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Abstract. The state and strategic scenarios of restoration of sustainable development of Poltava region of Ukraine in the post-war period are studied. To develop a strategic plan for the recovery of the Poltava region, a modern methodology of strategizing (scientific and strategic foresight) is used according to the principle "the future is determined by the trajectory into the future" and three strategic scenarios have been developed until 2027: realistic, optimistic and the scenario of entering the optimal zone of the EU countries, which correspond to the average annual growth rates of real GRP -4.94, -0.72 and 4.1%. The contribution of innovative factors to the economic growth of the region was determined using the modified Cobb-Douglas function and the Solow residual method, which prove the averaged contributions to economic growth: scientific and technological progress STP -3.7; labor 3.1; capital 0.38; production manufacturability 1.57; innovations 0.31%. The strategic dynamics of indicators of innovation and environmental safety on the trajectory of sustainable development are scientifically substantiated and the main threats are identified. The proposed methodology of adaptive response to threats of the environmental subsystem gives possibilities to preserve its stability and balanced sustainable development.

1. Introduction

In order to develop plans for the strategic post-war recovery of Ukraine and its economic regions, forecasts of the fall are urgently needed to identify the current state and develop strategic post-war recovery scenarios. Thus, according to various estimates by foreign and domestic experts, the forecasts of a fall in Ukraine's real GDP range from (-20) to (-45) %. To overcome such a decline, the principles of a new economic policy are proposed, which, unfortunately, are only slogans, and some are more like ultimatums to the EU.

Although, it should be recognized that they are necessary, at the same time they are not sufficient, because they do not provide clear, concrete results of the action of the declared principles - quantitative strategic guidelines of indicators and macro indicators, the monitoring of which would allow controlling the development process of these directions.

After the war, Ukraine will face the need to change its strategic plans, including regional development, given the significant changes in internal and external factors. However, there are no forecasts of a decline in the economy of the industrial regions of Ukraine, which are extremely necessary to answer the question: what should be the indicators and macro indicators of the sustainable development of the regions of Ukraine to restore the pre-war state, or even better. Domestic and foreign scientists continue to research aspects of building regional development strategies, forming author's methods of their development and forecasting their implementation [1-3].

In the view of modern researchers, the problems of regional strategizing mainly include issues of the development of depressed regions and regions with tourism potential [4]. At the same time, there are general trends of orientation towards the goals of sustainable development and adherence to the concept of complex (integrated) development (horizontal and vertical integration) [5-7]. A positive trend is the search by scientists for new sources of statistical data that reflect the socio-economic situation of cities [8-10], individual territories in dynamics [11-13], research on energy issues [14-15], the use of production functions for sustainable development [16-17] and the impact of innovations [18-19]. However, it is worth noting that some of the noted scientific approaches to regional strategizing do not have clearly defined and systematized indicators, which complicates the processes of goal setting, location of regions, analysis and forecasting.

In this regard, the development of new methodical approaches to the scientifically based strategizing of spatial associations, especially during the war period, becomes extremely relevant. Therefore, the purpose of the article is to develop strategic scenarios of military recovery and adaptation of the development of spatially united regions (using the example of the Poltava region of Ukraine) to the influence of external and internal threats in order to preserve the trajectory of sustainable development in the medium term.

2. Materials and Methods

The concept of sustainable development in the safety dimension is used to develop strategic scenarios for the post-war recovery of regions [20]. The theoretical basis of the concept is applied systems theory, management theory and economic cybernetics and includes two stages.

2.1. Identification

Determination of the structure of the security object; forming a system of indicators; the choice of the form of the integral index is multiplicative:

$$I_t = \prod_{i=1}^{n} Z_{i,t}^{a_t}; \quad \sum_{i=1}^{n} a_i = 1; \quad a_i \geq 0, \tag{1}$$

where are $z_{i,t}$ – the normalized values of the indicators; a_i – dynamic weighting coefficients; the selection of the rationing method is combined:

$$\text{S (stimulants): } z_{i,t} = x_{i,t} / k_{norm,i}; \quad \text{D (destimulants): } z_{i,t} = (k_{norm,i} - x_{i,t}) / k_{norm,i}; \tag{2}$$

where are $x_{i,t}$ – the current values of the indicators; $k_{norm,i}$ – normalization coefficient (for stimulants – the maximum value $x_{max,i}$ from a sample of indicators and their limit values; for destimulators – $1{,}1x_{max,i}$); weighting coefficients are dynamic, according to the methods of "principal components" and "sliding matrix" [20]; determination of the limits of safe existence - the number of gradations of safety (critical, threshold, optimal) on both sides of the homeostatic plateau [21] is associated with the concept of an extended "homeostatic plateau" [20] and the spheres of positive, neutral and negative feedback.

