SIMULATION OF SOCIO-ECONOMIC SECURITY OF RURAL AREAS IN THE CONDITIONS OF SUSTAINABLE DEVELOPMENT: A CASE STUDY OF UKRAINE

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Abstract

In the article we proved that, the need to take into account the identified indicators of social tension and indicators of the level of social and economic security in rural areas becomes especially relevant for the formation and implementation of sustainable development programs. Since the resource provision of programs to support the development of rural areas is limited and in the process of their implementation questions will arise regarding the priority of financing the needs of this or that region or community, the results of modeling the indicators of dynamics and the state of socio-economic security can provide an answer to the question of specifying the process of identifying the region, which most needs the implementation of appropriate measures to stabilize the situation and bring it to a qualitatively higher level.

Key words: *rural areas, rural population, socio-economic security, sustainable development, socio-economic development*

INTRODUCTION

The specificity of the current state of development of the world economic system consists in the emergence of a whole complex of negative trends in the sphere of formation of high standards of the quality of life of the rural population. In turn, this also directly affects the effectiveness and functionality of the state's socio-economic policy to ensure the sustainable development of rural areas. At the same time, the need to create a sufficient level of socioeconomic security in the countryside is determined by a number of factors, the most important of which are the specific features of the nature and results of work, characteristics of rural areas, socio-demographics, and other conditions. It should be noted that state policy in the field of socio-economic development of rural areas is always complex and represents a combination of targeted development projects of the central government and local self-government bodies. In turn, this approach allows combining the central and regional budgets to finance targeted programs for the development of rural areas. However, as practice shows, the needs of sustainable development usually exceed the resource capabilities of budget financing, which requires the search for additional sources of investment in the development of rural areas, including under the conditions of private-state partnership.

The most significant threats to the socio-economic security of rural areas in Ukraine

are of a financial, legislative, and social nature. At the same time, each type of threat is revealed in a combination of factors of a different nature. At the same time, each such factor can be endowed with different natural features. For example, the legislative field, having a number of subjective features at the state level, has an objective nature in relation to the region. Financial threats, on the contrary, depending on the place of their localization, can have both objective and subjective nature. All of this determines the increasing relevance of research aimed at ensuring the socio-economic security of rural areas through the formation of functional systems for their sustainable development in conditions of increased destructive influence of external externalities.

The study of issues related to ensuring an adequate level of socio-economic security of rural areas is not new for modern economic science, as it is based on the principles of ensuring the minimization of the gap in the socio-economic development of the territories, and also provides for the observance of the principles of sustainable development defined by the relevant programs of the OUN. In this aspect, it is appropriate to note the works of such researchers as I. Balaniuk [1], O. Binert [2], I. Britchenko [3-11], Y. Chaliuk [12], M. Dziamulych [13-21], N. Khomiuk [22], S. Koshova [23-24], A. Marcuta [26], M. Masl'an [27], A. Nikolaeva [29], A. Popescu [30-39], T. Shmatkovska [40-42], R. Sodoma [43-48], O. Stashchuk [49-51], I. Tofan [52], I. Tsymbaliuk [53], I. Yakoviyuk [54], V. Yakubiv [55], O. Yatsukh [56], and many others. At the same time, there was an objective need to improve existing efforts to ensure the social and economic security of rural areas, which is caused by the dynamic development of destructive processes in the global and regional economic systems. According to the results of the assessment of modern economic policy trends, it was established that there is an objective need to model the processes of socio-economic development in the countryside to ensure the proper level of its socio-economic security both in the short-term and the long-term perspective.

MATERIALS AND METHODS

In the process of implementing the research, we normalized the indicators selected for modeling the socio-economic security of rural areas, i.e., the transition to indicators that do not have units of measurement, using a system of formulas:

− for stimulants:

$$Z_i = \frac{x_i - x_{min}}{x_{max} - x_{min}}$$

− for destimulators:

$$Z_i = \frac{x_{max} - x_i}{x_{max} - x_{min}}$$

where:
Z_i – a normalized value of the i-th indicator;
x_i – indicator value i;
x_{max} and x_{min} − respectively, the maximum and minimum value of the i-th indicator in all regions.

The calculation of the integral indicator of the level of economic security of the rural areas of the Ivano-Frankivsk region was carried out by the method of weighted sums:

$$I = \sum_{i=1}^{n} a_i z_i, \qquad \sum a_i = 1, \qquad 0 \le a_i, z_i \le 1$$

where:
a_i − weighting factors that determine the degree of contribution of the i-th indicator to the integral index;
z_i − normalized assessment of the i-th indicator.

