоди.*

***Keywords:*** *environmental safety, waste management, military waste, infrastructure, environmental risks, security space, sustainable development, institutional environment.*

***Ключові слова:*** *екологічна безпека, управління відходами, військові відходи, інфраструктура, екологічні ризики, безпековий простір, сталий розвиток, інституційне середовище.*

**Statement of the Problem.** Imperfect industrial processes, irrational land use, inadequate infrastructure to meet modern production requirements, and outdated waste collection, processing, and disposal systems cause significant pollution of the air, water, and soil. This, in turn, worsens the sanitary and hygienic state of the environment and the overall environmental situation.

The absence of an integrated approach to spatial planning of settlements, their improvement, location of waste disposal facilities, as well as to the regulation of land relations, organization of land use, land management and land protection, combined with fragmentation of management processes and duplication of management functions, leads to low efficiency in the field of waste management. In this context, the problem of creating a proper infrastructure for waste management and land regulation is of particular relevance.

The current environmental situation in Ukraine and globally demonstrates the importance of a systematic approach to waste management. Growing volumes of industrial, household, agricultural and hazardous waste, combined with an underdeveloped infrastructure for their processing, utilization and disposal, pose

complex threats to the environment, public health and sustainable development of territories.

Under these conditions, the development and implementation of scientifically based methodological approaches to identifying, assessing and minimizing environmental risks associated with waste is of particular relevance. One of the most important tasks is to build an effective model for the formation of a safe space that takes into account both waste flows and the specifics of the spatial location of infrastructure facilities, the institutional environment, and the level of public participation.

**Analysis of Recent Research and Publications**. The issue of waste management as a key component of environmental safety is considered in numerous scientific studies covering various aspects - legal, managerial, technological, spatial and social. Particular attention is paid to the classification of waste by hazard level, assessment of risks to the environment and public health, development of infrastructure for storage, utilization, neutralization and processing of waste.

The works of domestic researchers indicate that the modern waste management system in Ukraine remains fragmented, with insufficient coordination between state bodies, low efficiency of the regulatory framework, and the absence of a comprehensive regional development strategy in the field of environmental safety. The studies emphasise the need to move from a linear ‘collection-disposal’ model to a circular economy that includes recycling, reuse and minimisation of waste generation [2,3].

International experience, presented in the works of authors from the European Union, such as P. Börner, M. Scarlat, A. Watson, demonstrates the effectiveness of the extended producer responsibility (EPR) system, which allows placing responsibility for waste on the producer, as well as the importance of using GIS technologies for spatial planning of waste infrastructure [1,4].

Modern research indicates the need to take into account the multifactorial nature of risks in the field of waste management. For example, the works of J.

Seadon and M. Wilson examine the interrelationships between political, social and economic conditions in the formation of the waste management system, as well as the importance of public participation in ensuring transparency in decision-making and reducing protest potential [5,6,7].

Of particular interest are works devoted to the spatial aspect of risk management. The studies of V. Kravets and I. Yakimenko (2021) emphasize the need to integrate environmental planning into the process of forming master plans for settlements, taking into account environmentally hazardous objects and waste streams.[8]

Despite the significant scientific work, the issue of methodological generalization of all factors within the concept of forming a safe space - as a category that includes risks, infrastructure, spatial planning, institutional support and strategies for influencing them - remains insufficiently developed. There is also a lack of applied risk assessment models adapted to Ukrainian realities and the capabilities of the management system at the local level.

**Formation of the objectives of the article.** Formation of the objectives of the article. Given the current environmental threats associated with the accumulation and improper management of waste, there is a need to rethink approaches to managing this area. Traditional management models, focused mainly on the utilitarian logic of waste extraction and disposal, do not take into account the complex systemic nature of risks that arise as a result of man-made environmental impacts, as well as socio-economic consequences caused by habitat degradation.

The formation of a safe space in the field of waste management requires the integration of multi-level factors - from the generation of waste flows to the spatial placement of infrastructure and institutional support for management processes. At the same time, the lack of effective monitoring, insufficient coordination between authorities, low levels of public participation and underdeveloped infrastructure exacerbate environmental and social risks.

In this regard, the main objective of the study is to form a methodological approach to identifying and systematizing risks in the field of waste management, as well as to develop a structured model of the safety space taking into account the classification of waste flows by hazard level and management features, and to identify endogenous and exogenous factors that influence the formation of environmental threats.

