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# Socio-economic security of the region in war conditions: Damage assessment, modelling of recovery paths and their regulatory support

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**Abstract**. The realities of today and the active phase of the war determine the search for new ways to form the economic potential of Ukraine, considering direct and indirect losses that have arisen as a result of military operations, which determines the relevance of the research topic. Accordingly, the purpose of the study was to analyse the factors of destabilising influence on the economic security of regions and develop ways to restore their socio-economic potential. Special attention in the course of the study was paid to the assessment of losses as a result of military operations and other processes that accompany the functioning of regions in conditions of extreme aggravation of threats. A model for assessing the negative consequences of the impact of temporary emigration, mobilisation, and internal displacement of the population on the socio-economic security of the region is developed. Within the framework of the model, the state of losses was determined depending on the ratio of the main components of temporary emigration, which include: departure from Ukraine and return, the level of job vacancies, and the demand for jobs of medical workers. The main conditions of losses from mobilisation and temporary migration of the population are also determined. It was proved that the implementation of regional rehabilitation programmes will reduce the amount of losses and ensure the growth of the socio-economic potential of the regions in the medium term, including by improving the regulatory support for financing such processes. This will allow getting a substantial social, economic, security, and legal effect. At the same time, an absolutely new field was being formed for further research on the implementation of security mechanisms at the macro, meso, and micro levels in the conditions of war and post-war reconstruction of territories. The results of the study can be used by state institutions and investment funds interested in reconstructing the socio-economic potential of Ukraine and creating safe, favourable conditions for its implementation

**Keywords**: socio-economic development; economic security; damage assessment model; rehabilitation; regional development

**Suggested Citation**

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## Introduction

Socio-economic security of the region covers various aspects, such as economic development, employment levels, access to education and health, social programmes, life safety, and much more. Military operations in Ukraine substantially affect the socio-economic security of the regions and cause a number of negative factors that increase stagnation and crisis processes. These factors should include temporary emigration (mainly of the working-age female population; however, the share of emigrants from the western regions is substantially less than the share of emigrants from the central and eastern regions of Ukraine), which affects the economy of the country and individual regions through the loss of labour, and creates social and economic difficulties for family members who remain in the country. In addition, while the population's involvement in military operations is a critically necessary phenomenon, it decreases labour efficiency at the main place of work, and the attraction of financial and material resources for military needs affects the region's economic stability. The growing number of internally displaced persons poses humanitarian, social, and economic challenges for the country and regions. There are substantial imbalances in the development of individual communities, and there is a shortage of funding for measures aimed at ensuring their socio-economic development even in the medium term.

Research on the functioning of the socio-economic security system emphasises that the effectiveness of its functioning depends on the examination of the environment and an adequate response to each of the possible impacts and adaptive capabilities of the system. Ye. Ziabina *et al.* (2020) noted that it is necessary to consider the specifics of the development of socio-economic and motivational processes. The authors emphasise the importance of motivation for making managerial decisions in ensuring economic security at different levels and examine various indicators for assessing the state of socio-economic processes at the macro and meso levels. T.G. Vasyltsiv *et al.* (2023) focused on such modern trends in the development of society as artificial intelligence and socio-political transformations since they allow gaining substantial competitive advantages and, on the other hand, generate new threats to socio-economic systems that require the formation of new approaches to their levelling and management to respond promptly in a clearly defined time frame. Migration processes are considered separately. As indicated by O.P. Mulska *et al.* (2020) and E. Çıtak (2020), such processes negatively affect the security of the state and regions due to a decrease in the number of working people and the movement of the most active part of them abroad, which is an extremely negative trend in recent times. The movement of intellectual capital is investigated by M.I. Kopytko *et al.* (2023), emphasising the importance of intellectual potential for the development of the state and focusing on the deterioration of the security of socio-economic systems due to the decline in the country's intellectual capital, considering the negative trends of war. It is proposed to develop new approaches to the preservation of intellectual capital and implement appropriate strategic decisions at various levels of development of socio-economic systems.

A substantial part of researchers focus their attention on the specific features of the functioning of organisations in conditions of socio-economic destabilisation and rapid changes, for example, J.R. Anderson (2019) and I.R. Mihus *et al.* (2020). The authors emphasise the importance of considering the influence of a set of organisations on the behaviour of state agents and the formation of an environment that contributes or does not contribute to business development. Economic security depends on this not only at the micro level but also at the level of the socio-economic system in general (Klemenc, 2021).

The purpose of this study was to analyse the factors of destabilising influence on the economic security of regions and develop ways to restore their socio-economic potential. The main objective of the study is to substantiate the feasibility of implementing rehabilitation programmes for the population based on the use of a model for assessing the region's socio-economic development losses in the medium and long term.

## Materials and methods

The methodology for forming a system of economic security at the macro, meso, and micro levels provides for the prevention or minimisation of negative environmental influences, but there is an opinion that it is impossible to level absolutely all negative factors of influence, especially those related to military operations. Such factors are described in detail in the state policy strategy on internal displacement for the period up to 2025, Decree of the Cabinet of the Ministers of Ukraine No. 312-p (2023), namely: "large-scale aggression against Ukraine and the risk of its further escalation, destruction of the infrastructure of settlements, both close to the war zone and those in which military operations are already underway, and located on the rest of the country, create risks of a substantial increase in internal displacement". This situation leads to the need to develop a number of regulatory provisions that would not only provide for a certain level of financial support for communities but also regulate the issues of rehabilitation of the population, since according to the above-mentioned strategy, "...the insufficient level of available psychological assistance and rehabilitation for internally displaced persons, especially children affected by armed aggression against Ukraine, complicates the processes of adaptation in the new environment... In addition, it is equally important to create conditions for organising psychosocial support in the new workplace for internally displaced persons". The procedure for using the funds provided in the state budget for the implementation of measures to provide social and psychological assistance by the Centers for Social and Psychological Rehabilitation of the Population Decree of the Cabinet of the Ministers of Ukraine No. 149 (2015) was approved to implement the high-quality performance of social security functions at the macro level. Such a regulatory document regulates the distribution of budget funds, but as practice shows, it requires systematic improvement of the mechanism of its application, especially considering the situation in certain regions. Therewith, the inability to eliminate all the negative consequences for the socio-economic security of the region does not mean that they should not be eliminated. This process can be generalised by transforming these consequences into input factors (variables) of medium- and long-term economic planning functions. The factors described above are indicated by TE (temporary emigration), M (mobilisation), ID (internal displacement). The relative decline in employment (rising unemployment) is a function of *cnz**) from these factors:

$$cnz^{*}_{1000} = CnZ(TE, M, ID). \quad (1)$$

Function (1) returns dimensionless quantities (denoted as $cnz^{*}_{1000}$) – either the shares or percentages by which employment decreases or unemployment increases for 1000 people of the working population over a certain period of time (quarter or year). The relative decline in production (*RDP*), which is the result of a growing shortage of labour resources, is a certain function *cnb*(*) from these factors:

$$cnb^{*} = CnB(TE, M, ID), \quad (2)$$

where which returns the value $RDP^{*}$, which shows by what share (percentage) production will decline over a certain period of time (from a month to a quarter). Due to the evident limitations of statistical observation, the reflection of a decline in employment (1) is more inert than the reflection of a decline in production. Finally, the function:

$$cncp^{*} = CDD(TE, M, ID), \quad (3)$$

where returns a value $CDD^{*}$, which shows by what share (percentage) consumer demand will decline (during the same period. Functions (1) – (3) can formally acquire negative values, but at non-zero levels of *TE*, *M*, and , the values of these functions are at least zero. In real conditions, even insubstantial levels of temporary emigration, mobilisation, and migration provoke a decline in production and destabilisation of consumer demand. Resources to compensate for the negative impact of the consequences of factors *TE*, *M*, and  (after their manifestation for several months) are estimated using a certain transformation ψ (•) with respect to the fractions or percentages of the decline (1) – (3) and the factors that cause these declines:

$$\psi^{*} = \psi(TE, M, ID; cnz^{*}_{1000}, cnb^{*}, cncp^{*}). \quad (4)$$

Strictly speaking, value (4) is something that, one way or another, the state or regional administration should allocate in the near future so that the negative impact does not continue to destabilise the regional economy. On the other hand, directing resources immediately to eliminate these consequences in advance can be attempted, without waiting for them to manifest. After, there is an assessment of losses (*L*) from the negative impact of the consequences of factors *TE*, *M*, and  as dimensionless values

$$Z(TE), Z(M), \text{ i } Z(ID), \quad (5)$$

where within a standardised scale (for example, from 0 to 1). Then, the sum of the values (5) is converted to the resource (financial) equivalent. This equivalent (*Inv*) is actually an investment in the post-war future. If:

$$Inv = Z(TE), Z(M), Z(ID) < \psi, \quad (6)$$

where this will prove that such investment (conducted within the framework of a government or regional programme, respectively) is quite appropriate both for eliminating negative consequences for the socio-economic security of the region and for partially preventing problems of post-war adaptation. It will also help accelerate the restoration of the region's labour potential. Moreover, the future post-war reality of Ukraine will require the concentration of colossal labour resources on the production and construction sector for the dynamic restoration of municipal and other infrastructure facilities in the country (possibly according to improved quality standards to strengthen protection during enemy terrorist attacks).

## Results

It is necessary to justify the actual feasibility of a rehabilitation programme in the medium term, in addition to its clear aspirations and virtues. It is necessary to estimate (predict) losses (5) and prove inequality (6) to do this. The loss (5) forecast can only be relative on a standardised scale from 0 to 1. Losses are divided into five groups – minor, moderate, substantial, very substantial, and critical. These groups are considered to correspond to five classes or states, one of which is caused by the negative impact of the effects of factors *TE*, *M*, and *ID*. Given the uncertainty of the data, decision trees will be used as a model for determining the level of losses, which, even in conditions of strong uncertainty, can relatively reliably indicate the most relevant class (Kamiński *et al.,* 2017). The factor of temporary emigration causes losses due to the action of its three components: the difference in the number of citizens who left Ukraine and the number of citizens who returned to Ukraine (*KGVP* and $x_1$ for the tree); the relative level of job vacancies (mainly for women; are denoted by *LJV* and $x_2$ for the tree); relative demand (jobs) for medical workers (*JMW* and $x_3$ for the tree).

It is emphasised that *KGVP* is calculated directly by the state border service of Ukraine, whereas *LJV* and *JMW* are more akin to the consequences of emigration (and their exact calculation is almost impossible – they are only evaluated). It is equally important to consider that these three components have a certain mutual influence, that is, there is some correlation, although not equivalent, between each pair of the three *KGVP*, *LJV*, *JMW*. Next, a table of different states (levels) of losses is compiled depending on the ratio of the three components of temporary emigration (Table 1).

**Table 1.** States of losses depending on the ratio of the three components of temporary emigration

| State of losses | Departures from Ukraine and returns (*KGVP*) | Level of job vacancies (*LJV*) | Demand (jobs) for medical workers (*JMW*) |
|---|---|---|---|
| 1 | 0 | 0 | 0 |
| 1 | 0.4 | 0.15 | 0 |
| 1 | 0.8 | 0 | 0 |
| 2 | 0.25 | 0 | 0 |
| 2 | 0.25 | 0 | 0.25 |
| 2 | 0 | 0 | 0.25 |

Table 1, Continued

| State of losses | Departures from Ukraine and returns (*KGVP*) | Level of job vacancies (*LJV*) | Demand (jobs) for medical workers (*JMW*) |
|---|---|---|---|
| 3 | 0 | 0 | 0.5 |
| 3 | 0.5 | 0 | 0.5 |
| 3 | 0.5 | 0.25 | 0.5 |
| 4 | 0 | 0 | 0.75 |
| 4 | 0.5 | 0.25 | 0.75 |
| 4 | 0.75 | 0.6 | 0.5 |
| 5 | 0.25 | 0.5 | 1 |
| 5 | 0.5 | 0.5 | 1 |
| 5 | 0 | 1 | 1 |

**Source:** compiled by the author

Surely, it is impossible to go through all possible (even basic) options, so only specific cases are indicated as examples, using judgments about the shares of decline (1) – (3). A total of 15 examples were compiled – three examples for each state of damage. With the help of experts, some values were corrected. To build a decision tree that is later accessed simply as *Z*(*TE*), it is necessary to increase the amount of data, otherwise, it is impossible to build a reliable tree that can pass validation. This is done artificially using data augmentation by V. Romanuke (2020). To each three values from Table 1, the normal noise of V. Romanuke (2019) is added as a three-component vector:

$$[KGVP\ PPB\ PMP] + 0{,}015 \cdot [\xi_1\ \xi_2\ \xi_3], \qquad (7)$$

where $\xi_1$ $\xi_2$ $\xi_3$ – the values of three mutually independent random variables distributed normally with zero mean and unit variance (i.e., with a single root-mean-square deviation). Operation (7) is repeated 10 times. Thus, 150 data samples were obtained. Of these, a third (i.e. 50 samples) are used for testing the decision tree *Z*(*TE*). The remaining 100 samples are used to directly determine the coefficients (with which variables $x_1$, $x_2$, $x_3$) in the nodes of branches should be com. The decision tree *Z*(*TE*) is shown in Figure 1.

