

ECONOMIC MODELING OF SUSTAINABLE RURAL DEVELOPMENT UNDER THE CONDITIONS OF DECENTRALIZATION: A CASE STUDY OF UKRAINE

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Abstract

The content of rural territories development as a socio-economic-ecological system has been determined. It has been also proved that the study of rural development is of crucial importance because of the necessity to solve some socio-economic problems such as preservation of local customs, historical and ethnic characteristics. We have identified the decentralization as one of the vital components of democratic reformation, contributing to the transparency of the authorities' activity. The impact of decentralization processes on the indicators of sustainable rural development in Ukraine has been revealed. It manifests itself in the growth of employment and income of rural population, provision of medical and educational institutions, enhancements of road transport infrastructure, creation of conditions for business development and further diversification of economic activity in rural areas, environmental protection. The analysis of sustainable development of rural territories in the conditions of decentralization based on the application of the proposed methodology has been done. Integral indices of sustainable development of rural territories of Ukraine have been calculated using the determination of partial indices of social sphere development, economic and ecological situation. The results of modelling rural territories sustainable development in the context of decentralization can be used to make management decisions for the development and implementation of economic instruments with the aim of achieving such strategic prospects as reformation of local self-governments and territorial organization of central government in Ukraine. To analyze the impact of decentralization on achieving sustainable rural development prospects, the benefits and risks of this process have been identified.

Key words: rural territories, decentralization, territorial community, sustainable development, social-economic sphere

INTRODUCTION

One of the consequences of the crisis, which is characteristic of the development of the economy of Ukraine and its regions at the present stage, is the aggravation of the problems of rural improvement. Now rural territory occupies almost 90% of the total area of the country, where a third of the total population lives [7, 8, 29]. High unemployment rate, unfavorable demographic situation, migration processes, low availability of infrastructure and other

negative trends require the development and implementation of effective mechanisms to ensure the competitiveness of rural areas and to improve the quality of life of rural population.

The current processes of creation and development of united territorial communities, which are taking place during the implementation of the decentralization reform in Ukraine and the Association Agreement with the EU, open up new prospects for enhancing the competitive advantages of rural territories and help to

increase the efficiency of utilization of both available and potential rural development opportunities.

Theoretic-methodological and applied provisions on the essence of rural areas and ensuring their sustainable economic development in the context of decentralization are the subject of research by many scientists, including: Akimova L. [1], Boiar A. [2], Dziamulych M. [7, 8], Kravtsiv V. [12], Kitsyuk I. [15], Tymbaliuk I. [16, 36, 37], Popescu A. [20, 21, 22, 23, 24, 25, 26, 27], Sodoma R. [31], Tofan I. [33], Yakubiv V. [38], Zhurakovska I. [39] and others.

Generalization of scientific approaches to ensuring the sustainable development of rural territories gives grounds to claim that there is currently no single conceptual approach to the concept of decentralization.

We reckon, rural development should be seen as a dynamic process that leads to structural changes in social, economic, financial, natural-environmental, institutional objects and phenomena occurring in a multicomponent spatial system formed on the territories outside cities [10].

Sustainable development is an enhancement that makes it possible to «meet the needs of the present generation without sacrificing the ability of future generations to meet their own needs» [15] Taking this into account, the sustainable development of rural territories is a socio-ecological-economic process of extended reproduction of rural territories development, which ensures the harmonious growth of economic, social, demographic, ethnic and environmental spheres.

In April 2014, the Government of Ukraine approved the Concept of Reforming Local Self-Government and Territorial Organization of Power in Ukraine. Issues related to administrative, budgetary, financial and land decentralization as well as the development of rural territories on which integrated territorial communities have been formed are often discussed on the pages of scientific journals, at scientific conferences and in political circles [11]. Issues concerning the development of recommendations for sustainable development of rural territories in

the context of decentralization are currently relevant in Ukraine.

Theoretical, methodological and applied provisions concerning the nature of rural territories and ensuring their sustainable development in the conditions of decentralization have been revealed in many scientific works [15, 16, 2, 29]. In particular, Borshchevskyy V. V. considers the theoretical and applied aspects of functioning the mechanisms which increase the socio-economic potential of rural territories. Among the priority tasks in the context of ensuring the efficient functioning of the institutional mechanism for enhancing their socio-economic potential, the scientist emphasizes the decentralization of power and the increase of the institutional capacity of local governments [4]. Borshevskyy V., Zalutskyy I. outline the causes and consequences of stagnation in the process of improving the socio-economic status of rural territories in the context of decentralization of power and argue for the priority of taking into consideration territorial factors for ensuring sustainable development of rural territories and self-sufficiency of the united territorial communities [5].

Prytula Kh. reveals the nature and features of rural territories in the context of the implementation of national regional policy, generalizes approaches to the identification and classification of these territories. The scientist defines models of rural territories development and their application for ensuring their effective management [28].