In the process of implementing the presented research, we applied the algorithm of discriminant analysis, which includes the following steps.

1. We determine for the input data matrices X and Y the estimates of the vectors of the average values of $\underline{x}$ and $\underline{y}$ and the covariance matrices $\overline{S}_x$ and $\overline{S}_y$:

$$\underline{x} = \begin{pmatrix} \overline{x_1} \\ \overline{x_2} \end{pmatrix}; \qquad S_x = \begin{pmatrix} S_{11_x} & S_{12_x} & S_{21_x} & S_{22_x} \end{pmatrix}$$

$$\underline{y} = \begin{pmatrix} \overline{y_1} \\ \overline{Y_2} \end{pmatrix}; \qquad S_x = \begin{pmatrix} S_{11_y} & S_{12_y} & S_{21_y} & S_{22_y} \end{pmatrix}$$

where: $\underline{x_j} = \frac{1}{n_1}\sum_{i=1}^{n_1} x_{ij}$; $\underline{y_j} = \frac{1}{n_2}\sum_{i=1}^{n_2} y_{ij}$

$$S_{kj(x)} = \sum_{i=1}^{n_1} (x_{ij} - \underline{x_j})(x_{ik} - \underline{x_k})$$

$$= \underline{x_j x_k} - \underline{x_j}\,\underline{x_k};$$

$$S_{kj(x)} = S_{jk(x)};$$

$$S_{kj(y)} = \sum_{i=1}^{n_1} (y_{ij} - \underline{y_j})(y_{ik} - \underline{y_k})$$

$$= \underline{y_j y_k} - \underline{y_j}\,\underline{y_k};$$

$$S_{kj(y)} = S_{jk(y)};$$

$$j = (1,2).$$

2. We calculate the unbiased estimate of the total covariance matrix:

$$\hat{S} = \frac{1}{n_1 + n_2 - 2}\left[n_1 S_x + n_2 S_y\right]$$

3. We calculate the inverse matrix $\hat{S}^{-1}$.

4. We calculate the estimation vector of the coefficients of the discriminant function:

$$Z_a = \hat{S}^{-1}(\underline{x} - \underline{y})$$

5. We find estimates of the discriminant function:

$$Z_x = x^T \times a,$$
$$Z_y = y^T \times a,$$

where: x^T, y^T – transposed to the x and y matrices.

6. We calculate the average values:

$$\underline{Z_x} = \frac{1}{n_1}\sum_{i=1}^{n_1} Z_{xi}; \quad \underline{Z_y} = \frac{1}{n_2}\sum_{i=1}^{n_2} Z_{yi}$$

7. We find the limit of discrimination:

$$c = \frac{1}{2}(\underline{Z_x} + \underline{Z_y})$$

8. We write down the discriminant function (model):

$$Z = a_1 z_1 + a_2 z_2$$

If $Z \geq C$, then the territorial system (rural areas) should be assigned to the population X, and if $Z > C$, then to the population Y.
We used the formula given below to calculate social tension in the rural areas of the studied region of Ukraine:

$$CH = \ln \left|\frac{\sum_1^6 x_i}{\sum_1^8 z_i}\right|,$$

where:
X_1 – number of dropped-out persons;
X_2 – number of registered unemployed;
X_3 – number of families and singles who are on the apartment register;
X_4 – number of registered crimes (units);
X_5 – emissions of pollutants (thousand tons);
X_6 – number of deaths (mortality rate) (per 1,000 of the existing population);
Z_1 – number of subjects of the unified state register of enterprises and organizations of Ukraine;
Z_2 – capital investment per person, hryvnias;
Z_3 – number of arrivals;
Z_4 – number of employed citizens;
Z_5 – average monthly nominal salary, UAH/month;
Z_6 – provision of housing for the population (on average per person; m2 of total area);
Z_7 – number of hospital and outpatient clinics;
Z_8 – number of births (per 1,000 of the available population).

RESULTS AND DISCUSSIONS

The absence or significant limitation of statistical data on the assessment of socio-economic security of rural areas makes it impossible to use certain common methods. We offer a slightly modified approach, which makes it possible to conduct a study of the specified problem based on the basis of the existing statistical base.
Note that in order to ensure the evaluation of the food component of the economic security