Quantitative values of security gradations (bifurcation points) are associated with the extension of the "t-criterion" method through the construction of the probability density function, the determination of belonging to the type of distribution with the calculation of the statistical characteristics of the "sample" selection (mathematical expectation μ, standard deviation σ and asymmetry coefficient k_{as}) and formalized definition of bifurcation points for characteristic types of distribution (normal, lognormal, exponential) (Table 1) [20].

Table 1. Formalized threshold vector values

Type of Indicator Probability Density Function	Lower Threshold	Lower Optimal Value	Upper Optimal Value	Upper Threshold
Normal	$\mu - t \times \sigma$	$\mu - \sigma$	$\mu + \sigma$	$\mu + t \times \sigma$
Lognormal (tail right)	$\mu - t \times \sigma / k_{as}$	$\mu - \sigma / k_{as}$	$\mu + \sigma$	$\mu + t \times \sigma$
Lognormal (tail left)	$\mu - t \times \sigma$	$\mu - \sigma$	$\mu + \sigma / k_{as}$	$\mu + t \times \sigma / k_{as}$
Exponential (tail right)	$\mu - \sigma / k_{as}$	μ	$\mu + \sigma$	$\mu + t \times \sigma$
Exponential (tail left)	$\mu - t \times \sigma$	$\mu - \sigma$	μ	$\mu + \sigma / k_{as}$

When calculating the reduced vector of marginal values (Table 1), you can use the confidence level of probability 0.98 or 0.99. Then, to calculate the critical values of the safety indicators (lower critical, upper critical) – a confidence level of probability 0.998-0.999 to determine the "t" parameter of Student's t-distribution tables [22]: simultaneous integral convolution of indicators and their threshold values; determination of the list (according to the method of imbalances) and importance (according to elasticity coefficients) of the impact of threats.

2.2. Strategizing

Goal setting – defining strategic goals; construction of the future trajectory of the desired development; synthesis of strategic orientations of components and indicators of the security object through the decomposition of integral indices using adaptive regulation methods from management theory [23]. To implement the specified methods, the developed standard subprogram "Strategy" is used, which implements the adaptive regulation scheme [20] (Figure 1) in the C++ programming language; performing the "denormization" procedure - transition from dimensionless indicators to macro indicators in natural units of measurement.

