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CRISIS MANAGEMENT OF RADIOACTIVELY CONTAMINATED TERRITORIES: SOCIO-ECONOMIC BARRIERS TO RECOVERY IN UKRAINE'S POLISSIA REGION

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The article is devoted to a comprehensive analysis of the socio-economic barriers to the recovery of radioactively contaminated territories in Ukraine's Polissia region within the framework of crisis ecological management. The study covers the five regions most affected by the Chornobyl nuclear disaster — Volyn, Zhytomyr, Kyiv, Rivne, and Chernihiv oblasts — for the period 2010–2021, with a retrospective analysis of demographic processes since 1991 and an assessment of the impact of the full-scale war that began in 2022. The methodology is based on an interdisciplinary approach that combines statistical and correlation analysis, the comparative-geographical method, and dynamic time-series analysis. The information base consists of data from the State Statistics Service of Ukraine, regional statistical offices, the Ministry of Education and Science of Ukraine, and international organisations. The results reveal a catastrophic demographic crisis, with population decline ranging from 11% to 31% depending on the region, critically high unemployment with pronounced gender differentiation, and a dangerous economic dependence of the population on subsistence farming. Up to 40% of rural households' income is derived from the sale of products from private plots and forest goods, creating a vicious circle of consumption of potentially contaminated produce. The study also identifies the problem of energy poverty: more than half of rural dwellings are heated with firewood from local forests in the complete absence of legislative standards for radioactive contamination of fuel wood. Correlation analysis established a non-linear relationship between the level of radioactive contamination and socio-economic indicators, with the strongest linkages observed in the most heavily contaminated zones. Four self-reinforcing vicious cycles were identified: poverty — risk, depopulation — degradation, disinvestment, and education — human capital, collectively forming a "depression trap". The superimposition of the military conflict has created a "triple crisis" situation, dramatically narrowing the scope for managerial solutions. The findings demonstrate that radioactive contamination does not act as a direct cause but rather as a catalyst of socio-economic depression, generating additional barriers to development. The conclusions have practical implications for the design of crisis management strategies and regional policy, emphasising the need for comprehensive rehabilitation programmes supported by large-scale external assistance and systemic structural reforms.

Keywords: *Chornobyl disaster, Ukrainian Polissia, complex crisis, ecological management, depopulation, human capital, full-scale war.*

INTRODUCTION

Crisis environmental management has gained particular significance in the context of the 21st century's global challenges, as territories increasingly face compounding crises of various origins — from industrial disasters to armed conflicts. The radioactive contamination of vast territories following the Chornobyl Nuclear Power Plant accident created a unique situation requiring long-term management strategies addressing not only radioecological but also socio-economic consequences of the disaster.

International research has repeatedly emphasized the contradictory nature of existing assumptions about the direct link between radioactive contamination and socio-economic decline in affected regions, pointing to the need for a comprehensive approach to understanding how environmental crises impact territorial development [1].

Global experience in managing radioactively contaminated territories demonstrates how difficult it is to clearly separate the direct and indirect consequences of radiation exposure from the effects of other socio-economic factors. This is particularly true for long-term effects that manifest only decades after an accident. Moreover, most research focuses predominantly on radioecological and medical aspects, while systematic analysis of the socio-economic barriers preventing recovery of affected territories remains insufficiently developed.

In the Ukrainian context, the situation is complicated by the overlap of several crisis factors: the decades-long consequences of the Chornobyl disaster, systemic socio-economic depression in the region, demographic crisis, and, since 2022, the consequences of full-scale war. Ukrainian Polissia demonstrates persistent negative trends across most socio-economic indicators [2]. Total unemployment, caused by the absence of jobs, and consequently low household incomes, contributed to the development of illegal amber mining, particularly in Rivne and Zhytomyr oblasts [3]. As of 2021, the poverty risk for residents of the Chornobyl zone exceeded the national average by 1.7 times [4], indicating the systemic nature of the problem.

Despite nearly four decades since the accident, the question of the relationship between the direct impact of radioactive contamination and indirect socio-economic factors on the quality of life in affected territories remains unresolved. The lack of clear understanding of these interconnections makes it impossible to develop effective crisis management strategies that account for both environmental and socio-economic dimensions of the problem. The question of food consumption patterns among the population under economic depression becomes particularly urgent, when consumption of locally produced radioactively contaminated products becomes not a conscious choice but a consequence of poverty and lack of alternatives [5–7]. Income from selling products grown in household plots on radioactively contaminated territory in Zhytomyr oblast accounts for approximately 25% for rural families, while forest products contribute 14.3%, totaling nearly 40% [8].

An additional dimension of the problem is the transformation of the environmental education system under conditions of armed conflict, since education determines changes in population behavior, including consumption patterns, which is critically important for radioactively contaminated territories. The destruction of educational infrastructure, emigration of teachers and students, and deterioration of mental health among educational participants create additional barriers to forming an environmentally conscious population capable of adequately responding to radioecological challenges [9–11].

The aim of this work is to characterize the socio-economic barriers to recovery of radioactively contaminated territories in Ukrainian Polissia in the context of crisis environmental management and to identify the interconnections between radioecological conditions, the socio-economic status of the population, and opportunities for balanced regional development under conditions of multi-level crises.

REVIEW OF RECENT RESEARCH AND PUBLICATIONS

The problem of managing radioactively contaminated territories and their socio-economic recovery is the subject of interdisciplinary research at the intersection of radioecology, social geography, environmental economics, and crisis management. In the global scientific literature, studies of the consequences of major radiation accidents have traditionally focused on the medical and biological aspects of population exposure and long-term health effects. Fundamental works published under the auspices of international organizations (IAEA, WHO, UNSCEAR) have formed a basic understanding of radioecological processes and their impact on ecosystems. However, by the early 2000s, it became evident that a purely radiological approach does not explain the scale of socio-economic depression in affected regions. A landmark report for UNDP and UNICEF was the first to systematically question the direct causal relationship between radioactive contamination levels and population quality of life, emphasizing the role of psychosocial factors, economic depression, and ineffective governance [1].