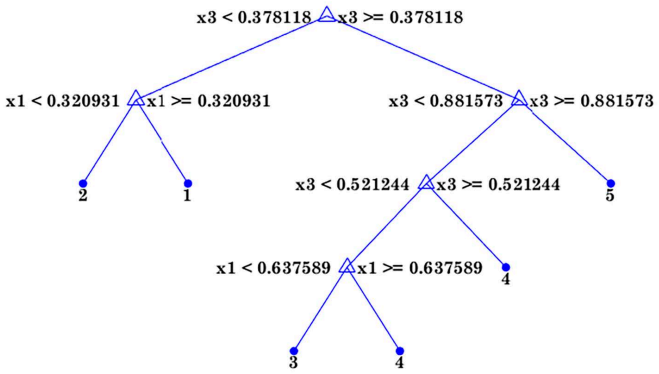


**Figure 1.** Decision tree *Z*(*TE*), based on the data in Table 1 and data augmentation (7), where there are no nodes with job vacancy levels $x_2$

**Source:** compiled by the author

Thus, the root node is *JMW*. Minor and moderate losses from temporary emigration are most quickly determined by the *KGVP* verification. Critical losses are also detected relatively quickly, and high demand for medical workers leads to them. Substantial and very substantial losses are determined additionally by the level of departures from Ukraine and returns. There is no level of job vacancies in the nodes of this tree ($x_2$). Thus, changes in the level of job vacancies (whether for women or without regard to gender) do not determine the damage caused by temporary migration. In other words, an increase in the number of job vacancies does not necessarily mean losses in the near future. This is explained by the fact that the registration of vacancies (new arrivals), despite the effects of digitalisation, is a somewhat inert process and does not reflect the real state of the labour market. In addition, the potential shortage of labour resources is partially covered by internally displaced persons.

Testing the decision tree *Z*(*TE*) showed that it has an accuracy of 94% (for three of the 50 variants of the ratio of the three components of temporary emigration, the state of losses was determined incorrectly – all three cases of minor losses were "confused" with moderate losses, that is, "reinsured"). This is an acceptable accuracy that confirms the validity of decisions based on this tree. In addition, the decision on minor and moderate losses is made on the basis of *KGVP*, and substantial and very substantial damage is also located on neighbouring *Z*(*TE*) tree branches, decisions on which are also made on the basis of *KGVP*. Very substantial losses, in turn, are located next to critical losses. All these features further confirm the validity of the decision tree *Z*(*TE*).

The mobilisation factor causes losses due to the action of the following three components: the actual level of mobilised citizens (as the share of mobilised per 1000 citizens; is

indicated by *PMG* and $x_1$ for the tree); the share of mobilised citizens who are in the ranks of territorial defence (indicated by *MGTO* and $x_2$ for the tree); the relative level of job vacancies (mainly for men; denoted by *PPBH* and $x_3$ for the tree). Of these components, only *PPBH*, which is a consequence of mobilisation, is evaluated more roughly, and the data on *PMG* and *MGTO* are calculated directly by the military. Thus, *PMG* and *MGTO* are more clearly correlated. However, they affect *PPBH*. A table of different states (levels) of losses is compiled depending on the ratio of the three components of the mobilisation factor (Table 2) and increases the amount of data by augmenting the data, similar to operation (7) to build a decision tree Z(*TE*):

$$[PMG\ MGTO\ PPBH] + 0{,}01 \cdot [\xi_1\ \xi_2\ \xi_3], \qquad (8)$$

where operation (8) is repeated 10 times. The multiplier before the triple pseudo-random values in the case of the mobilisation factor was reduced because registration and statistics of *PMG* and *MGTO* are much more reliable than *PPB* and *JMW* for temporary migration (*KGVP* is tracked clearly). Of the 150 data samples, a t hird were again used to test the decision tree.

**Table 2.** States of damage depending on the ratio of the three components of the mobilisation factor

| State of losses | Total number of people mobilised (*PMG*) | Share of mobilised citizens who are in the ranks of territorial defence (*MGTO*) | The level of vacancies (mainly for men) (*PPBH*) |
|---|---|---|---|
| 1 | 0 | 0 | 0 |
| 1 | 0.15 | 0.05 | 0.1 |
| 1 | 0.05 | 0.5 | 0.05 |
| 2 | 0.1 | 0.05 | 0.5 |
| 2 | 0.2 | 0.1 | 0.1 |
| 2 | 0.25 | 0.5 | 0.2 |
| 3 | 0.4 | 0.2 | 0.5 |
| 3 | 0.45 | 0.35 | 0.35 |
| 3 | 0.35 | 0.75 | 0.45 |
| 4 | 0.35 | 0.15 | 0.75 |
| 4 | 0.2 | 0.5 | 0.7 |
| 4 | 0.3 | 0.6 | 0.4 |
| 5 | 0.25 | 0.5 | 0.9 |
| 5 | 0.55 | 0.5 | 0.9 |
| 5 | 0.8 | 0.55 | 0.95 |

**Source:** compiled by the author

The decision tree *Z*(*M*) that was constructed is shown in Figure 2. Like the decision tree for temporary emigration losses, the decision tree *Z*(*M*) has four levels. The root node here is the level of job vacancies, which immediately determines critical losses. Minor and moderate losses are most quickly determined by sequential verification of *PPBH* and *PMG*. Another branch that determines moderate losses is also tested twice by *PPBY* and once by *PMG* and *MGTO*. Very substantial losses are determined by the two longest branches, which also consider all three components of the mobilisation factor. Testing the decision tree *Z*(*M*) showed that it has an accuracy of 90%. Here, five out of 50 variants of the ratio of the three components of the mobilisation factor were problematic. In particular, five times moderate losses were "confused" with very substantial losses by this tree. This is due to the fact that these two states are located on adjacent branches of the tree, and the decision on them is made based on *MGTO*. However, 90% accuracy is acceptable, which confirms the validity of solutions based on this tree. In addition, other damage states that are logically adjacent (minor and moderate, substantial, and very substantial) are also adjacent on the branches of this tree.