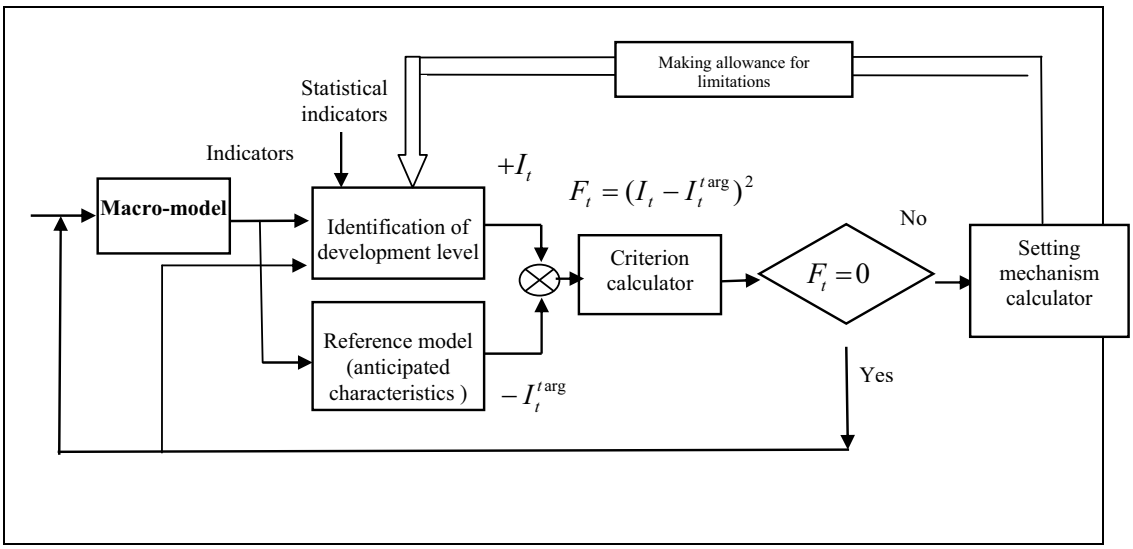


Figure 1. Generalized scheme of adaptive control system with a reference model

3. Theory

In the conditions of the post-war recovery of the economies of the countries and their regions, innovative factors of influence and sustainable management of natural resources, i.e. environmental factors of influence, are of the most importance for preserving the trajectory of sustainable development. In this regard, it is important to determine the impact of innovative factors on economic growth, as well as scientific substantiation of the target values of safety indicators, the methodology of adaptive response to environmental threats. The final result of this is the scientific substantiation of the volumes of innovative and environmental costs and the necessary dynamics of innovative and environmental indicators that ensure the balance of economic, social and environmental components of sustainable development.

Taking into account the impact of innovative factors on economic growth is carried out through the expansion of the Cobb-Douglas production function (3) by adding labor costs, capital costs, as well as the innovation factor to the macro factors of STP [24]:

$$V_t^S(P_t) = e^{\gamma t}\left[\xi_t N_t(P_t)\frac{W_t}{P_t}k_{sn}\right]^{a_t}(\vartheta_t K_t)^{1-a_t-\beta_t}\left(\frac{G_{in,t}}{P_t}\right)^{\beta_t}; \quad (3)$$

where is V_t^S the actual release of the aggregate supply; $e^{\gamma t}$ – scientific and technological progress of STP); γ – STP pace; $\xi_t = N_{ef,t}/N_{zag,t}$ – share of the effective number of taxpayers in total employment; $N_{ef,t}$ – the effective number of taxpayers (salaried employees plus another category of employed, reduced to the equivalent of salaried employees for all taxes and wages); $N_{zag,t}$ – total employment; $N_t(P_t)$ – the function of the optimal demand for labor, determined from the condition that the value of the marginal product of labor is equal to the nominal wage rate; W_t – average annual nominal salary of employees; $k_{sn,t}$ – coefficient of social loads; ϑ_t – capital loading factor; K_t – capital costs; α_t – coefficient of elasticity for labor costs; β_t – coefficient of elasticity for innovation costs; $1-\alpha_t-\beta_t$ – coefficient of elasticity at capital expenditure; $G_{in,t}$ – nominal innovation costs (the sum of gross internal costs for research, innovation costs, general education costs); p_t – GDP deflator; t – a time period.

By applying the "Solow residual method" [25] through logarithmization and logarithmic derivatives in the production function of equation (1), it is possible to obtain formalized information about the contribution of each factor to economic growth, for example, innovation factors as in equation (4):

$$Tempo\_Innov = \dot{\beta}(\ln G_{inn} - \ln P) + \beta\left(\frac{\dot{G}_{inn}}{G_{inn}} - \frac{\dot{P}}{P}\right), \quad (4)$$

where $\dot{\beta}$ is the derivative of the elasticity coefficient;

$\dot{G}_{inn}/G_{inn}, \dot{P}/P$, $\frac{\dot{G}_{inn}}{G_{inn}}, \frac{\dot{P}}{P}$ are the rates of the corresponding variables.

And the efficiency of innovation can be defined as the ratio of the volumes of innovative products sold ($Q_{inn,t}$) to the total costs of innovation factors ($G_{inn,t}$), as in equation (5):

$$Ef_t = Q_{inn,t}/G_{inn,t}. \quad (5)$$

The methodology of adaptive response consists in building a new trajectory for achieving set goals after the impact of threats (for example, military actions) and sequential decomposition of the new dynamics of the integral index into components and separate indicators of innovation and environmental security using an automatic strategy procedure based on the principle "the future is determined by the trajectory into the future" - the technology of scientific and strategic foresight [26].