of the territorial systems of the Ivano-Frankivsk region of Ukraine under our study, a set of the following indicators was selected:
1) grain production per person, t;
2) potato production per person, t;
3) production of vegetables per person, t;
4) production of fruits and berries per person, t;
5) meat production per person, t;
6) milk production per person, t;
7) egg production per person, million pieces;
8) sales area of stores that sell food products, m^2.
To evaluate the investment component, we selected the following indicators:
1) capital investment per person, hryvnias;
2) direct foreign investment (share capital), UAH per person.
To evaluate the foreign trade component, we selected the following indicators:
1) volumes of exports of goods per capita, thousands of US dollars;
2) volumes of import of goods per capita, thousands of US dollars;
3) coefficient of export coverage by import.
To evaluate the social component of economic security, we selected the set of indicators presented below:
1) real wage index, %;
2) unemployment rate of the working population, %;
3) the number of persons brought to administrative responsibility (per thousand inhabitants);
4) the number of hospital beds (per person);
5) provision of housing for the population (on average per person; m^2 of total area);
6) the number of preschool educational institutions (per thousand inhabitants);
7) the number of full-time general educational institutions (per thousand inhabitants).
In the process of conducting the research, we normalized the selected indicators, i.e. transition to indicators that do not have units of measurement, using the appropriate system of formulas (the formulas are presented above).

Note that the calculation of the integral indicator of the level of socio-economic security of the rural areas of the Ivano-Frankivsk region of Ukraine was carried out using the method of weighted sums, using the formula presented above.
The weighting coefficients were found using the service capabilities of the MS Excel spreadsheet using the coefficients of determination between the relevant components of economic security and demographic indicators in the rural areas of the Ivano-Frankivsk region of Ukraine. The integral indicator was calculated separately for each component, and then for the Ivano-Frankivsk region of Ukraine in general.
Based on the results of the research (complex analytical calculations and grouping), we established that the indicator of the integral indicator of socio-economic security of the rural areas of the studied region of Ukraine is low. A very low level of economic security in 2020 can be observed in the Nadvirna, Tysmenytsia, Rozhniativ, Bohorodchany districts, low – in Kosiv, Kolomyia, Kalush, Dolyna, Verkhovyna, Horodenka, Tlumach, Sniatyn, Halych districts, medium – in Rohatyn district of Ivano-Frankivsk region (Fig. 1, Table 1).

Table 1. Grouping of territorial systems of the Ivano-Frankivsk region according to the integral indicator of the level of socio-economic security of rural areas in 2020

An integral indicator of economic security	Level	Territorial systems
0.20 – 0.36	Very low	Nadvirna, Tysmenytsia, Rozhniativ, Bohorodchany districts
0.37 – 0.51	Low	Kosiv, Kolomyia, Kalush, Dolyna, Verkhovyna, Horodenka, Tlumach, Sniatyn, Halych districts
0.52 – 0.67	Average	Rohatyn district

Source: own development.

The cartogram we constructed (Fig. 1) makes it possible to visualize the obtained research results (Table 1).

Analysing the dynamics of indicators of socio-economic security of rural areas of Ukraine in the studied period (Fig. 2) made it possible to establish their instability and difficulty in forecasting and does not follow clear trends of its change in a positive direction during the studied period.

Fig. 1. Cartogram of the grouping of districts of the Ivano-Frankivsk region of Ukraine according to the integral indicator of the level of social and economic security of rural areas in 2020
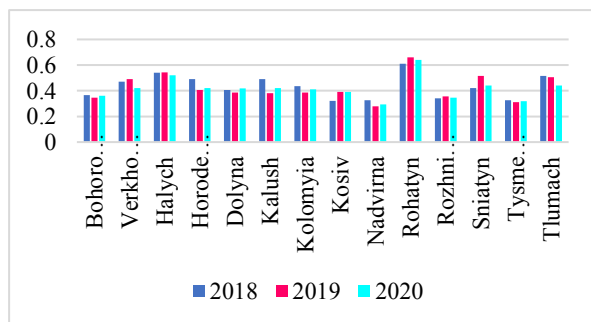Source: own development.

Fig. 2. Dynamics of the level of social and economic security of rural areas of the Ivano-Frankivsk region of Ukraine in 2020 - 2018.
Source: own development.

The method of discriminant analysis was used in the study in order to predict the threshold levels of indicators of socio-economic security of the rural areas of the studied region of Ukraine. At the same time, aggregates X and Y were formed from the values of rural

population growth and the integral indicator of socio-economic security of rural areas of the studied region of Ukraine, while one aggregate included values with positive population growth, and the other – with a negative.

Based on the algorithm of discriminant analysis (which we set out in this study above), given and described in detail in the work [25], discriminant functions were developed for the studied periods, which are presented in Table 2.