Contemporary research increasingly recognizes the complex nature of radiation accidents' impact on socio-economic systems. In works by Japanese researchers on the consequences of the Fukushima Daiichi Nuclear Power Plant accident, particular attention is paid to the social consequences of evacuation, destruction of local communities, and economic losses from removing territories from economic circulation. For instance, A. Hasegawa et al. analyzed the psychosocial consequences of forced evacuation and found that psychological stress, stigmatization, and loss of social capital may have longer-lasting effects than the direct radiation impact on population health [12]. M. Murakami et al. investigated the relationship between radiation risk perception and quality of life among evacuated populations, demonstrating that socio-economic factors play a more important role in long-term well-being than actual radiation doses [13].

In the context of post-Chornobyl research, particular attention is drawn to works on the long-term socio-economic consequences of the disaster. J. M. Samet and J. Seo analyzed the economic losses of the three most affected countries (Belarus, Ukraine, Russia) and concluded that indirect economic damages related to restrictions on economic activity, population resettlement, and social payments exceeded direct accident losses by tens of times [14]. Research by A. M. Danzer and N. Danzer revealed long-term economic consequences of the Chornobyl disaster for the Ukrainian labor market, particularly persistent declines

in employment and income in affected regions even 25 years after the accident, with these effects not fully explained by territorial radioactive contamination [15]. A. Petryna proposed the concept of "biological citizenship," describing how affected populations construct their identity around the status of radiation disaster victims, which has ambivalent consequences for the region's socio-economic development [16]. Studies of migration processes in affected territories demonstrate complex dynamics. H. Lehmann and J. Wadsworth found that migration from radioactively contaminated territories is selective: predominantly young, educated, and economically active individuals leave the regions, exacerbating depopulation and economic decline [17].

An important research direction is analyzing the effectiveness of rehabilitation and recovery strategies for affected territories. IAEA summarized international experience with remediation measures and concluded that the most effective are comprehensive programs combining technical radiation protection measures with economic support and social interventions [18]. J. T. Smith and N. A. Beresford analyzed the environmental and social consequences of the accident and emphasized the need for an integrated approach to managing radioactively contaminated territories that considers not only radiological but also socio-economic and psychological aspects [19].

Particular attention in international literature is given to the problem of risk communication and forming adequate perception of radiation threats among the population. P. Slovic et al. demonstrated that radiation risk perception often does not correlate with actual danger levels and is largely determined by trust in authorities and institutions [20]. This problem is especially relevant for the post-Chornobyl context, where the history of information concealment by Soviet authorities formed persistent public distrust of official information sources.

In the context of agricultural use of radioactively contaminated lands and forestry, a number of works by both domestic and foreign scientists, as well as reports from international organizations [21], are important, having summarized experience in agricultural land rehabilitation and proposed strategies for reducing radionuclide transfer into agricultural products.

In the context of military actions and their impact on radioactively contaminated territories, scientific discourse is only forming. The World Bank estimated damages to Ukraine's education sector from full-scale Russian aggression at $13.923 billion [22]. As of May 2022 alone, 25,000 educators (6% of the total) left Ukrainian territory, and 665,000 students and schoolchildren (16% of the total) departed from Ukraine [23]. However, a comprehensive analysis of the impact of military actions on the radioecological situation and prospects for recovery of Chornobyl-affected territories is still lacking. Conceptual frameworks for crisis environmental management are being developed in works [24; 25], which proposed theoretical models for managing crisis situations that can be adapted to the context of long-term environmental crises.

At the same time, significant gaps in scientific understanding of the problem must be acknowledged. First, there is a lack of research integrating radioecological, socio-economic, and psychological aspects into a unified analytical model of crisis management for post-Chornobyl territories. Second, the mechanisms of forming consumption behavior patterns among the population under compounding crises (radioactive contamination + economic depression + armed conflict) remain insufficiently studied. Third, research on the impact of military actions on the radioecological situation and socio-economic prospects of affected territories is practically absent. Fourth, the role of education in forming population adaptation strategies to life on radioactively contaminated territories requires deeper analysis, especially in the context of environmental education system transformation under martial law.

Thus, despite a significant body of scientific publications on individual aspects of the problem, comprehensive research on socio-economic barriers to recovery of radioactively contaminated territories in the context of crisis management and multi-level crises remains an urgent task for contemporary science.

MATERIALS AND METHODS

The research was conducted based on a comprehensive interdisciplinary approach combining methods of spatial analysis, socio-economic statistics, and correlation modeling.

The research objects were five oblasts of Ukrainian Polissia that experienced the greatest radioactive contamination following the Chornobyl Nuclear Power Plant accident: Volyn, Zhytomyr, Kyiv, Rivne, and Chernihiv oblasts. The analysis was conducted differentially for four zones of radioactive contamination. The main analysis covers the period 2010–2021, which allows assessment of long-term socio-economic development trends under relatively stable conditions. Retrospective data from 1991 was used for analyzing demographic trends. The impact of full-scale war (from 2022) on the education system and socio-economic situation in the region was analyzed separately. The research information base consisted of: official

statistical data from the State Statistics Service of Ukraine for 1991–2021 [26]; data from regional statistical offices of Volyn, Zhytomyr, Kyiv, Rivne, and Chernihiv oblasts [27–31]; information from the Ministry of Education and Science of Ukraine, Unified State Electronic Database on Education [32]; official data on radioactive contamination of territories [33]; assessments by international organizations, particularly the World Bank report [22].

To achieve the stated goal, a complex of general scientific and special methods was used: *statistical analysis* — for processing arrays of socio-economic indicators; *correlation analysis* — for identifying relationships between radioecological parameters and socio-economic indicators (Pearson correlation coefficient); *comparative-geographical method* — for comparing socio-economic indicators of the studied oblasts and identifying regional characteristics of radioactive contamination's impact on territorial development; *dynamic (temporal) analysis* — for identifying trends and patterns of changes in socio-economic indicators.

Statistical data processing was conducted using software packages for statistical analysis. The critical significance level for testing statistical hypotheses was set at 0.05 ($p<0.05$).

RESULTS AND DISCUSSION

Demographic crisis as an indicator of multi-level crisis. Analysis of the demographic situation in radioactively contaminated territories of Ukrainian Polissia revealed a persistent trend toward population decline caused by both natural decrease and migration loss (*Fig. 1, 2*).