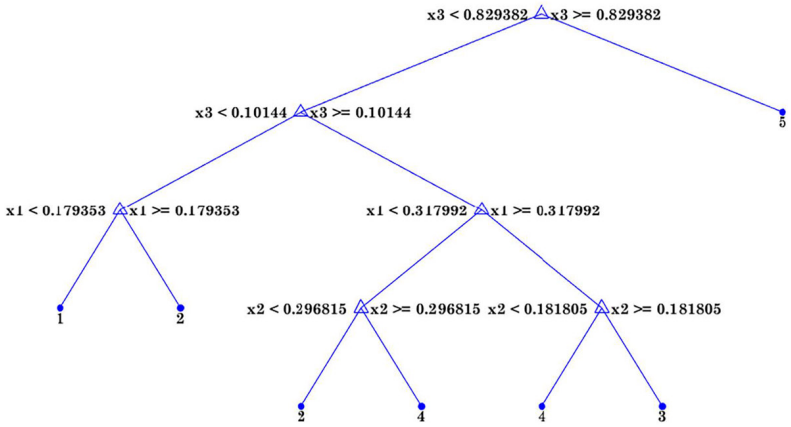


**Figure 2.** Full-node decision tree *Z*(*M*), based on the data in Table 2 and data augmentation (8), where all three components of the mobilisation factor are used ($x_1$, $x_2$, $x_3$)

**Source:** compiled by the author

The factor of temporary migration (internally displaced persons) causes losses due to the action of the following four components: changes in the number of people living in a given period of time on the territory of the community, region (indicated by *OP* and $x_1$ for the tree); the number of applications of internally displaced citizens for assistance to local self-government bodies, including registration at the place of temporary residence (indicated via *KZ* and $x_2$ for the tree); the level of real estate prices (indicated by *CN* and $x_3$ for the tree); the total volume of job vacancies offered on the labour exchange (indicated by *OPPB* and $x_4$ for the tree);

Component *OP* and indirectly the component *KZ* are closely related to temporary migration, *CN*, and *OPPB* are already its consequences. A mutual correlation between each pair of four *OP*, *KZ*, *CN*, and *OPPB* is also present. The strongest correlation is observed between *OP* and *KZ* and between *KZ* and *CN* (although the connection in this pair after the summer of 2022 substantially weakened – real estate prices stabilised). The weakest correlation, as recent observations show, is characteristic of *CN* and *OPPB*.

A table of different states (levels) of losses is compiled depending on the ratio of the four components of the temporary migration factor (Table 3), where the minimum level for each component is 0.01 to build a decision tree *Z*(*ID*). Since another component was added in this case, the number of base relationships must be larger; otherwise, the decision tree will not pass validation. That is why Table 3 contains four different ratios for each damage state. In addition, an operation is used to augment data.

$$[OP\ KZ\ OPPB] + 0{,}35 \cdot [\xi_1\ \xi_2\ \xi_3], \qquad (9)$$

where which is repeated 20 times ($\xi_4$ – additional, fourth, value of an independent random variable distributed normally with zero mean and single root-mean-square deviation). As a result, 400 data samples were obtained, of which 100 were used for testing the Z(*ID*) decision tree.

**Table 3.** Damage states depending on the ratio of the four components of the temporary migration factor

| State of losses | Change in the number of people (*OP*) | Number of requests from internally displaced persons for assistance (*KZ*) | Real estate price level (*CN*) | Total volume of job vacancies offered on the labour exchange (*OPPB*) |
|---|---|---|---|---|
| 1 | 0.01 | 0.05 | 0.05 | 0.01 |
| 1 | 0.2 | 0.1 | 0.1 | 0.02 |
| 1 | 0.01 | 0.01 | 0.15 | 0.03 |
| 1 | 0.1 | 0.15 | 0.05 | 0.02 |
| 2 | 0.25 | 0.01 | 0.01 | 0.01 |
| 2 | 0.01 | 0.25 | 0.01 | 0.01 |
| 2 | 0.01 | 0.01 | 0.25 | 0.01 |
| 2 | 0.02 | 0.05 | 0.05 | 0.3 |
| 3 | 0.45 | 0.05 | 0.05 | 0.05 |
| 3 | 0.05 | 0.45 | 0.05 | 0.1 |
| 3 | 0.1 | 0.25 | 0.5 | 0.35 |
| 3 | 0.05 | 0.45 | 0.45 | 0.65 |
| 4 | 0.7 | 0.5 | 0.5 | 0.1 |
| 4 | 0.35 | 0.65 | 0.25 | 0.1 |
| 4 | 0.35 | 0.4 | 0.75 | 0.55 |
| 4 | 0.6 | 0.7 | 0.8 | 0.85 |
| 5 | 0.75 | 0.75 | 0.5 | 0.6 |
| 5 | 0.8 | 0.5 | 0.5 | 0.9 |
| 5 | 0.9 | 0.65 | 0.85 | 0.95 |
| 5 | 0.85 | 0.95 | 0.55 | 0.9 |

**Source:** compiled by the author

The decision tree *Z*(*ID*) that was built is shown in Figure 3. This tree is more complex than *Z*(*TE*) and *Z*(*M*). It has six levels. Each of the four components of the temporary migration factor is involved in deciding on the state of damage. The longest branch contains small to moderate losses, which ultimately differ in property prices. Stronger damage is easier to detect. The distinction between very substantial and critical losses is made in one of two ways: by the number of requests from internally displaced persons for help (*KZ*) or by the total volume of job vacancies offered on the labour exchange (*OPPB*).