**Results of the Study.** Within the framework of the implementation of the Association Agreement with the EU, which provides for the institutional development of the environmental sector, Ukraine is gradually approaching European environmental standards. This is additionally facilitated by the implementation of the EU Environment project, which is being implemented with the support of the European Union.

Generalizing the European experience in waste management in the context of the organizational and economic state of producers in Ukraine allows us to identify a number of key mechanisms: regulatory and legal framework; institutional responsibility; financing system; economic incentives; identification and classification of waste as secondary raw materials. The above indicates the need to transition from an extensive to an integrated policy in the field of waste management, which includes: prioritizing resource conservation; establishing a hierarchy of waste management goals; supporting producers; implementing a system of accounting, registration and control.

The accumulation of waste generates a complex of interrelated risks, which negatively affects both the living conditions of people and, ultimately, their economic well-being. The problem of managing such risks is now becoming global. Its effective solution is becoming one of the determining factors of sustainable development of society both in terms of environmental safety and preservation of natural resources.

Considering it in the national context, it should be taken into account that waste management goes beyond technological issues, since it essentially concerns complex issues. At the regulatory and legal level, the requirements for waste

management in the conditions of the modern economy are not met, and the places for their placement in landfills at existing landfills have largely exhausted their resource, while the landfills themselves have become a factor in environmental pollution. Due to opposition from the population, public organizations and the lack of practice of providing social guarantees, the resolution of issues regarding the allocation of land plots for the construction of new landfills for household and other waste is delayed, or even blocked. Therefore, the problem arises of creating, primarily at the regional level, an adequate management system for the specified area, capable of responding to the challenges that have arisen in their current and strategic dimensions. (see Fig. 1)