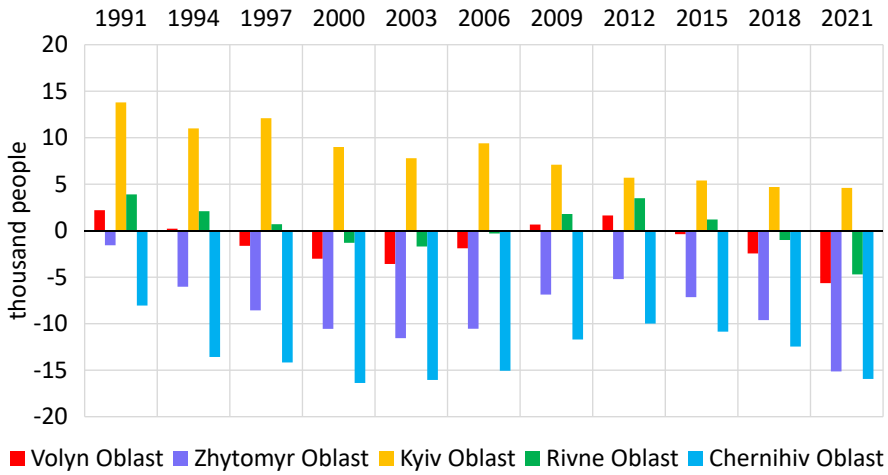

Fig. 1. Natural population increase/decrease in Ukrainian Polissia, 1991–2021, thousand persons

Source: compiled by the author based on [27–31].

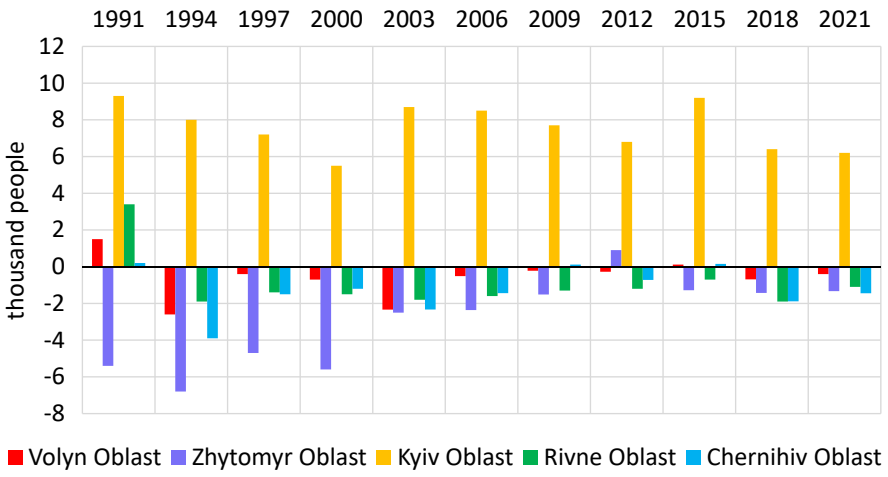

Fig. 2. Migration increase/decrease in Ukrainian Polissia, 1991–2021, thousand persons

Source: compiled by the author based on [27–31].

All oblasts of the region, except Kyiv, are characterized by negative natural population growth, indicating a deep demographic crisis. The dynamics relative to the baseline year of 1990 are particularly revealing: as of 2021, the population decreased by 31% in Chernihiv oblast, 24% in Zhytomyr, 11% in Volyn, and 13% in Rivne. Kyiv oblast demonstrates a different trajectory with moderate population growth since 2012, explained by its capital status and higher investment attractiveness.

Analysis of the age structure of migration is critically important. The greatest outflow is observed in the 15–19 age category, traditionally associated with leaving for education. However, from age 25 onward, the migration balance remains persistently negative, indicating young people's unwillingness to return to the region after obtaining education. This pattern is critical for crisis management, as it indicates not temporary but irreversible loss of human capital by the region. Kyiv oblast, conversely, accumulates labor force from the 20+ age category, including through outflow from neighboring Polissia oblasts, which intensifies peripheralization of the latter.

Interestingly, contrary to the widespread belief about catastrophic rural depopulation, official data do not confirm significant differentiation in the rates of rural and urban population decline — the dynamics proved approximately the same for both settlement types. This refutes the hypothesis about the predominantly rural nature of the demographic crisis and points to the systemic nature of the problem encompassing the entire settlement network of the region.

Unemployment as a marker of structural economic crisis. The unemployment rate in all studied oblasts without exception for 2019–2021 demonstrated steady growth, with pronounced gender and spatial differentiation. Female unemployment exceeds the corresponding indicator for males by 2 times in Volyn oblast, 1.2 times in Zhytomyr and Kyiv oblasts, and 2.4 times in Rivne oblast. Only Chernihiv oblast shows the opposite trend with female unemployment 20% lower than among males, which may be explained by the specifics of sectoral employment structure.

Analysis by locality type revealed that rural unemployment everywhere except Rivne oblast predominates over urban. This Rivne anomaly is explained by employment structure: in the region's most common industries (agriculture and forestry), predominantly male population is employed, which correlates with data on the gender structure of unemployment.

From a crisis management perspective, critically important is the fact that high unemployment serves not merely as an economic indicator but as a determinant of dangerous population behavior. The absence of legal income sources pushes residents toward risky practices: illegal amber mining (especially in Rivne and Zhytomyr oblasts) [16], poaching, collection and sale of radioactively contaminated forest products [8]. This creates the phenomenon of "dose export" — contaminated products entering spontaneous markets in large cities, expanding the geography of radiation risk.

Expenditure structure as an indicator of economic vulnerability. Analysis of total household expenditures revealed a paradoxical trend: during 2010–2021, the structure of consumer spending shows an increase in the share of non-food goods and a decrease in food expenditures. Formally, this indicates slight improvement in population welfare. However, detailed analysis of population distribution by income level refutes the optimistic interpretation: the share of population with incomes below 6,000 UAH per month is highest precisely in Rivne, Zhytomyr, and Volyn oblasts (71.0%, 70.9%, and 70.7% respectively) (*Fig. 3*).