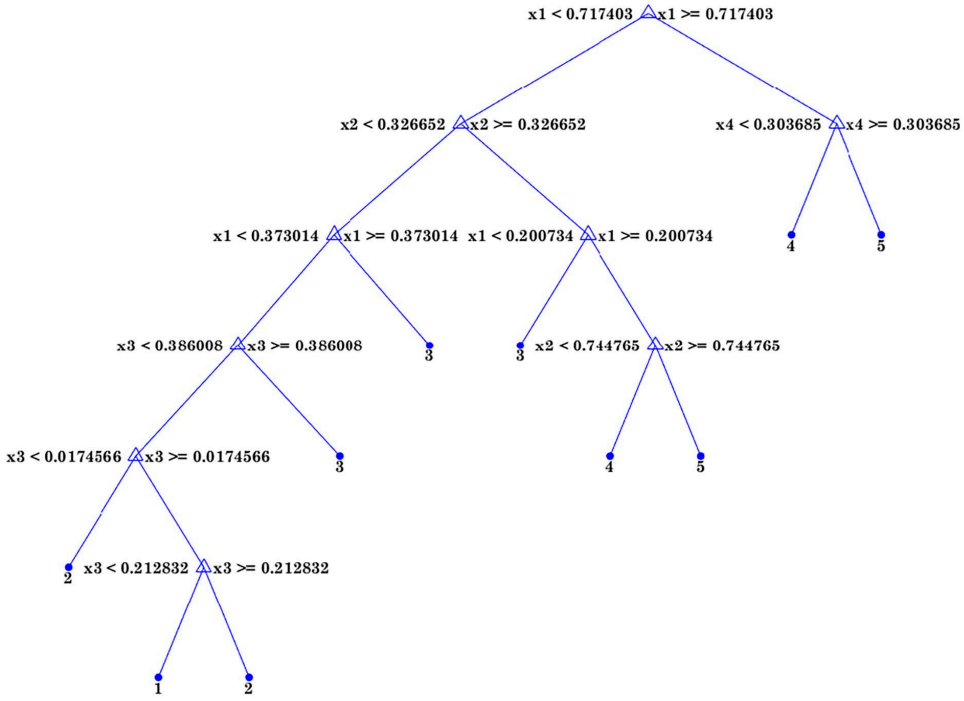


**Figure 3.** Full-node decision tree *Z*(*VR*), based on data 3 and data augmentation (9), where all four components of the time migration factor are used ($x_1$, $x_2$, $x_3$, $x_4$)

**Source:** compiled by the author

The accuracy of the decision tree *Z*(*ID*), as shown by testing, is acceptable and is at least 85%. Minor and moderate losses are problematic here, which are the most difficult to predict. Moreover, unlike a *Z*(*TE*) tree, this tree "confuses" moderate losses with minor ones and not vice versa. In general, the damage caused by temporary migration is the most unstable and has strong uncertainty. This is why the multiplier before the four pseudo-random values in (9) was increased to 0.035 to simulate the corresponding uncertainty. However, the validity level of tree-based solutions *Z*(*TE*) is at least 85%, which is quite an acceptable result in conditions of strong instability, uncertainty, and complex predictability.

Since the processes of forced temporary emigration, mobilisation, and internal migration are interrelated, the socio-economic losses from these processes are also closely related. Therefore, a situation in which, for example, losses of *Z(TE)* are insubstantial and the losses of *Z*(*ID*) are very substantial or critical is almost impossible. This means that the list of all variants of three (5), which theoretically could be $5^3 = 125$, is actually bounded. Such a list is evaluated in more detail to fill it realistically, and therefore, it is necessary to identify whether a situation is possible when losses for one factor are moderate and for another – critical. In such a situation, the gap between the levels of losses is two steps (very substantial losses are "missed"). The answer here is yes because, for example, the rate of temporary emigration has substantially decreased over the past half of the year, and, consequently, losses *Z(TE)* do not increase, while the level of *Z*(*ID*) during the entire period since the beginning of a full-scale war is palpable. Therewith, the gap between lower-level losses (from minor to moderate) cannot be greater than one step. Therefore, when compiling a list of all variants of the three (5), the following two considerations are used. If the losses on one of the three factors are insubstantial or moderate, then the losses on the other factors cannot be two steps stronger. Otherwise, the gap between the damage levels can be no more than two steps. As a result, a much shorter list of 41 situations was obtained (Table 4). The remaining $125 - 41 = 84$ situations outside this list are almost impossible, given the development of socio-economic processes in Ukraine, which protects its citizens and territory from terrorist attacks.

**Table 4.** List of all realistic combinations of damage states

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 1 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 5 | 5 | 5 | 3 | 3 | 3 | 4 | 4 | 4 | 5 | 5 | 5 | 3 | 3 | 3 | 4 | 4 | 4 | 5 | 5 | 5 |
| 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 4 | 5 | 3 | 4 | 5 | 3 | 4 | 5 | 3 | 4 | 5 | 3 | 4 | 5 | 3 | 4 | 5 | 3 | 4 | 5 | 3 | 4 | 5 | 3 | 4 | 5 |

**Source:** compiled by the author

It is necessary to estimate the amount of losses (5) as the equivalent of the minimum investment for the implementation of a rehabilitation programme. However, the transition to a standardised scale can be made after summation. In other words, standardisation of the *Inv* value. Thus, instead of *Inv*, on the left side of inequality (6), the following is obtained:

$$Inv = \frac{Z(TE)+Z(M)+Z(ID)}{\max\{Z(TE)+Z(M)+Z(ID)\}}. \quad (10)$$

The dependence of the standardised value (10) on the number of combinations of loss states in Table 1 is shown in Figure 4. As can be seen, with the growth of this number, the financial needs of the rehabilitation programme grow non-linearly and unevenly. This is caused by an uneven increase in losses for each factor *TE*, *M*, *ID* separately. As soon as critical losses appear in conjunction with other losses (in this case, critical losses appear for *ID* in the 17th list), the line of dependence of the standardised value *Inv* gets more fluctuations and becomes more chaotic.