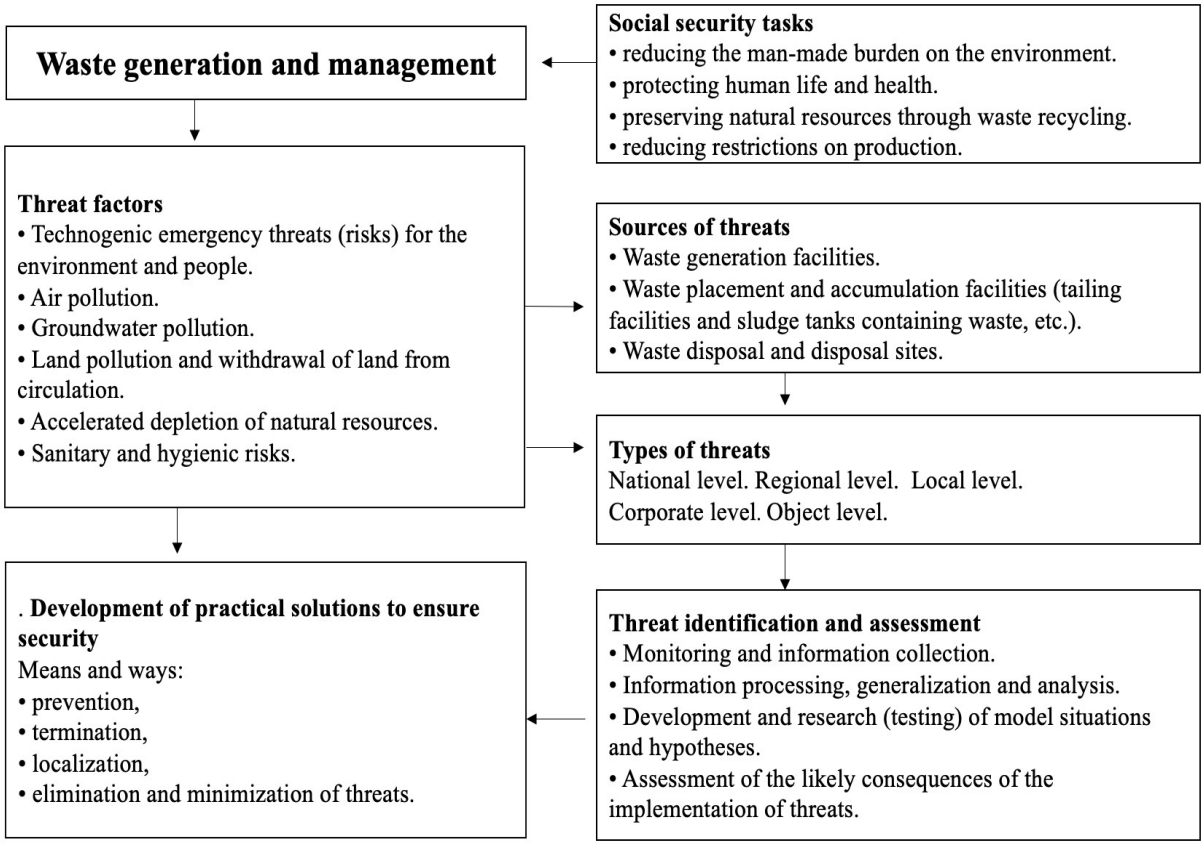


**Figure 1. Generalized system for the emergence and prevention of threats associated with the generation and accumulation of waste**

Environmental safety issues related to waste should be considered as a component of the overall environmental safety system. This aspect is closely integrated into production and consumption processes, which necessitates its

structural distribution in accordance with the nature and directions of waste flow formation in these areas. (Table 1)

**Table 1. Waste streams as source objects for identifying environmental risks and threats**

| Basic waste streams | Features of safety identification |
|---|---|
| Industrial waste | A significant range of hazardous properties. Various types of placement and disposal systems |
| Mining waste | Mainly low-hazard, inert. Open storage |
| Construction waste | Safe, possible toxic contamination. Open storage, backfilling, etc. |
| Energy waste | Highly pronounced low-hazard. Industrial storage and disposal |
| Agricultural waste | Dominance of disposal management. Active pollutants with improper storage |
| Chemical waste, sludge, mixed materials | Often high degree of hazard. Local disposal systems |
| Municipal (solid household) and similar | Low-hazard, possible contamination with toxic components. Disposal dominant |
| Medical waste | Infectious. Autonomous low-power destruction systems (incineration) |
| Unusable pesticides and agrochemicals | Highly toxic. Centralized disposal system |
| Metal waste | Fully involved in recycling (targeted collection and procurement) |
| Waste oil products | Disposal dominant management |
| Worn tires and rubber products | Disposal dominant management |
| Worn vehicles | Disposal dominant management |
| Waste containers and packaging | Disposal dominant management |
| Waste electronic and electrical equipment | Disposal dominant management |
| Military waste (munitions fragments, destroyed equipment, contaminated materials) | High level of hazard. Requires specialized technologies for disposal, disposal and reclamation |

Each waste stream and the corresponding waste management facility form a separate zone or safety space. Such a space includes specific risk factors that can negatively affect the environment, living organisms and public health. As a result, these individual safety zones are superimposed on the general ecological background, modifying it and affecting the state of environmental safety in general. [9,10]The formation of such a space at the state level or individual regions should be focused on effectively reducing potential threats as a key condition for strengthening the safety of production and consumption systems. (see Fig. 2)