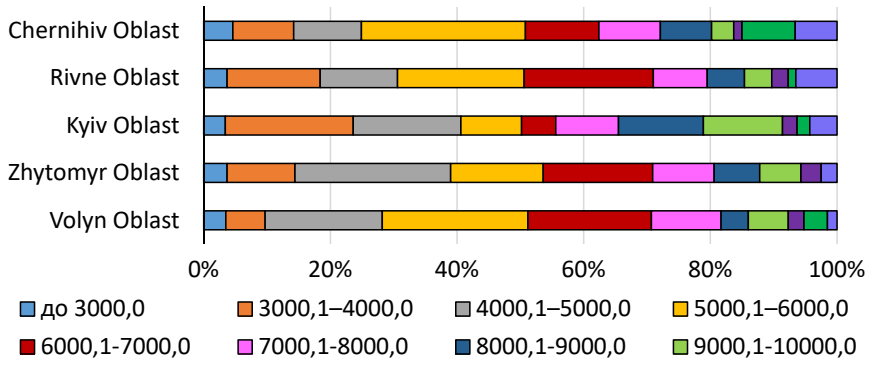

Fig. 3. Distribution of population (%)
by level of average per capita equivalent total monthly income in 2021, UAH

Source: compiled by the author based on [27–31].

From a crisis management perspective, particular attention deserves the structure of rural population income: up to 40% consists of income from selling household plot products (25%) and forest products (14.3%) [6; 7]. This creates a vicious circle: low income → dependence on subsistence farming → consumption of own potentially contaminated products → increased radiation dose → health deterioration → reduced work capacity → further impoverishment.

Revealing is the share of expenditures on alcoholic beverages and tobacco products: the highest indicators were recorded in Rivne and Zhytomyr oblasts (2.7% and 2.8% respectively) — precisely those regions characterized by the worst socio-economic indicators. Combined with data on population mortality from circulatory system diseases and neoplasms — the most common long-term medical consequences of the disaster — this points to the synergistic effect of radiation and socio-economic stress on population health.

Energy poverty and radiation risk. Research on housing conditions revealed a critical problem demonstrating a direct link between economic depression and radiation risk. According to a survey of Zhytomyr oblast residents, 51.4% of rural dwellings are heated with firewood from the nearest forest, and only about a quarter use natural gas [6; 7]. Under the energy crisis conditions of 2022–2023, caused by energy infrastructure destruction, this problem acquired nationwide scale; however, for radioactively contaminated territories it has a specific dimension. Critical is that permissible levels of radioactive contamination in fuel wood are not legally regulated, making effective control and management of this risk impossible.

From a crisis management perspective, this situation illustrates the classic conflict between short-term survival and long-term safety. The population consciously or unconsciously chooses energy accessibility at the expense of radiation safety, since alternatives are absent or economically inaccessible.

Education as both a factor and victim of crisis. Education expenditures remain critically low in all oblasts of the region (1.0–1.6% of total household expenditures) [27–31]. This indicates insufficient investment in human capital — the primary resource for crisis recovery. Full-scale war added new dimensions to the education crisis. According to data from the Ministry of Education and Science of Ukraine, in 2024 only 3,765 applications were submitted for the specialty (101) Ecology for bachelor's degree compared to 10,028 applications in pre-war 2021 — a nearly threefold reduction [32]. The average entrance score decreased by 20 points, reflecting both emigration of potential students and deterioration of school education quality.

Correlation analysis: identifying systemic connections. Correlation analysis revealed a complex system of interconnections between radioecological and socio-economic parameters (*Table 1*). The strongest relationship is observed between the number of settlements in the mandatory resettlement zone and the level of urban (r=0.71) and rural unemployment (r=0.64), as well as with total household expenditures (r=−0.79). This confirms that the most contaminated territories experience the most acute socio-economic crisis.

Interesting is the moderate correlation between the area of contaminated agricultural land and potato planting areas (r=0.65), indicating adaptation of the agricultural sector: potatoes as a crop with lower radionuclide accumulation become a priority on contaminated territories. At the same time, the strong negative relationship between contamination area and grain crops (r=−0.95) points to forced transformation of agricultural specialization.

The most important conclusion of the correlation analysis is revealing the nonlinear nature of the relationship between radioactive contamination and socio-economic indicators. For the most contaminated zones, the connection is strong and obvious; however, for less contaminated territories, the radiation factor recedes to the background, yielding to other development determinants — distance from regional centers, transport accessibility, presence of large enterprises. This refutes the simplified notion of direct causality "contamination → depression" and points to the need for differentiated crisis management strategies for different zones.

CONCLUSIONS

The research illuminated the clear role of socio-economic barriers as a systemic problem. Integrated analysis revealed that socio-economic barriers to recovery of radioactively contaminated territories are systemic in nature and form closed cycles of mutual reinforcement:

1. Poverty — risk cycle: low income → dependence on subsistence farming → consumption of contaminated products → health deterioration → reduced work capacity → further impoverishment.

2. Depopulation — degradation cycle: youth outflow → population aging → decreased economic activity → infrastructure deterioration → further outflow → depopulation.

3. Disinvestment cycle: low investment attractiveness → absence of jobs → migration → market contraction → further disinvestment.