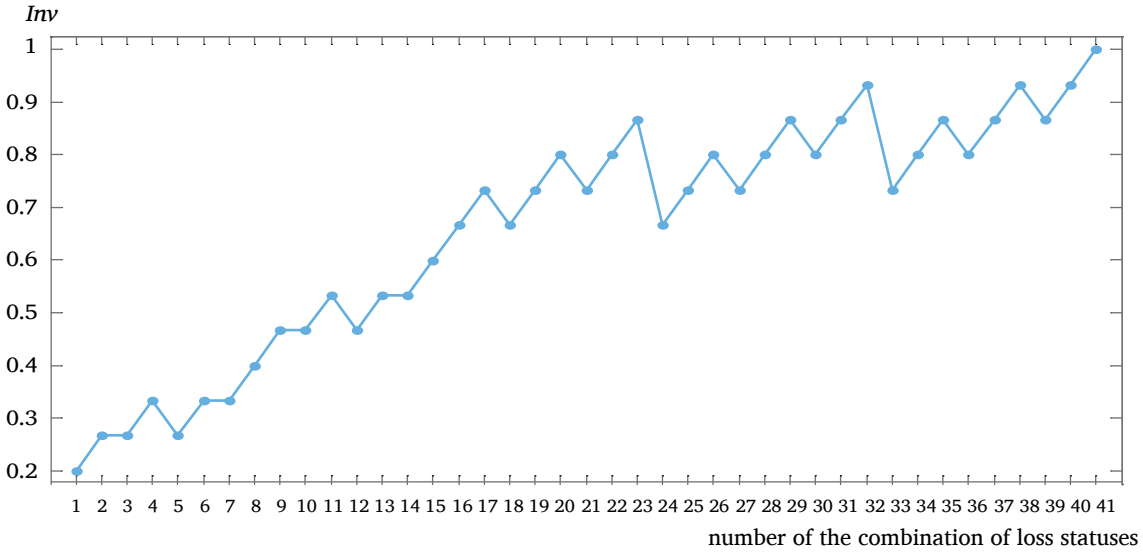


**Figure 4.** Polyline of the standardised value dependency *Inv* at (10) from the number of combinations of loss states in Table 4

**Source:** compiled by the author

Now, it is necessary to build a model for assessing damage in the medium and long term when there is no rehabilitation programme. One option is to consider the gradual increase in losses according to the exponential law, which uses the ratio of the average current losses to the geometric mean of all losses due to the action of each factor *TE*, *M*, and *ID*:

$$\psi_1^* = \left(\frac{Z(TE)+Z(M)+Z(ID)}{3\cdot\sqrt[3]{Z(TE)\cdot Z(M)\cdot Z(ID)}}\right)\times$$
$$\times \exp(-\beta\cdot\max\{Z(M)-Z(TE),\ Z(ID)-Z(M)\}), \quad (11)$$

where $\beta>0$ is a certain coefficient that considers a decrease in the rate of increase in total loss due to gaps in losses for individual factors, which allows balancing the cost of compensation for total loss. On the other hand, another additional option is the inverse exponential relationship, where the exponent sign contains values that are inverse to losses for individual factors weighted with the corresponding coefficients:

$$\psi_2^* = \frac{1}{\exp\left(\frac{\mu_1}{Z(TE)}+\frac{\mu_2}{Z(M)}+\frac{1-(\mu_1+\mu_2)}{Z(ID)}\right)}, \quad (12)$$

where $\mu_1>0$. $\mu_2>0$ and $1-(\mu_1+\mu_2)>0$. In the most favourable case, when the losses for individual factors are minimal, that is: $Z(TE)=Z(M)=Z(ID)=1$, the value of (12) is the minimum:

$$\psi_2^* = \frac{1}{exp(\mu_1+\mu_2+1(\mu_1+\mu_2))} = \frac{1}{e} = 0{,}368.$$

In the worst-case scenario, losses for individual factors are maximal, i.e.: $Z(TE)=Z(M)=Z(ID)=5$, and then the value of (12) is the maximum:

$$\psi_2^* = \frac{1}{exp\left(\frac{\mu_1}{5}+\frac{\mu_2}{5}+\frac{1(\mu_1+\mu_2)}{5}\right)} = \frac{1}{e^{0,2}} = 0{,}8187.$$

Thus, dependence (9) clarifies exponential growth (11). In conditions of uncertainty, this clarification is fundamentally necessary not to lose estimates of additional losses, although they are less than (11). In addition, under conditions of uncertainty, both models are considered, so:

$$\psi = \lambda_1\psi_1^* + \lambda_2\psi_2^*, \quad (13)$$

where for undefined coefficients $1>\lambda_1>0$ and $1>\lambda_2>0$. Explicitly, function (13) has the form:

$$\psi = \lambda_1\cdot\exp\left(\frac{Z(TE)+Z(M)+Z(ID)}{3\cdot\sqrt[3]{Z(TE)\cdot Z(M)\cdot Z(ID)}}\right)\cdot$$
$$\times\exp(-\beta\cdot\max\{Z(M)-Z(TE),\ Z(ID)-Z(M)\}+$$
$$+\frac{\lambda_2}{\exp\left(\frac{\mu_1}{Z(TE)}+\frac{\mu_2}{Z(M)}+\frac{1-(\mu_1+\mu_2)}{Z(ID)}\right)}, \quad (14)$$

where five coefficients are unknown: $\lambda_1$, $\lambda_2$, $\beta$, $\mu_1$, $\mu_2$. It is necessary to first find the minimum of function (14) for the corresponding values of these five coefficients and then standardise the resulting minimum to compare function (14) with the equivalent of the minimum investment (10) for implementing a rehabilitation programme. This time, constraints on variables $\lambda_1$, $\lambda_2$, $\beta$, $\mu_1$, $\mu_2$, which determine the minimum of function (14) for any list from Table 1, are as follows:

$$0.1\le\lambda1\le0.9,\ 0.1\le\lambda2\le0.9,$$
$$0.05\le\beta\le0.95,\ 0.1\le\mu1\le0.9,\ 0.1\le\mu2\le0.9.$$

The result of minimising function (14) under the specified constraints is: $\lambda_1^* = 0.569$, $\lambda_2^* = 0.428$, $\beta^* = 0.069$, $\mu_1^* = 0.222$, $\mu_2^* = 0.222$. Hence, an explicit formula is obtained for calculating the minimum value of the function (14), which corresponds to the most favourable case of the development of the influence of negative factors on the socio-economic security of the region:

$$\psi = 0{,}569 \cdot \exp\left(\frac{Z(TE)+Z(M)+Z(ID)}{3\cdot\sqrt[3]{Z(TE)\cdot Z(M)\cdot Z(ID)}}\right) \times$$
$$\times \exp(-0{,}069 \cdot \max\{Z(M)-Z(TE),\ Z(ID)-Z(M)\}) +$$
$$+ \frac{0{,}428}{\exp\left(\frac{111}{500\cdot Z(TE)}+\frac{111}{500\cdot Z(M)}+\frac{139}{250\cdot Z(ID)}\right)}. \qquad (15)$$

The standardised resulting minimum (15) will have the form:

$$\psi^* = \frac{\psi}{\max\limits_{36(\text{TE}),\ 36(\text{M}),\ 36(\text{ВП})}\{\psi\}}. \qquad (16)$$

Figure 5 shows a comparative graph of the dependence (16) on the background of (10), which also shows the components (11) and (12) in the minimised function (15). Consequently, the polyline of losses (in the medium and long term without starting a rehabilitation programme) is generally higher than the polyline of the financial needs of the rehabilitation programme. The only exceptions are connection numbers 23 (substantial losses due to temporary emigration and critical losses due to mobilisation and temporary migration), 32 (substantial losses due to emigration, the rest are critical), 35 (critical losses due to emigration and migration, *Z*(*M*) – substantial), 38 (where *Z*(*M*) become very substantial), 41 (all types of losses – critical). In general, the polyline (16) corresponds to the most favourable case, so in reality, it will be even higher than the polyline financial needs of the rehabilitation programme.