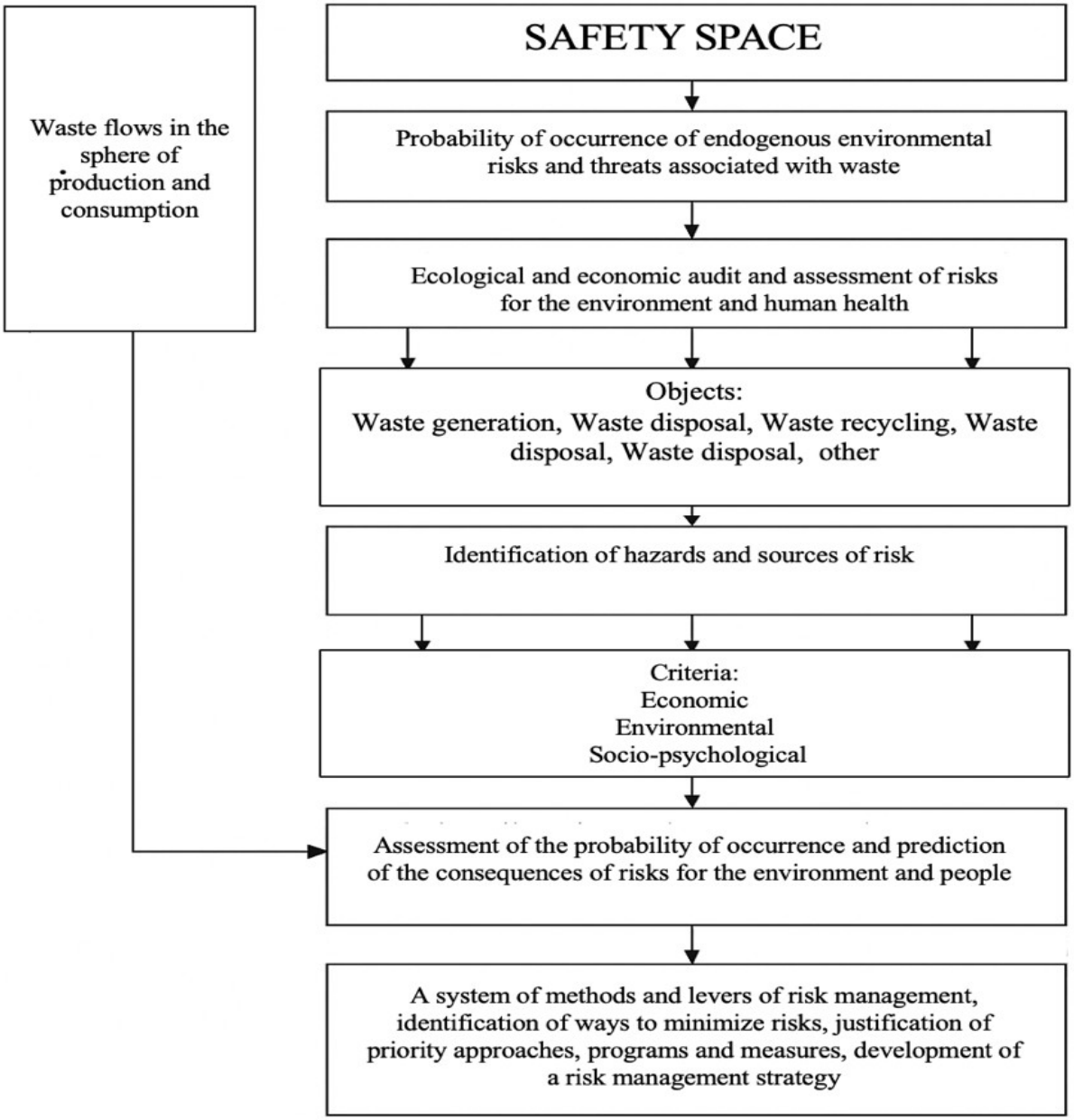


**Figure 2. A generalized system for the emergence and prevention of threats arising from the accumulation of waste**

Thus, environmental safety in the context of waste management is considered as a dynamic system with spatial characteristics, the elements of which are classified by functional purpose - transportation, storage, processing, utilization, neutralization, disposal, etc. The main safety characteristic of such an approach is the identification of risks, both by types of waste streams and between individual

stages of their processing. Therefore, the identification of endogenous environmental risks and threats should be carried out systematically - according to the structure of waste flows and all components of the chain.

Reducing the volume of waste remains a key theoretical and methodological prerequisite for ensuring environmental safety in the field of waste management. This becomes especially relevant in the context of a full-scale war, which has led to a significant increase in the volume of not only household, industrial or medical waste, but also military waste - in particular, ammunition fragments, destroyed equipment, contaminated building materials, etc. Therefore, within the framework of the system for identifying environmental risks and threats, it is advisable to distinguish three levels of analysis and management.

The first level concerns the classification of waste by its origin and physicochemical characteristics, which allows the formation of separate waste flows. This is the basis for the development of specialized management programs, which must take into account the need for specialized regulatory and legal regulation. Such flows, along with traditional ones (domestic, medical, industrial), must now include military waste as a separate group with an increased degree of danger. The second, object level covers specific infrastructure facilities for collecting, storing, processing and disposing of waste. In this context, the formation of specialized facilities and logistical solutions for handling waste of military origin is particularly important. It is important to ensure strict compliance with environmental standards, hygiene requirements and technological regulations, as well as the development integrated networks of waste disposal facilities of all types.