4. Results

4.1. Identification and strategizing sustainable development

To develop strategic scenarios for the post-war recovery of the Poltava region, a forecast of macro indicators and relevant indicators was made using official data and model calculations for the end of 2021-2022. The proposed structure of sustainable development of the regions is presented in Figure 2, which includes 60 indicators.

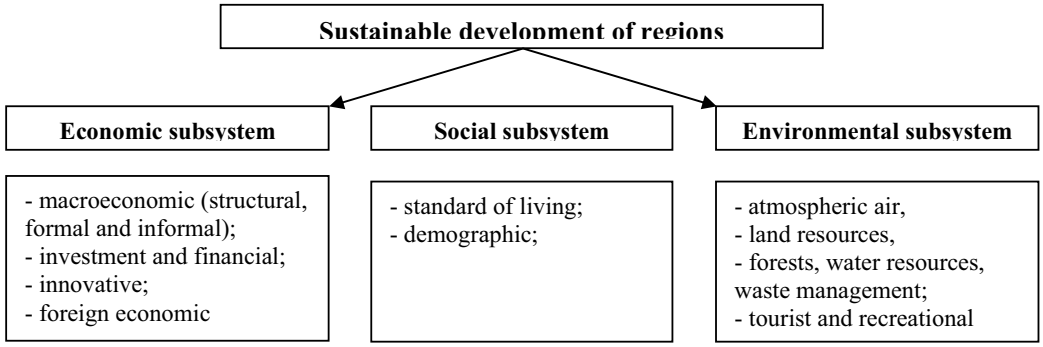


Figure 2. The structure of sustainable development of the regions of Ukraine

Using the identification methodology specified in section 2, we will obtain the dynamics of integral indices of sustainable development of the Poltava region until 2022 (Figure 3).

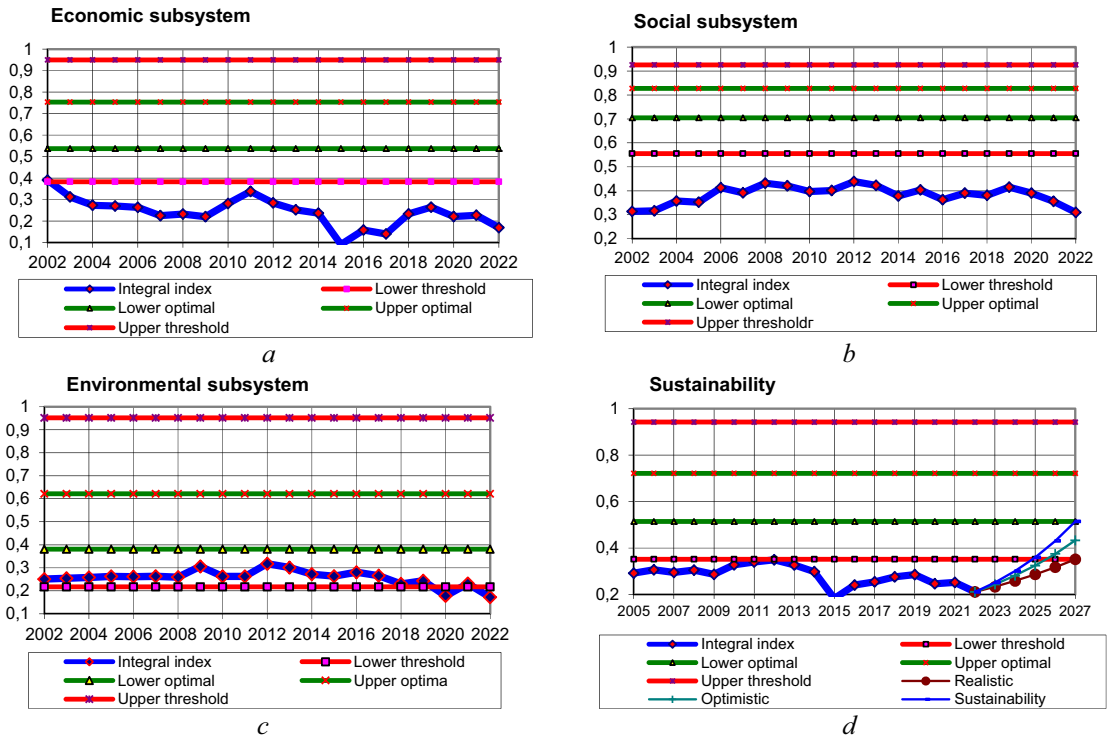


Figure 3. Dynamics of integral indices of the Poltava region

According to the results of calculations, out of 14 components of sustainable development of the Poltava region, 10 are in the critical zone - below the lower threshold value, the other 4 balance on the edge of the lower threshold value. Out of 60 indicators, 43 are critical. Therefore, the integral convolution of all components confirms the occurrence of the integral index of sustainable development also in the critical zone, which determines the following strategic exponential development scenarios (Figure 3, d):