4. Education — capital cycle: education un-

Table 1

Correlation matrix of sustainable development indicators for Ukrainian Polissia

	cont_ag	cont_forest	zone1	zone2	zone3	zone4	total_sett	unemp_city	unemp_rural	expenses	nat_growth	mig_growth	population	forest_reprod	cattle	pigs	sheep_goats	poultry	grains	sugar_beet	sunflower	potato	vegetables	fruit	cap_invest	cur_invest
cont_ag	1.00																									
cont_forest	1.00	1.00																								
zone1	0.30	0.22	1.00																							
zone2	−0.51	−0.46	−0.42	1.00																						
zone3	0.95	0.95	0.20	−0.44	1.00																					
zone4	0.85	0.86	0.10	−0.38	0.97	1.00																				
total_sett	0.79	0.80	0.25	−0.04	0.88	0.88	1.00																			
unemp_city	−0.17	−0.11	−0.50	0.71	−0.29	−0.38	−0.13	1.00																		
unemp_rural	−0.22	−0.15	−0.68	0.64	−0.32	−0.38	−0.23	0.97	1.00																	
expenses	−0.82	−0.83	−0.25	−0.02	−0.72	−0.58	−0.79	−0.32	−0.17	1.00																
nat_growth	−0.14	−0.20	0.78	0.22	−0.22	−0.29	0.08	−0.05	−0.29	−0.16	1.00															
mig_growth	0.15	0.07	0.99	−0.33	0.07	−0.00	0.16	−0.50	−0.69	−0.13	0.84	1.00														
population	0.41	0.34	0.98	−0.34	0.32	0.22	0.41	−0.41	−0.62	−0.43	0.79	0.95	1.00													
forest_reprod	0.62	0.68	−0.37	0.17	0.76	0.80	0.81	0.19	0.20	−0.63	−0.43	−0.45	−0.20	1.00												
cattle	0.54	0.55	−0.15	−0.72	0.65	0.72	0.30	−0.59	−0.43	0.00	−0.70	−0.24	−0.16	0.41	1.00											
pigs	−0.02	−0.09	0.95	−0.24	−0.12	−0.21	−0.01	−0.38	−0.58	−0.04	0.89	0.98	0.89	−0.60	−0.40	1.00										
sheep_goats	0.39	0.31	0.92	−0.74	0.29	0.20	0.15	−0.70	−0.80	−0.12	0.49	0.88	0.86	−0.39	0.19	0.81	1.00									
poultry	0.23	0.15	0.98	−0.25	0.16	0.09	0.31	−0.44	−0.66	−0.26	0.87	0.99	0.98	−0.31	−0.26	0.95	0.83	1.00								
grains	0.29	0.25	0.30	−0.95	0.18	0.11	−0.26	−0.59	−0.48	0.21	−0.27	0.23	0.18	−0.37	0.60	0.19	0.64	0.11	1.00							
sugar_beet	0.35	0.30	0.84	−0.01	0.20	0.06	0.40	0.01	−0.24	−0.60	0.86	0.82	0.91	−0.13	−0.47	0.81	0.60	0.87	−0.11	1.00						
sunflower	0.41	0.37	0.42	−0.99	0.31	0.24	−0.10	−0.65	−0.58	0.08	−0.19	0.33	0.32	−0.30	0.63	0.27	0.74	0.23	0.98	0.01	1.00					
potato	0.65	0.66	0.10	−0.20	0.85	0.94	0.88	−0.45	−0.46	−0.43	−0.17	0.04	0.21	0.77	0.61	−0.16	0.13	0.15	−0.09	0.04	0.04	1.00				
vegetables	0.42	0.35	0.98	−0.45	0.36	0.28	0.41	−0.55	−0.73	−0.35	0.72	0.96	0.99	−0.20	−0.03	0.88	0.91	0.97	0.27	0.83	0.41	0.28	1.00			
fruit	0.27	0.22	0.85	0.02	0.13	−0.01	0.34	0.01	−0.24	−0.53	0.90	0.83	0.90	−0.19	−0.52	0.84	0.60	0.89	−0.13	1.00	−0.02	−0.01	0.82	1.00		
cap_invest	0.24	0.17	0.81	−0.73	0.05	−0.09	−0.15	−0.48	−0.56	−0.04	0.43	0.77	0.72	−0.60	0.05	0.77	0.92	0.68	0.74	0.54	0.78	−0.23	0.74	0.54	1.00	
cur_invest	0.21	0.15	0.76	−0.60	−0.03	−0.21	−0.21	−0.25	−0.35	−0.12	0.47	0.72	0.68	−0.62	−0.12	0.75	0.82	0.63	0.65	0.60	0.68	−0.38	0.67	0.60	0.97	1.00

Legend: cont_ag — area of radioactively contaminated agricultural land, thousand ha; cont_forest — area of radioactively contaminated forests, thousand ha; zone1 — number of settlements in zone 1 (exclusion zone); zone2 — number of settlements in zone 2 (mandatory resettlement zone); zone3 — number of settlements in zone 3 (guaranteed voluntary resettlement zone); zone4 — number of settlements in zone 4 (enhanced radioecological control zone); total_sett — total number of settlements (sum across all zones); unemp_city — unemployment rate of working-age urban population in 2021, %; unemp_rural — unemployment rate of working-age rural population in 2021, %; expenses — total expenditures on average per month per household, UAH; nat_growth — natural population increase, thousand persons, 2021; mig_growth — migration increase, thousand persons, 2021; population — present population; forest_reprod — artificial forest reproduction, ha; cattle — cattle livestock, thousand heads; pigs — pig livestock, thousand heads; sheep_goats — sheep and goat livestock, thousand heads; poultry — poultry livestock, thousand heads; grains — sown area of grains and legumes, thousand ha; sugar_beet — sown area of sugar beet, thousand ha; sunflower — sown area of sunflower, thousand ha; potato — sown area of potatoes, thousand ha; vegetables — sown area of vegetables, thousand ha; fruit — area of fruit and berry plantations, thousand ha; cap_invest — capital investments in protection and rehabilitation of soil, underground and surface waters, total for 2006–2020, thousand UAH; cur_invest — current investments in protection and rehabilitation of soil, underground and surface waters, total for 2006–2020, thousand UAH.

Source: calculated by the author based on [26–33].

derfunding → low workforce qualification → labor market uncompetitiveness → migration of educated individuals → human capital loss → further education degradation.

The overlay of military crisis on chronic radioecological and socio-economic crises created a "triple crisis" situation that sharply narrowed the space of possible management decisions. Infrastructure destruction, territory mining, and population traumatization transformed the recovery problem from complex to critically complex.

Fundamentally important is the conclusion that radioactive contamination acts not so much as a direct cause of socio-economic depression but rather as a catalyst and amplifier of general crisis processes. This aligns with conclusions of international research on the contradictory nature of direct links between radiation exposure and quality of life, but adds critically important understanding: even in the absence of direct impact, the radiation factor creates additional barriers to economic development, investment, and social mobility, which collectively form a "depression trap" from which the region cannot escape without large-scale external support and systemic structural reforms and implementation of crisis management strategy in regional governance.