The third level concerns technological operations. Risk identification should be carried out in accordance with such stages as transportation, sorting, selection, burial, utilization, recycling, energy use. In the case of military waste, special technologies for demilitarization, neutralization of hazardous components and reclamation of contaminated areas should also be envisaged.

A systematic study of endogenous and exogenous risks, including those of a military nature, allows for a comprehensive classification of factors that determine the level of threats to the environment. The analysis (see Table 2) reveals key gaps in management and indicates the need to update the institutional structure adapted to war conditions.

**Table 2. System of endogenous and exogenous environmental risk factors**

| Endogenous factors | Exogenous factors |
|---|---|
| High rates of accumulation of all types of waste, including military waste (ammunition fragments, equipment, construction ruins) | Armed aggression, active hostilities, shelling of settlements |
| Imperfect infrastructure for the collection, storage and disposal of hazardous and toxic waste | Destruction of engineering, logistical and communal infrastructure |
| Lack of specialized facilities for the neutralization of military waste | Military occupation, mining of territories, lack of access to certain areas |
| Low level of management coordination between civilian and military structures | Lack of strategic environmental policy during the war |
| Fragmentation of the regulatory framework for the classification and management of military waste | Military-political instability, weak international support for the environmental direction |
| Insufficient databases and mapping of military contamination zones | High level of risk to public health, growth of technogenic and environmental threats |
| Limited funding for environmental monitoring and post-war reclamation | Mass internal displacement of the population, changes in land use |

***Conclusion.*** Analysis of the current state of waste management in Ukraine indicates the need for systematic and coordinated management, without which it is impossible to ensure environmentally and socially safe development. This problem becomes particularly urgent in conditions of martial law, when significant volumes of military, including hazardous, waste are added to the total mass of waste. This applies to debris of equipment, ammunition, contaminated soil, construction debris of destroyed facilities and other remnants of military activity.

In conditions of armed conflict, special attention is required for effective cross-sectoral management of lands and infrastructure facilities for handling all types of waste, including military. Such an approach should include the comprehensive application of administrative, economic, legal and information

management tools, as well as the integration of modern mechanisms of state regulation that take into account new security challenges.

Today, the legal framework of Ukraine creates the prerequisites for expanding the powers of local authorities in the field of land resources management and waste management infrastructure facilities, in particular in conditions of military operations. This allows for a prompt response to new threats associated with the environmental consequences of war, and to involve organizational and scientific and intellectual potential.

Regional management bodies should implement state policy taking into account the specifics of the regions, the level of military load, the volume of military and domestic waste, the peculiarities of logistics and infrastructure. Their functions should be implemented through the preparation and implementation of comprehensive programs for socio-economic and environmental restoration, including the reclamation of destroyed territories, monitoring the management of hazardous waste, ensuring environmental control and coordinating the actions of enterprises at the local level.

Decision-making processes should be based on an integrated assessment of the state of the waste management sector, taking into account the security context, forecasting risks, identifying development alternatives and optimizing costs for the restoration and operation of infrastructure.

Planning land use and the placement of facilities for the storage, neutralization and disposal of both conventional and military waste is of particular strategic importance. In these conditions, compliance with environmental standards, minimizing the negative impact on the population, limiting land withdrawal, logistical convenience, and taking into account the socio-economic situation of the territories are critically important.

The methodology of rational management involves the analysis of a set of alternatives (projects, solutions), each of which is evaluated according to the criteria of safety, technical feasibility, economic efficiency, and environmental expediency. Particular attention should be paid to the location of facilities for the

disposal and neutralization of military waste that pose an increased threat to the environment. All decisions should be made taking into account the opinion of the public and the needs of local communities.

The system of land management and waste management facilities should be implemented as a single whole. This involves the coordination of land and economic relations at all stages of the operation of facilities, in particular in military and post-war realities. Based on this approach, it is possible to achieve a balance between environmental and social requirements, support sustainable development, preserve natural resources, and create prerequisites for the economic recovery of Ukraine.

**Література**

1. Borner, J., Kreuter, J., Werner, F. Circular economy and waste governance in the EU: Instruments and innovations. *Environmental Policy Journal*, 34(2), 2017, p. 45-61.