Therefore, even under the most favourable circumstances, losses increase and unnecessary expenses in the future can be prevented in advance by investing in rehabilitation. It will cost less in the end. In addition, additional revenues are expected from the provision of paid services in rehabilitation centres. In general, this will contribute to strengthening the socio-economic security of any region with a geographical position similar to that of the Khmelnytskyi region relative to the front line. However, it is not difficult to realise that for the frontline regions (if possible – regular, planned), rehabilitation measures are also needed – it is quite likely that in an even larger volume.

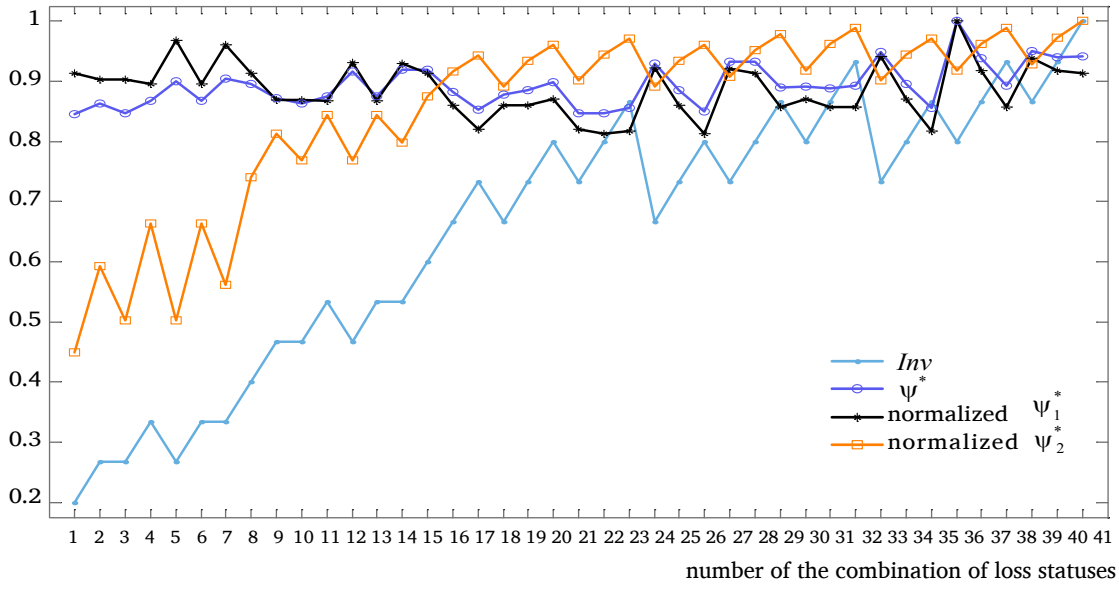


**Figure 5.** Polyline of the standardised value dependency *Inv* at (10) from the number of combinations of loss states in Table 4

**Source:** compiled by the author

The socio-legal aspect of the problem under study is an important component of the successful implementation of the developed provisions. Such programmes require modern regulatory support that would regulate the procedures for their practical application and proper funding. One of the main regulatory documents regulating the procedures for financing these activities is the "procedure for using funds provided in the state budget for the implementation of measures to provide social and psychological assistance by centres for social and psychological rehabilitation of the population" of the Decree of the Cabinet of the Ministers of Ukraine No. 149 (2015). Thus, the detail of most provisions is regulated by a substantial number of other regulatory documents that are not fully agreed upon. Accordingly, due to such inconsistency, contradictions may arise that will not allow quickly solving the problems of financing the rehabilitation of the population and military personnel. This also creates an additional financial burden on territorial communities, as noted in the "Strategy of state policy on internal displacement for the period up to 2025 and approval of the operational action plan for its implementation in 2023-2025" of the Decree of the Cabinet of the Ministers of Ukraine No. 312-p (2023). Only the development of new approaches to the processes of rehabilitation of the population and their proper regulatory support will allow getting a tangible socio-economic effect at the macro, meso, and micro levels.

## Discussion

Scientific papers note that changes that occur in the external environment cause the emergence of destabilising factors that affect the company's activities, and constantly emerging various dangers, threats, and risks form an objective need for effective protective mechanisms that are formalised in security systems of various levels and their content at the institutional level. As noted by Ye. Rudnichenko *et al.* (2019), "The quality of the business environment in most countries depends substantially on the institutional impact of state structures and the protection of the interests of business entities". This position is quite justified since support for socio-economic development at the regional level is influenced by norms and institutions that ensure the functioning of security mechanisms at various levels.

In addition, as noted in the publication of Ye. Rudnichenko *et al.* (2020): "Modern developments on the economic security of enterprises practically do not consider possible scenarios of the behaviour of business entities and their populations in interaction with regulatory entities, although this process substantially affects the state of their economic security and requires theoretical and practical tools to optimise such interaction. Moreover, optimisation should provide harmonisation of relations within the system since natural processes are characterised by a desire for a balanced system in general and reaching harmony, and when this state is achieved, a feeling of safety, comfort and the ability to reproduce the population arises". In general, business entities' behaviour substantially modifies depending on the specifics of their external (institutional) and internal (adaptive) environments, and their functioning at the level of a particular region occurs in strict correlation with the effectiveness of management at different levels.

Most researchers, such as T. Salihaj and S. Pryimenko (2017) and P. Pylypyshyn *et al.* (2022), believe that the critical impact on security systems of different levels occurs precisely in the external environment, but it is extremely difficult for individual entities to influence such an environment through individual management decisions, which is also confirmed by N. Chen and M. Hu (2023). The study can partially agree with this position, but if individual entities are united into certain communities, such as industry associations, their influence on the external environment can be quite substantial, especially given the possibility of creating lobbying groups at the legislative level.