REFERENCES

1. United Nations Development Programme, & United Nations Children's Fund. (2002, January 25). *The human consequences of the Chernobyl nuclear accident: A strategy for recovery* [Report]. UN Office for the Coordination of Humanitarian Affairs; World Health Organization. Retrieved from http://www.reliefweb.int/library/documents/2002/undp_rus_25jan.pdf
2. Libanova, E. M. (2014). Demographic shifts in the context of social development. *Demography and Social Economy, 1*, 9–23.
3. Baranovskyi, M. O. (2021). Ukrainian Polissia in the post-Soviet period: Development problems, economic transformations, current features. In *Ukrainian Polissia: Problems and trends of modern development: Proceedings of the All-Ukrainian scientific-practical conference* (pp. 86–89). Nizhyn: NDU im. Hoholia.
4. Libanova, E. M. (2011). The Chornobyl catastrophe: 25 years later. *Demography and Social Economy, 2*, 3–18.
5. Libanova, E. M. (Ed.). (2015). *Human development in Ukraine. Modernization of social policy: Regional aspect*. Kyiv: Ptoukha Institute for Demography and Social Studies of the National Academy of Sciences of Ukraine.
6. Romanchuk, L. D., Dovzhenko, V. A., Fedoniuk, T. P., Borisiuk, L. B., & Lopatiuk, O. V. (2017). In L. D. Romanchuk (Ed.), *Assessment of quality of life and radiation safety of rural population of radioactively contaminated territories* [Monograph]. Zhytomyr: Hrafium.
7. Romanchuk, L. D., Herasymchuk, L. O., Kovalyova, S. P., Kovalchuk, Yu. V., & Lopatyuk, O. V. (2019). Quality of life of the population resident at the radioactively contaminated area in Zhytomyr Region. *Ukrainian Journal of Ecology, 9*(4), 478–485.
8. Kachur, D. P., Zamostian, P. V., Pankovska, H. P., Raichuk, L. A., Kuchma, M. D., & Sviatetska, A. V. (2010). Socio-environmental factors of consumer behavior of the population in radioactively contaminated areas of Polissia. *Agroecological Journal [Special issue]*, 106–110.
9. Anjum, G., Aziz, M., & Hamid, H. K. (2023). Life and mental health in limbo of the Ukraine war: How can helpers assist civilians, asylum seekers and refugees affected by the war? *Frontiers in Psychology, 14*, article number 1129299. doi: 10.3389/fpsyg.2023.1129299
10. Khrushch, O., Moskalets, V., Fedyk, O., Karpiuk, Y., Hasiuk, M., Ivantsev, N., ... Arjjumend, H. (2023). Environmental and psychological effects of Russian war in Ukraine. *Grassroots Journal of Natural Resources, 6*(1), 37–84. doi: 10.33002/nr2581.6853.060103
11. Kurapov, A., Pavlenko, V., Drozdov, A., Bezliudna, V., Reznik, A., & Isralowitz, R. (2023). Toward an understanding of the Russian-Ukrainian war impact on university students and personnel. *Journal of Loss and Trauma, 28*(2), 167–174. doi:10.1080/15325024.2022.2084838
12. Hasegawa, A., Ohira, T., Maeda, M., Yasumura, S., & Tanigawa, K. (2016). Emergency responses and health consequences after the Fukushima accident: Evacuation and relocation. *Clinical Oncology, 28*(4), 237–244. doi:10.1016/j.clon.2016.01.002
13. Murakami, M., Sato, A., Matsui, S., Goto, A., Kumagai, A., Tsubokura, M., ... Ochi, S. (2017). Communicating with residents about risks following the Fukushima nuclear accident. *Asia Pacific Journal of Public Health, 29*(2 Suppl.), 74S–89S. doi: 10.1177/1010539516681841
14. Smith, J. (2016). *The financial costs of the Chernobyl nuclear power plant disaster: A review of the literature* [Report]. University of Southern California, USC Institute on Inequalities in Global Health. Retrieved from https://globalhealth.usc.edu/wp-content/uploads/2016/01/2016_chernobyl_costs_report.pdf
15. Danzer, A. M., & Danzer, N. (2016). The long-run consequences of Chernobyl: Evidence on subjective well-being, mental health and welfare. *Journal of Public Economics, 135*, 47–60. doi: 10.1016/j.jpubeco.2016.01.001
16. Petryna, A. (2013). *Life exposed: Biological citizens after Chernobyl* (New and updated ed.). Princeton, Oxford: Princeton University Press.
17. Lehmann, H., & Wadsworth, J. (2011). The impact of Chernobyl on health and labour market performance. *Journal of Health Economics, 30*(5), 843–857. doi: 10.1016/j.jhealeco.2011.07.011
18. International Atomic Energy Agency. (2006). *Environmental consequences of the Chernobyl accident and their remediation: Twenty years of experience* [Technical Reports Series No. 444]. Vienna: IAEA. Retrieved from https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1239_web.pdf

19. Smith, J. T., & Beresford, N. A. (2005). *Chernobyl: Catastrophe and consequences*. Berlin, Heidelberg: Springer. doi: 10.1007/3-540-28079-0
20. Slovic, P., Flynn, J., & Layman, M. (1991). Perceived risk, trust, and the politics of nuclear waste. *Science, 254*(5038), 1603–1607. doi: 10.1126/science.254.5038.1603
21. Vandenhove, H., & Turcanu, C. (2016). Agricultural land management options following the Chernobyl and Fukushima accidents: The articulation of science, technology, and society. *Integrated Environmental Assessment and Management, 12*(4), 662–666. doi: 10.1002/ieam.1826
22. World Bank, Government of Ukraine, European Union, & United Nations. (2024). *Ukraine — third rapid damage and needs assessment (RDNA3): February 2022–December 2023*. Washington, DC: World Bank Group. Retrieved from http://documents.worldbank.org/curated/en/099021324115085807/P1801741bea12c012189ca16d95d8c2556a
23. Nikolaiev, Ye., Rii, H., & Shemelynets, I. (2023). *Higher education in Ukraine: Changes due to the war*. Kyiv: Borys Grinchenko Kyiv University.
24. Quarantelli, E. L. (1988). Disaster crisis management: A summary of research findings. *Journal of Management Studies, 25*(4), 373–385. doi: 10.1111/j.1467-6486.1988.tb00043.x
25. Pearson, C. M., & Clair, J. A. (1998). Reframing crisis management. *Academy of Management Review, 23*(1), 59–76. doi: 10.5465/amr.1998.192960
26. Official website of the State Statistics Service of Ukraine. (n.d.). Retrieved from http://www.ukrstat.gov.ua
27. Official website of the Main Department of Statistics in Volyn Region. (n.d.). Retrieved from http://www.lutsk.ukrstat.gov.ua
28. Official website of the Main Department of Statistics in Zhytomyr Region. (n.d.). Retrieved from http://www.zt.ukrstat.gov.ua
29. Official website of the Main Department of Statistics in Kyiv Region. (n.d.). Retrieved from http://kyivobl.ukrstat.gov.ua
30. Official website of the Main Department of Statistics in Rivne Region. (n.d.). Retrieved from http://www.gusrv.gov.ua
31. Official website of the Main Department of Statistics in Chernihiv Region. (n.d.). Retrieved from https://www.chernigivstat.gov.ua
32. Ministry of Education and Science of Ukraine. (n.d.). *Register of educational activity entities. Unified State Electronic Database on Education*. Retrieved from https://registry.edbo.gov.ua
33. Institute of Geography, National Academy of Sciences of Ukraine. (2024). *Contamination of territory with cesium-137 (consequence of the accident at the Chornobyl Nuclear Power Plant, 1986). National Atlas of Ukraine*. Retrieved from http://wdc.org.ua/atlas/7030100.html