2. Нижниченко Я. Є. Світові тенденції управління відходами та аналіз ситуації в Україні. *Актуальні питання економічних наук*, (5), 2024. https://doi.org/10.5281/zenodo.14187042

3. Колодійчук І. А. Формування територіально збалансованих систем управління відходами: регіональний вимір : монографія. Львів : ДУ «Інститут регіональних досліджень імені М. І. Долішнього НАН України», 2020. 524 с.

4. Watson A., Williams R., Kociuba D. GIS-based modeling in waste infrastructure planning: Tools for sustainable urban development. *Journal of Urban Management*, 8(1), 2019, p. 25-40.

5. Seadon J. K. Sustainable waste management systems: Global insights and innovations. *Waste Management Journal*, 56, 2016, p. 1-10. https://doi.org/10.1016/j.wasman.2015.12.015

6. Scarlat M., Motola V., Dallemand J.-F. (2019). Waste-to-energy pathways and their potential in Europe. *Renewable and Sustainable Energy Reviews*, 103, 2019, p. 13-30. https://doi.org/10.1016/j.rser.2018.12.041

7. Wilson D. C. From waste disposal to resource management: Evolution of waste governance models. *Waste Management & Research*, 38(8), 2020, 789-801. https://doi.org/10.1177/0734242X20938400

8. Кравець В, Якименко І. Просторовий аналіз ризиків управління відходами в регіональному плануванні. Економіка та управління навколишнім середовищем, 9(3), 2021, с. 97-106.

9. Національний план управління відходами до 2030 року. Розпорядження Кабінету Міністрів України від 20 лютого 2019 р. №117-р. URL: https://zakon.rada.gov.ua/laws/show/117-2019-%D1%80#Text

10. Про управління відходами: Закон України від 20 червня 2022 року № 2320-IX. URL: https://zakon.rada.gov.ua/laws/show/2320-20#Text

## References

1. Borner, J. Kreuter, J. and Werner, F. (2017), “Circular economy and waste governance in the EU: Instruments and innovations”, Environmental Policy Journal, vol. 34(2), pp. 45-61.

2. Nyzhnychenko, Ya.Ye. (2024), “World Trends in Waste Management and Analysis of the Situation in Ukraine”, *Aktualni pytannia ekonomichnykh nauk*, vol. 5, pp. 1-24. https://doi.org/10.5281/zenodo.14187042

3. Kolodijchuk, I.A. (2020), Formuvannia terytorial'no zbalansovanykh system upravlinnia vidkhodamy: rehional'nyj vymir [Formation of territorially balanced waste management systems: regional dimension], DU «Instytut rehional'nykh doslidzhen' imeni M.I. Dolishn'oho NAN Ukrainy», L'viv, Ukraine.

4. Watson, A. Williams, R. and Kociuba, D. (2019), “GIS-based modeling in waste infrastructure planning: Tools for sustainable urban development”, Journal of Urban Management, vol. 8(1), pp. 25-40.

5. Seadon, J.K. (2016), “Sustainable waste management systems: Global insights and innovations”, Waste Management Journal, vol. 56, pp. 1-10. https://doi.org/10.1016/j.wasman.2015.12.015

6. Scarlat, M. Motola, V. and Dallemand, J.-F. (2019), “Waste-to-energy pathways and their potential in Europe”, Renewable and Sustainable Energy Reviews, vol. 103, pp. 13-30. https://doi.org/10.1016/j.rser.2018.12.041

7. Wilson, D.C. (2020), “From waste disposal to resource management: Evolution of waste governance models”, Waste Management & Research, vol. 38(8), pp. 789-801. https://doi.org/10.1177/0734242X20938400

8. Kravets', V. and Yakymenko, I. (2021), “Spatial analysis of waste management risks in regional planning”, Ekonomika ta upravlinnia navkolyshnim seredovyschem, vol. 9(3), pp. 97-106.

9. Cabinet of Ministers of Ukraine (2019), Resolution “National Waste Management Plan until 2030”, available at: https://zakon.rada.gov.ua/laws/show/117-2019-%D1%80#Text (Accessed 05 Oct 2025).

10. Verkhovna Rada of Ukraine (2022), The Law of Ukraine “About waste management”, available at: https://zakon.rada.gov.ua/laws/show/2320-20#Text (Accessed 05 Oct 2025).

*Стаття надійшла до редакції 15.10.2025 р.*