1. Realistic – reaching the lower threshold value.
2. Optimistic – reaching the average value between the lower optimal and lower threshold values of the integral index.
3. The scenario of entering the zone of optimal sustainable development.

Using the value of the integral index in the reference model (Figure 1), we will obtain the dynamics of the integral indices of the components, which are, in fact, a strategic plan for restoring the trajectory of sustainable development and are a benchmark for monitoring (Table 2).

Table 2. Strategic dynamics of integral indices of the Poltava region

Recovery scenarios/ year	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
Realistic						
Economic subsystem	0,1694	0,2019	0,2334	0,2621	0,2934	0,3274
Social subsystem	0,3094	0,3241	0,3409	0,3601	0,3819	0,4065
Environmental subsystem	0,1719	0,1994	0,2248	0,2489	0,2754	0,3044
Optimistic						
Economic subsystem	0,1694	0,2193	0,2607	0,3076	0,3607	0,4207
Social subsystem	0,3094	0,3318	0,3591	0,3921	0,4314	0,4778
Environmental subsystem	0,1719	0,2130	0,2477	0,2875	0,3331	0,3849
Entering the optimal zone						
Economic subsystem	0,1694	0,2296	0,2846	0,3491	0,4245	0,5128
Social subsystem	0,3094	0,3384	0,3757	0,4227	0,4808	0,5521
Environmental subsystem	0,1719	0,2216	0,2679	0,3231	0,3882	0,465

Therefore, the main task of the regional authorities is to ensure the implementation of planned indicators by measures of macroeconomic policy.

4.2. Strategic orientations of innovative security in the post-war period

Innovative factors and the assessment of the contribution of innovative factors and the development of appropriate measures of their effectiveness become of primary importance in the policy of economic growth.

Calculations performed using the Solow residual method of the production function (1) make it possible to determine the average annual (for 22 years) contribution of production factors for the period 2001-2022 to the economic growth of the Poltava region (**Table 3**), where the STP, unfortunately, had a negative the contribution of which reduced returns from macro factors.

Table 3. Average annual values of the contribution of production factors to GRP growth

% growth per year

Region	GRP	Scientific and technological progress	labor	capital	manufacturability of production	Innovative contribution
Poltava	1,555	-3,7462	3,0517	0,3767	1,5667	**0,3074**

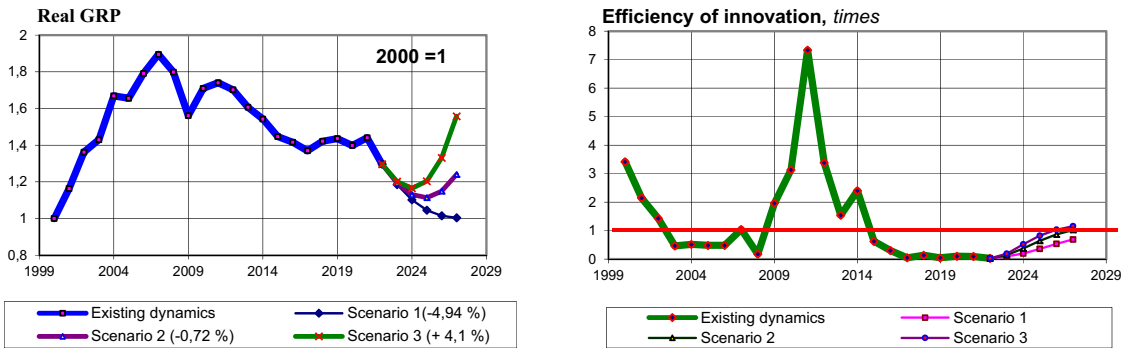
Setting the values of integral indices from Table 2 as reference values in the model of adaptive regulation (Figure 1) makes it possible to obtain the dynamics of changes in indicators of innovative safety to preserve the trajectory of sustainable development (Table 4).