КРИЗОВИЙ МЕНЕДЖМЕНТ РАДІОАКТИВНО ЗАБРУДНЕНИХ ТЕРИТОРІЙ: СОЦІАЛЬНО-ЕКОНОМІЧНІ БАР'ЄРИ ВІДНОВЛЕННЯ УКРАЇНСЬКОГО ПОЛІССЯ

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Стаття присвячена комплексному аналізу соціально-економічних бар'єрів відновлення радіоактивно забруднених територій Українського Полісся в контексті кризового екологічного менеджменту. Дослідження охоплює п'ять найбільш постраждалих від аварії на Чорнобильській атомній електростанції областей: Волинську, Житомирську, Київську, Рівненську та Чернігівську, за 2010–2021 рр. з ретроспективним аналізом демографічних процесів від 1991 р. та оцінкою впливу повномасштабної війни від 2022 р. Методологія базується на міждисциплінарному підході, що поєднує статистичний і кореляційний аналіз, порівняльно-географічний метод і динамічний аналіз часових рядів. Інформаційну базу становлять дані Державної служби статистики України, обласних управлінь статистики, Міністерства освіти і науки України та міжнародних організацій. Результати виявили катастрофічну демографічну кризу зі скороченням населення на 11–31% залежно від області, критично високе безробіття з гендерною диференціацією та небезпечну економічну залежність населення від натурального господарства. До 40% доходів сільських родин формується від продажу продукції підсобних господарств і лісових продуктів, що створює замкнене коло споживання потенційно забрудненої продукції. Виявлено проблему енергетичної бідності, коли понад половина сільських осель опалюється дровами з місцевих лісів за відсутності законодавчих норм радіоактивного забруднення паливної деревини. Кореляційний аналіз встановив нелінійний характер залежності між радіоактивним забрудненням та соціально-економічними показниками, виявивши найсильніший зв'язок для найбільш забруднених зон. Дослідження ідентифікувало чотири замкнені цикли взаємопідсилення проблем: бідності — ризику, депопуляції — деградації, дезінвестування та освіти — капіталу, що формують "пастку депресії". Накладення воєнного конфлікту створило ситуацію "потрійної кризи", різко звузивши простір управлінських рішень. Результати доводять, що радіоактивне забруднення виступає не прямою причиною, а каталізатором соціально-економічної депресії, створюючи додаткові бар'єри для розвитку. Висновки

мають практичне значення для розробки стратегій кризового менеджменту та регіональної політики, підкреслюючи необхідність комплексних програм реабілітації з масштабною зовнішньою підтримкою та системними структурними реформами.

Ключові слова: *Чорнобильська катастрофа, Українське Полісся, комплексна криза, екологічний менеджмент, депопуляція, людський капітал, повномасштабна війна.*