Table 2. Models of threshold levels of economic security (taking into account the growth of the rural population) of the Ivano-Frankivsk region of Ukraine for 2015-2020

Year	Discriminant model, limit of discrimination
2015	$Z = 1.452P + 13.618I.\ C=5.847$
2016	$Z = 0.914P–1.296I.\ C=1.026$
2017	$Z = 0.731P + 2.193I.\ C=0.998$
2018	$Z = 0.629P – 0.343I.\ C=0.146$
2019	$Z = 0.858P + 3.547I.\ C=1.387$
2020	$Z = 0.353P + 5.764I.\ C=2.978$

where: Z – discriminant model, P – population growth, I – integral index of economic security, C – the limit of discrimination.
Source: own calculations.

By setting the value of the increase in the rural population and the integral index of economic security in each analyzed period in the discriminant model Z and comparing its value with the discriminant limit C, we obtained the following research results: the threshold level in 2015 is exceeded by Bohorodchany, Verkhovyna and Nadvirna districts; in 2016 – Bohorodchany, Kosiv, Verkhovyna, Dolyna, Nadvirna, Rozhniativ and Tysmenetsia districts; in 2017 – Dolyna, Bohorodchany, Verkhovyna, Kolomyia, Nadvirna districts; in 2018 – Bohorodchany, Verkhovyna, Dolyna and Nadvirna districts; in 2019 – Bohorodchany and Dolyna districts; in 2020 – Bohorodchany, Nadvirna, Dolyna, Kalush, Tysmenetsia, Kolomyia districts (Fig. 3).

At the same time, the discriminant analysis was formed from the aggregates X and Y, which were constructed, respectively, from the values of social tension and the integral indicator of economic security of the territorial systems of the Ivano-Frankivsk

region of Ukraine in the studied period. Note that the indicator of social tension was calculated based on the methodology of V. Nahornyi [28], which was modified in accordance with the available statistical base.

Fig. 3. Cartogram of the visualization of the value of the discriminant function and the limit of discrimination (taking into account the growth of the

rural population) in the Ivano-Frankivsk region of Ukraine in 2020.
Source: own development.

Thus, we have visualized the results of the study for 2018-2020 regarding the rural territorial systems of the base region of Ukraine (Fig. 4).

Models of threshold levels of socio-economic security (taking into account social tensions) of rural areas of the Ivano-Frankivsk region of Ukraine for 2015-2020 are given in Table 3.

Table 3. Models of threshold levels of socio-economic security (taking into account social tensions) of rural areas of the Ivano-Frankivsk region of Ukraine for 2015-2020

Year	Discriminant model, limit of discrimination
2015	$Z = -2.131CH - 0.5012.\ C=-2.056$
2016	$Z = -4.623CH–1.0992.\ C=-4.085$
2017	$Z = -5.761CH +0.1593.\ C=-4.195$
2018	$Z = -10.386CH – 14.7091.\ C= -15.581$
2019	$Z = -6.621CH + 3.622.\ C=-6.3$
2020	$Z = -7.543CH + 0.957.\ C=-3.953$

where: Z – discriminant model,
CH – index of social tension,
I – integral index of economic security,
C – the limit of discrimination.
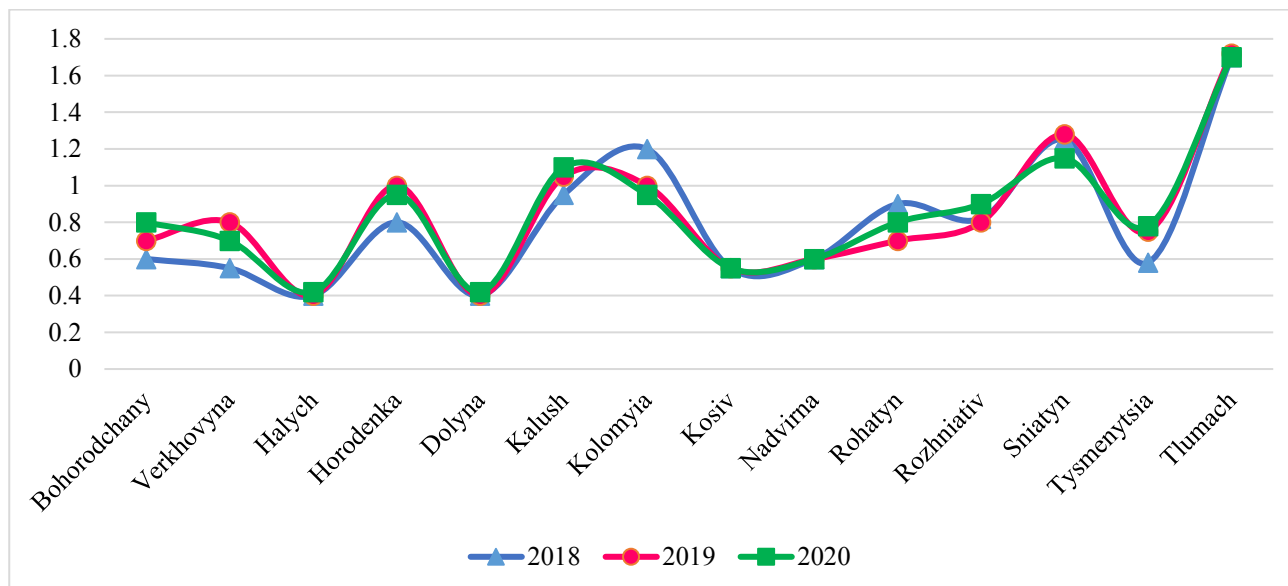Source: own calculations.