Table 4. Evaluation of strategic values of innovative security indicators*

Indicators / year	2022	2023	2024	2025	2026	2027
1) the level of expenditures on scientific and technical works, % of GRP (S);	0,0081	0,0692 0,1081 0,1511	0,1695 0,3331 0,5131	0,3431 0,7053 1,0733	0,5843 1,1775 1,7360	0,8791 1,7034 2,4595
2) rate of scientific and technological progress, % per year (S);	-3,1134	-3,1098 -3,1059 -3,0998	-3,0965 -3,0517 -2,9705	-3,0481 -2,8483 -2,5178	-2,9294 -2,4028 -1,6454	-2,7074 -1,6955 -0,3815
3) the level of financing of innovative activities, % of GRP (S);	0,2019	0,2067 0,2136 0,2244	0,2299 0,2971 0,3947	0,3019 0,5126 0,7575	0,4372 0,8294 1,2240	0,6261 1,2008 1,7405
4) specific weight of implemented innovative products in the total volume of implemented industrial products, % (S):	0,1111	0,4206 0,6542 0,9153	1,0275 2,0264 3,1227	2,0874 4,2915 6,5362	3,5558 7,1743 10,619	5,3504 10,417 15,134
5) the level of inventive activity, the number of received protection of intellectual ownership documents, patents per 1 million people, (S).	83,333	83,438 83,589 83,833	83,962 85,722 88,862	85,864 93,476 105,40	90,427 109,39 134,25	98,651 132,67 172,12

* Indicator rows determine their values according to scenarios.

Adherence to the defined strategic benchmarks of the indicators ensures a corresponding increase in the real GRP of the Poltava region (**Figure 4**, a) and the efficiency of innovative factors, which should be greater than one (**Figure 4**, b).



a *b*

Figure 4. Dynamics of real GRP (a) and effectiveness of innovations (b) of Poltava region

Only scenario 3 (entering the optimal zone of sustainable development) ensures the achievement of the level of real GRP in 2014, and the efficiency of innovative factors is only one in 2027.

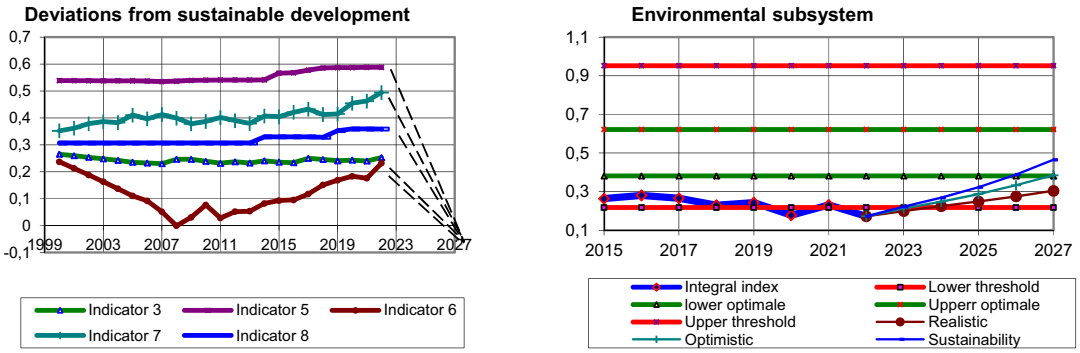
4.3. Strategic orientations of environmental security in the post-war period

Ensuring sustainable development a priori assumes the balance of three components of its development: economic, social and environmental. On the one hand, thanks to technology, the production process becomes more efficient, thereby increasing the competitiveness of countries and reducing their vulnerability to market fluctuations; on the other hand, economic growth causes an increase in the amount of used resources, materials and fossil fuels, which leads to environmental pollution and degradation, especially in low-income countries.

Therefore, it is of particular importance to find a compromise in all three directions through maintaining economic growth, promoting social development and striving for environmental sustainability.

Of the 10 indicators of the environmental subsystem by the end of 2022, 5 indicators do not meet the level of sustainable development and are below the lower threshold value, i.e. in the critical zone, namely: the level of the volume of recycled and consistently (re)used water, the capacity of treatment facilities, the level of loess reproduction , the level of investment in the environment and the specific weight of the resort and recreation area in the total territory of the region.