ЛІТЕРАТУРА

1. The human consequences of the Chernobyl nuclear accident: a strategy for recovery. Report commissioned by the United Nations Development Programme and the United Nations Children's Fund with the support of the UN Office for the Coordination of Humanitarian Affairs and the World Health Organization / UNDP, UNICEF. 25 January 2002. 82 p. URL: http://www.reliefweb.int/library/documents/2002/undp_rus_25jan.pdf (accessed: 15.10.2025).
2. Лібанова Е. М. Демографічні зрушення в контексті соціального розвитку. *Демографія та соціальна економіка*. 2014. № 1. С. 9–23.
3. Барановський М. О. Українське Полісся в пострадянську добу: проблеми розвитку, економічні трансформації, особливості сьогодення. *Українське Полісся: проблеми та тренди сучасного розвитку*: матеріали Всеукр. наук.-практ. конф. (м. Ніжин, 1–2 бер. 2021 року). Ніжин: НДУ ім. Гоголя, 2021. С. 86–89.
4. Лібанова Е. М. Чорнобильська катастрофа: 25 років потому. *Демографія та соціальна економіка*. 2011. № 2. С. 3–18.
5. Лібанова Е. М. Людський розвиток в Україні. *Модернізація соціальної політики: регіональний аспект*: кол. монографія / за заг. ред. Е. М. Лібанової. Київ: Інститут демографії та соціальних досліджень ім. М. В. Птухи НАН України, 2015. 356 с.
6. Оцінка якості життя та радіаційної безпеки сільського населення радіоактивно забруднених територій: монографія / Л. Д. Романчук, В. А. Довженко, Т. П. Федонюк та ін.; за заг. ред. Л. Д. Романчук. Житомир: Графіум, 2017. 268 с.
7. Romanchuk L. D., Herasymchuk L. O., Kovalyova S. P. et al. Quality of life of the population resident at the radioactively contaminated area in Zhytomyr region. *Ukrainian Journal of Ecology*. 2019. Vol. 9, iss. 4. P. 478–485.
8. Качур Д. П., Замостян П. В., Паньковська Г. П. та ін. Соціально-екологічні чинники споживчої поведінки населення на радіоактивно забруднених територіях Полісся. *Агроекологічний журнал*. 2010. Спецвипуск. С. 106–110.
9. Anjum G., Aziz M., Hamid H. K. Life and mental health in limbo of the Ukraine war: How can helpers assist civilians, asylum seekers and refugees affected by the war? *Frontiers in Psychology*. 2023. Vol. 14. 1129299. P. 1–14. DOI: https://doi.org/10.3389/fpsyg.2023.1129299
10. Khrushch O., Moskalets V., Fedyk O. et al. Environmental and psychological effects of Russian war in Ukraine. *Grassroots Journal of Natural Resources*. 2023. Vol. 6, iss. 1. P. 37–84. DOI: https://doi.org/10.33002/nr2581.6853.060103
11. Kurapov A., Pavlenko V., Drozdov A. et al. Toward an understanding of the Russian-Ukrainian war impact on university students and personnel. *Journal of Loss and Trauma*. 2023. Vol. 28, iss. 2. P. 167–174. DOI: https://doi.org/10.1080/15325024.2022.2084838
12. Hasegawa A., Ohira T., Maeda M. et al. Emergency responses and health consequences after the Fukushima accident; evacuation and relocation. *Clinical Oncology*. 2016. Vol. 28, iss. 4. P. 237–244. DOI: https://doi.org/10.1016/j.clon.2016.01.002
13. Murakami M., Sato A., Matsui S. et al. Communicating with residents about risks following the Fukushima nuclear accident. *Asia Pacific Journal of Public Health*. 2017. Vol. 29, iss. 2 (suppl.). P. 74S–89S. DOI: https://doi.org/10.1177/1010539516681841
14. Smith J. The financial costs of the Chernobyl nuclear power plant disaster: a review of the literature / USC Institute on Inequalities in Global Health. Los Angeles: University of Southern California, 2016. 49 p. URL: https://globalhealth.usc.edu/wp-content/uploads/2016/01/2016_chernobyl_costs_report.pdf (accessed: 20.10.2025).
15. Danzer A. M., Danzer N. The long-run consequences of Chernobyl: evidence on subjective well-being, mental health and welfare. *Journal of Public Economics*. 2016. Vol. 135. P. 47–60. DOI: https://doi.org/10.1016/j.jpubeco.2016.01.001
16. Petryna A. *Life exposed: Biological citizens after Chernobyl* (New and updated edition). Princeton, Oxford: Princeton University Press, 2013. xxv, 286 p. ISBN 978-0-691-15166-3.
17. Lehmann H., Wadsworth J. The impact of Chernobyl on health and labour market performance. *Journal of Health Economics*. 2011. Vol. 30, iss. 5. P. 843–857. DOI: https://doi.org/10.1016/j.jhealeco.2011.07.011
18. Environmental consequences of the Chernobyl accident and their remediation: twenty years of experience: Technical Reports Series, No. 444 / International Atomic Energy Agency. Vienna: IAEA, 2006. 166 p. ISBN 92-0-114705-8. URL: https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1239_web.pdf (accessed: 03.09.2025).
19. Smith J. T., Beresford N. A. Chernobyl: catastrophe and consequences. Berlin; Heidelberg: Springer, 2005. 334 p. (Springer Praxis Books). ISBN 978-3-540-23866-9. DOI: https://doi.org/10.1007/3-540-28079-0
20. Slovic P., Flynn J., Layman M. Perceived risk, trust, and the politics of nuclear waste. *Science*. 1991. Vol. 254, no. 5038. P. 1603–1607. DOI: https://doi.org/10.1126/science.254.5038.1603
21. Vandenhove H., Turcanu C. Agricultural land management options following the Chernobyl and Fukushima accidents: the articulation of science, technology, and society. *Integrated Environmental Assessment and Management*. 2016. Vol. 12, iss. 4. P. 662–666. DOI: https://doi.org/10.1002/ieam.1826
22. Ukraine — third rapid damage and needs assessment (RDNA3): February 2022 — December 2023 / World Bank, Government of Ukraine, European Union, United Nations. Washington, D.C.: World Bank Group. URL: http://

documents.worldbank.org/curated/en/099021324115085807/P1801741bea12c012189ca16d95d8c2556a (accessed: 23.10.2024).
23. Ніколаєв Є., Рій Г., Шемелинець І. Вища освіта в Україні: зміни через війну: аналітичний звіт. Київ: Київський університет імені Бориса Грінченка, 2023. 94 с.
24. Quarantelli E. L. Disaster crisis management: a summary of research findings. *Journal of Management Studies*. 1988. Vol. 25, iss. 4. P. 373–385. DOI: https://doi.org/10.1111/j.1467-6486.1988.tb00043.x
25. Pearson C. M., Clair J. A. Reframing crisis management. *Academy of Management Review*. 1998. Vol. 23, iss. 1. P. 59–76. DOI: https://doi.org/10.5465/amr.1998.192960
26. Офіційний вебсайт Державної служби статистики України. URL: https://ukrstat.gov.ua/ (дата звернення: 20.01.2022).
27. Офіційний вебсайт Головного управління статистики у Волинській області. URL: http://www.lutsk.ukrstat.gov.ua/ (дата звернення: 20.01.2022).
28. Офіційний вебсайт Головного управління статистики у Житомирській області. URL: http://www.zt.ukrstat.gov.ua/ (дата звернення: 20.01.2022).
29. Офіційний вебсайт Головного управління статистики у Київській області. URL: http://kyivobl.ukrstat.gov.ua/ (дата звернення: 20.01.2022).
30. Офіційний вебсайт Головного управління статистики у Рівненській області. URL: http://www.gusrv.gov.ua/ (дата звернення: 20.01.2022).
31. Офіційний вебсайт Головного управління статистики у Чернігівській області. URL: https://www.chernigivstat.gov.ua/ (дата звернення: 20.01.2022).
32. Реєстр суб'єктів освітньої діяльності. *Єдина державна електронна база з питань освіти (ЄДБО) Міністерства освіти і науки України*. URL: https://registry.edbo.gov.ua/ (дата звернення: 20.01.2022).
33. Забрудненість території цезієм-137 (наслідок аварії на Чорнобильській атомній електростанції, 1986 р.). *Національний атлас України* / Інститут географії НАН України. URL: http://wdc.org.ua/atlas/7030100.html (дата звернення: 16.01.2024).

ВІДОМОСТІ ПРО АВТОРА

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ЄС інвестує майже €3 млрд у проєкти з нульовим рівнем викидів. Проєкти реалізують у 18 країнах євроспільноти, очікують скорочення викидів CO_2 на 221 млн т за перші 10 років. Гранти отримає 61 проєкт різного масштабу, фінансування надходить з Інноваційного фонду ЄС. Проєкти охоплюють 19 секторів, зокрема енергоємні галузі, відновлювану енергетику, управління викидами та чисті технології, приклади — італійський проєкт DREAM з криогенним уловлюванням вуглецю та шведський BMS з виробництвом композитів PaperShell. В усіх проєктах обов'язковий інноваційний технологічний складник, який оцінювали поряд із екологічним ефектом, відтворюваністю та економічною ефективністю. Раніше повідомляли, що українські промислові гравці виконують "зелену" модернізацію за власний кошт, держенергоефективності підтримує лише точкові енергоефективні проєкти.