Fig. 4. Dynamics of changes in the level of social tension in rural areas of the Ivano-Frankivsk region of Ukraine for 2018-2020
Source: own development.

By entering the values of social tension and the integral index of socio-economic security in each studied period into the discriminant

model Z and comparing its values with the discriminant limit C, a complex of the following results was obtained: the threshold

level in 2015 is crossed by Dolyna, Halych, Nadvirna, Kosiv, Verkhovyna and Rohatyn districts; in 2016 – Halych, Dolyna, Kosiv, Nadvirna, Rohatyn districts; in 2017 – Dolyna, Halych, Nadvirna, Kosiv districts; in 2018 – Dolyna, Kosiv, Nadvirna, Halych, Bohorodchany, Rozhniativ, Verkhovina, Horodenka districts; in 2019 – Dolyna and Bohorodchany districts, in 2020 – Bohorodchany, Nadvirna, Dolyna, Halych, Kosiv and Kolomyia districts (Fig. 5).

Fig. 5. Cartogram of the visualization of the value of the discriminant function and the limit of discrimination (taking into account social tension) in the Ivano-Frankivsk region of Ukraine in 2020.
Source: own development.

Thus, it is possible to assert the need for the formation of an effective and efficient mechanism for ensuring the socio-economic development of rural areas, which should be based on a long-term regional state policy regarding the sustainable development of territories, which would, in particular, provide for the need to finance relevant projects at the expense of effective tax policy and investment sources of private-public partnership.

In our opinion, ensuring socio-economic security of rural areas in Ukraine should be carried out by forming a set of socio-economic goals and tools for their implementation. At the same time, practical control over the achievement of these goals should also be entrusted to the state, including regional authorities, which must directly participate in the formation of programs for the socio-economic development of the regions, and will also directly dispose of the funds necessary for financing the specified projects. At the same time, the sustainable development of rural areas will be based precisely on the implementation of the specified investment projects, as a result of which the general level of economic security of the regions will increase.

At the same time, it should be noted that the practical implementation of any projects and programs of socio-economic development of rural areas is impossible without an adequate amount of financial resources and sources of their replenishment. However, taking into account the systemic changes that are currently taking place in the economic system of Ukraine, determining the specifics of financing such projects requires additional research.

CONCLUSIONS

Based on the results of the conducted research, we come to a conclusion regarding the need to form effective programs for the development of rural areas of Ukraine, which is determined both by the need to ensure the socio-economic development of the village and the formation of labor resources for the agricultural sector of Ukraine. At the same time, the main obstacle to the implementation of such programs, which should be based on the principles of sustainable development of regions, are resource limitations, which are manifested in the insufficient amount of investment resources to achieve complex goals. At the same time, this resource limitation consists in the limitation of available resources, such as financial, human, material and natural resources. This can significantly affect the possibility of effective implementation of programs for the introduction of new technologies, infrastructure development, improvement of the quality of life and other initiatives aimed at the effective development of rural areas of Ukraine. Accordingly, such a lack of resources can become an obstacle in the development of certain industries, which are

essential for the economic development of rural areas - such as agriculture, tourism, agrarian processing, etc. Therefore, the effective use of available resources and their optimal distribution in the process of implementing programs of socio-economic development of rural areas is an important task of ensuring their sustainable development. Since the resource provision of programs to support the development of rural areas is limited and in the process of their implementation questions will arise regarding the priority of financing the needs of this or that region or community, the results of modelling the indicators of dynamics and the state of socio-economic security can provide an answer to the question of specifying the process of identifying the region, which most needs the implementation of appropriate measures to bring the situation to a qualitatively higher level. At the same time, as the analysis of the calculated indicators on the materials of the Ivano-Frankivsk region of Ukraine shows, within the studied region it was possible to form groups of rural areas with differentiated values of the studied indicators, which, in our opinion, should also affect the mechanism of funding distribution under socio-economic development programs rural areas of Ukraine.

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