The definition of threats based on the distance of the current values of the indicators from the point of sustainable development (the average optimal value of the vector of limit values - the homeostatic plateau) confirms the given list of indicators-threats (Figure 5, a) (numbering of indicators from Table 5). The task of the policy is to develop measures that reduce the deviation of indicators from their optimal values, and their equalization to zero will determine balanced sustainable development.



a *b*

Figure 5. Dynamics of threat indicators (*a*) and strategic development scenarios (*b*) of Poltava region

Among the threats of wartime and post-war times, which are not described by indicators of sustainable development, it is possible to identify: air and missile attacks on oil depots, and, as a result, significant pollution of the air and surrounding territories, destruction of infrastructure facilities, including critical and increased man-made danger, mined territories, forest fires, the death of animals, birds, plants, soil damage due to the construction of fortifications, a sharp decrease in the activity of the tourism and recreation sector of the economy. Together with the threats determined by the distance of the current values of the indicators from the point of sustainable development, they create modern environmental challenges both at the level of the region, in particular, and at the level of the state as a whole.

Setting the values of integral indices from Table 2 as reference values in the model of adaptive regulation (Figure 1) makes it possible to obtain the dynamics of changes in indicators of the environmental subsystem to preserve the trajectory of sustainable development (Table 5).

Thus, existing disparities are completely eliminated in the scenario of sustainable development, in which all deviations from the average optimal value are equal to zero.

The main threat to the implementation of the developed scenarios of the regions of Ukraine is corruption and excessive shadowing of the economy. For example, the general level of shadowing of Poltava region according to model estimates is set at 46.1%, the level of shadowing after payment of shadow wages is 35.2% of the official GRP, and the level of shadow wages relative to the official amount of wages is 34.5%.

Unfortunately, if pre-war economic policies, corruption and a high level of economic shadowing continue in Ukraine in the post-war state, any recovery strategies and principles will be useless and ineffective.

Table 5. Assessment of strategic values of environmental safety indicators

Indicators / year	2022	2023	2024	2025	2026	2027
Environmental						
1) level of pollutant emissions into atmospheric air per 1 km2, t (D);	1,0435	1,0068 1,0 1,0	0,9999 1,0 1,0	1,0 1,0 1,0	1,0 1,0 1,0	1,0 1,0 1,0
2) level of use of fresh water per 1 person, m3 (D);	60,0	59,69 59,56 59,0	59,02 58,45 57,97	57,75 56,1 56,96	55,53 55,0 55,97	54,99 54,99 55,0
3) level of volume of circulating and consecutively (re)used water per 1 person, m3 (S);	583,3	605,08 620,8 636,6	643,05 697,55 757,81	700,85 825,77 972,05	782,45 1018,1 1304,1	891,93 1285,5 1778,5
4) the level of discharge of polluted return water into surface water bodies per 1 person, m3 (D);	1,666	1,583 1,520 1,457	1,430 1,198 0,925	1,184 0,5937 0,5	0,8075 0,4998 0,5	0,4998 0,4996 0,4996
5) annual capacity of sewage treatment plants, million m3 (S);	45,0	79,375 98,5 115,2	121,6 168,9 210,8	170,6 253,5 334,4	226,8 357,9 493,4	291,4 485,0 697,8
6) level of loess reproduction, thousand hectares / million inhabitants (S);	0,42	0,472 0,51 0,546	0,561 0,678 0,796	0,684 0,923 1,176	0,843 1,252 1,702	1,039 1,674 2,405
7) environmental investment level, % of output (S);	0,1425	0,1695 0,1875 0,2046	0,2113 0,2642 0,3167	0,2672 0,3715 0,4796	0,337 0,5117 0,7001	0,4217 0,6889 0,9925
Tourism and recreation						
8) specific weight of the resort and recreation area in the total area of the region, % (S);	0,4417	1,0292 1,0647 1,0969	1,1094 1,2057 1,3017	1,2112 1,4032 1,6086	1,3392 1,6708 2,0414	1,4978 2,0180 2,6100
9) the share of sanatorium-resort facilities up to 1,000 people, (S);	3,0142	3,1969 3,2009 3,2138	3,2189 3,2599 3,3033	3,2623 3,3519 3,4582	3,3209 3,4925 3,7142	3,3996 3,6994 4,1100
10) share of cultural institutions per 1 person (S).	1339,2	1356,6 1358,0 1359,4	1359,9 1364,2 1368,7	1364,4 1373,8 1385,2	1370,6 1388,9 1413,4	1378,9 1411,8 1459,0