According to the postulates of institutional theory, intra-organisational changes may not always provide sustainable competitive advantages for individual actors, B. Giner and M. Luque-Vílchez (2022), because, even with the assistance of international institutions and the transformation of various forms of reporting and financial and credit relations, positive decisions on financing regional socio-economic development programmes are extremely difficult to achieve. This is due to a lack of resources, and not only financial ones, which is extremely important for ensuring economic security. M. Song *et al.* (2023) state, "Economic security means the unrealistic supply of natural resource assets and the highly volatile and stable prices here have led to unstable economic development, shocks to the industrial structure, and underemployment. The six natural resource assets of energy, minerals, oceans, water resources, land, and forests belong to the important natural resource assets that are an important basis for supporting the development of industrialisation, urbanisation, informatisation, and rapid modernisation". The remark, in general, corresponds to the idea of the above study since the rational use of resources at the regional level allows ensuring the region's economic security and attractiveness for people who are displaced and need rehabilitation. This will, in the future, have a positive impact on the provision of the working-age population with the needs of the economy. The study on the regional context of ensuring economic security is also presented in the works of M. Legrenzi and F. Lawson (2018), which focus on individual organisations that are able to influence the security situation at different levels but are not able to radically change the functioning environment of specific business entities in the short term, which can be agreed upon, but in the long term, such transformations are quite possible.

In many papers, only individual researchers F. Ghilès (2022) and Y. Romanovska *et al.* (2022) raise the issue of socio-economic security in war conditions, while it is necessary to state a limited number of studies with the presentation of specific tools for assessing losses at the regional level and the development of proposals for restoring the socio-economic potential of the region, and in the presented study, the authors propose specific tools for solving certain problems of regional development of complex socio-economic systems, focusing on the regulatory support of such processes and the need for their improvement.

Most of these studies do not consider the current conditions of functioning of socio-economic systems of Ukraine in war conditions. A special place in this process is given to proper regulatory support for the implementation of rehabilitation programmes since they are costly and require the support of the state and local self-government bodies. This will contribute to protecting the population and improving the quality of social security for military operations participants and their families. The preservation of the working-age population and the development of communities remains a priority task for the socio-economic development of territories.

## Conclusions

The proposed concept of eliminating negative consequences for the socio-economic security of the region is based on the paradigm of timely response to the current results of the military resistance of Ukraine to minimise the growth of negative socio-economic manifestations in the medium and long term. This response means, first of all, the establishment of special regional institutions, also with the involvement of the private sector, for rehabilitation and assistance at various levels of the negative impact of the liberation war. The prototype of such institutions is the "points of invincibility" throughout Ukraine, which were promptly created to eliminate several negative consequences during forced electricity balancing processes and partially prevent problems related to blackout threats. This example shows that if legislation is improved and initiative groups are created at the level of regions and individual communities, the situation with economic security can be substantially improved.

The effects of a timely, urgent response to threats to the socio-economic security of the region are quite evident. The social effect will consist in partial or full com-

pensation for the shortage of labour resources, restoring the working capacity of the population, encouraging the return of forced emigrants, reducing social tension, overcoming post-traumatic syndrome after military operations, etc. The economic effect will consist in the possibility of determining the specific amount of compensation of the aggressor state not only from direct destruction but also by compensating for the lost benefits of Ukrainian companies in connection with the mobilisation of labour resources, balancing the level of production and demand to prevent galloping inflation; for institutions, healthcare institutions, other participants in the rehabilitation programme-additional revenues, income growth. The security effect will consist in maintaining the competitiveness of the region by restoring the working capacity of the population, and, in general, proper support for micro- and macroeconomic processes will have a positive impact on restoring the combat capability of military formations, including territorial defence units. The legal effect will consist in improving the regulatory framework for regulating the socio-economic development of regions and ensuring the rights to rehabilitation of affected persons.

In addition to the above results, improving the management of the health care system is possible since the unprecedented challenges of war make it necessary for further thorough research not only in the context of population rehabilitation but also in the context of other aspects of socio-economic security of regions and the restoration of their economic potential with further improvement of regulatory support for these processes.

## Acknowledgements

None.

## Conflict of interest

None.

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# Соціально-економічна безпека регіону в умовах війни: оцінювання збитків, моделювання шляхів відновлення та їх нормативно-правове забезпечення

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**Анотація**. Реалії сьогодення та активна фаза війни обумовлюють пошук нових шляхів формування економічного потенціалу України з урахуванням прямих та непрямих збитків, які виникли внаслідок військових дій, що і обумовлює актуальність тематики дослідження. Відповідно, метою дослідження був аналіз факторів дестабілізуючого впливу на економічну безпеку регіонів та розробка шляхів відновлення їх соціально-економічного потенціалу. Особливу увагу у процесі дослідження приділено оцінюванню збитків внаслідок військових дій та інших процесів, які супроводжують функціонування регіонів в умовах граничного загострення загроз. Розроблено модель оцінювання негативних наслідків впливу тимчасової еміграції, мобілізації та внутрішнього переміщення населення на соціально-економічну безпеку регіону. У межах моделі визначено стан збитків залежно від співвідношення основних компонентів тимчасової еміграції, до яких належать: виїзд за межі України та повернення, рівень робочих вакансій, попит на робочі місця медичних працівників. Також визначено основні стани збитків від мобілізації та тимчасової міграції населення. Доведено, що впровадження регіональних програм реабілітації населення дозволить зменшити розмір збитків та забезпечить зростання соціально-економічного потенціалу регіонів у середньостроковій перспективі, у тому числі за рахунок удосконалення нормативно-правового забезпечення фінансування таких процесів. Це дозволить отримати вагомий соціальний, економічний, безпековий та правовий ефект. При цьому формується абсолютне нове поле для подальших досліджень впровадження безпекових механізмів на макро-, мезо-, та мікрорівні в умовах війни та поствоєнного відновлення територій. Результати дослідження можуть бути використані державними установами та інвестиційними фондами, зацікавленими в реконструкції соціально-економічного потенціалу України та створенні безпечних, сприятливих умов її реалізації

**Ключові слова**: соціально-економічний розвиток; економічна безпека; модель для оцінювання збитків; реабілітація; регіональний розвиток