Based on the results of the research, the current state of sustainable development of the Poltava region was identified by determining the dynamics of the integral index in comparison with the integral threshold values, which makes it possible to assess the level of sustainable development. Taking into account the current state of the level of sustainable development, strategic goals were defined and exponential trajectories of their achievement were built, according to which strategic scenarios of the post-war recovery of the economy of the Poltava region with an exit to the trajectory of sustainable development were developed. The contribution of innovative factors to economic growth was determined using the modified Cobb-Douglas function, the state of the environmental subsystem was assessed, the main threats were identified, and the strategic dynamics of indicators of sustainable development were scientifically substantiated to achieve the specified goals.

5. Discussion

The existing strategies of regional development will not fully meet the needs of the Ukrainian economy, therefore it is advisable to pay attention only to certain instruments of regional strategizing of foreign countries. At the same time, the basic trends should be the goals of sustainable development, SMART goals, digitalization, the concept of complex (integrated) development.

The analysis of the cited publications makes it possible to state that the problem of strategic planning of regional development is timely both for the EU countries and for Ukraine.

The European Community, based on its own experience in regional strategizing, as well as using the experience of implementing pilot international projects of regional strategizing in Ukraine, offers Ukraine certain methodological approaches that are characterized by the following features:

- the majority of all recommendation documents are aimed at analyzing the existing situation, much less attention is paid directly to strategic planning;
- all approaches include a typical set of regional strategizing tools: socio-economic analysis; SWOT analysis; PEST analysis; sociological analysis (survey, questionnaire, expert assessment); the work of focus groups, the involvement of various stakeholders, which is very important, as it will give an opportunity to take into account the interests of all interested parties and to use the intellectual potential of the region in a single cause, however, the vast majority of them are subjective in nature and therefore cannot serve as a basis for determining how a set of specific planned indicators of the strategic development of regions, as well as their values and desired absolute and relative growth for the strategic period;
- all the analyzed documents look rather weak and poorly substantiated with regard to the methods of determining strategic goals. Most of the analyzed documents propose to base the strategic goals of regional development on "judgments", "visions", ideas that arose during discussion, brainstorming (foresighting).

However, at the same time, there are no recommendations for determining their quantitative parameters, justifying the expediency of choosing certain indicators - measuring goals, their planned values, absolute and relative increases, urgency and order of achievement; modern methods of economic and mathematical modelling are not used. In contrast, the methodology of scientific and strategic foresight is proposed, which contains modern scientific approaches to the identification and strategizing of regional development, which are universal and suitable for any country, region, type of economic activity, enterprise, etc.

6. Conclusions

For an adequate assessment of the current state of sustainable development of the Poltava region, the structure of sustainable regional development is used. The structure contains 10 components and 60 indicators, the dynamics of which are determined by official statistical data (49) and model calculations, including shadow indicators (11).

The identification of the current level of sustainable development is carried out according to the modern methodology of integral assessment, which involves a multiplicative form of the integral index, a modified method of normalization, dynamic weighting coefficients and a formalized definition of the limits of safe existence.

To develop strategic scenarios for the post-war recovery of regional development, a modern methodology of strategizing (scientific-strategic foresight) is used according to the principle "the future is determined by the trajectory into the future".

On the basis of this methodology, strategic scenarios for the restoration of sustainable development of the Poltava region were developed (realistic, optimistic and the scenario of entering the optimal zone of the EU countries) with scientifically based quantitative dynamics of components and indicators until 2027, which ensure the achievement of defined goals.

As a result of modelling the modified Cobb-Douglas production function and the Solow residual method, the contribution of innovative factors to economic growth was determined along with the contribution of other factors of production (STP -3.7; labor 3.1; capital 0.38; production manufacturability 1 .57; innovation 0.31%).

The state of sustainable development of the environmental subsystem, which at the end of 2022 is in the critical zone - below the lower threshold value, has been determined. This situation is due to the occurrence of 5 indicators out of 10 in the critical zone.

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