Pavlov O. in the works [17, 18] defines the essence of rural territories as complex natural and socio-spatial formations, determines the factors of spatial development of rural territories, substantiates the strategic priorities of their development taking into account the levels, types and varieties of these territories. Pavlov O. reveals the shortcomings of the existing model of rural development on the basis of territorial communities [19], substantiates the positive effects of the integration of rural communities around urban territorial communities for the modern development of Ukraine.

Klyuchnik A. classified the rural areas by such features as production and economic orientation, natural potential, recreational and tourist activity, marketing potential, etc. [9].

Borodina O., Prokopa I. reveal the essence of inclusive rural development [3]. In his turn, Lupenko U. believes that in order to ensure sustainable development, villagers should be given the opportunity to implement their own entrepreneurial initiative, especially in agriculture [13].

Dax T., Copus A. believe that the main interest in rural territories development should be in focusing on pursuing policies that seek effective ways of nurturing local and regional assets across a range of policy areas in order to improve well-being and promote eco-friendly developments in European rural areas [6].

Siudek T., Czarnecki E., and Vashchuk M. assess the sustainability of rural development in all countries of the European Union. The study was conducted using economic, environmental and social indicators. As a result of the analysis, scientists find that there is a great deal of diversification of the economic, environmental and social development of rural areas among EU Member States. The authors believe that sustainable (rural) development exists only theoretically. In practice, this development somewhat deviates from equilibrium. In addition, rural development is a dynamic effect as it is constantly changing over time [30]. Tryhuba, A., Pavlikha, N., Rudynets reveal features of dairy development in rural communities [34, 35].

Scientists and practitioners state that the processes of decentralization reform have an impact on rural development. The results of the analysis of preconditions for sustainable development of rural territories in the context of decentralization will allow to make a conclusion on positive and negative sides of this influence.

The purpose of the article is to analyze the social, economic, environmental preconditions and to model the sustainable development of rural territories under decentralization to make managerial decisions in order to develop and implement the

guidelines for achieving strategic perspectives for reforming local self-government and territorial organization of government in Ukraine.

MATERIALS AND METHODS

In the study we calculated the normalized indicators of the development of the social sphere of the Ukrainian rural territories and calculated the partial index of development of the social sphere of rural territories in Ukraine ($I_{\text{rur}}^{\text{soc}}$) by the formula:

$$I_{\text{rur}}^{\text{soc}} = \frac{1}{21} (\sum_{j=1}^{21} I_{\text{rur}}^{\text{soc}}),$$

The calculation of the partial index of development of economic situation in rural territories in Ukraine ($I_{\text{rur}}^{\text{econ}}$) is calculated by the formula:

$$I_{\text{rur}}^{\text{econ}} = \frac{1}{18} (\sum_{j=1}^{18} I_{\text{rur}}^{\text{econ}}),$$

We calculated the partial index of the development of the ecological situation in rural territories in Ukraine ($I_{\text{rur}}^{\text{ecol}}$) by the formula:

$$I_{\text{rur}}^{\text{ecol}} = \frac{1}{9} (\sum_{j=1}^9 I_{\text{rur}}^{\text{ecol}})$$

We calculated the integrated index of sustainable rural development (I_{rur}) by the formula:

$$I_{\text{rur}} = \frac{1}{48} (\sum_{j=1}^{21} I_{\text{rur}}^{\text{soc}} + \sum_{j=1}^{18} I_{\text{rur}}^{\text{econ}} + \sum_{j=1}^9 I_{\text{rur}}^{\text{ecol}}),$$

A regression model of the dependence of the index of sustainable development of rural territories in Ukraine on partial indices of social, environmental and economic systems has been built according to the following formula:

$$I_{\text{rur}} = a_0 + a_1 I_{\text{rur}}^{\text{soc}} + a_2 I_{\text{rur}}^{\text{econ}} + a_3 I_{\text{rur}}^{\text{ecol}},$$

where:

a_0, a_1, a_2, a_3 -parameters of model,

I_{rur} – integral index;

$I_{\text{rur}}^{\text{soc}}$ – index of social sphere development;

$I_{\text{rur}}^{\text{econ}}$ – index of economic situation;

$I_{\text{rur}}^{\text{ecol}}$ – index of ecological situation.

Modeling was conducted to make management decisions on the development and implementation of directions for achieving sustainable development of rural areas in Ukraine. It includes the construction of a multiple regression model using the methods of correlation and regression analysis.

RESULTS AND DISCUSSIONS

The subject of our study is the development of rural areas, which are part of urban, township and rural united territorial communities. The relationship between the concepts of «rural area» and «urban united territorial

community» is schematically shown in Fig. 1. The relationship between the concepts of «rural area» and «settlement united territorial community» is schematically shown in Fig. 2. The relationship between the concepts of «rural area» and «rural united territorial community» is schematically shown in Fig. 3.

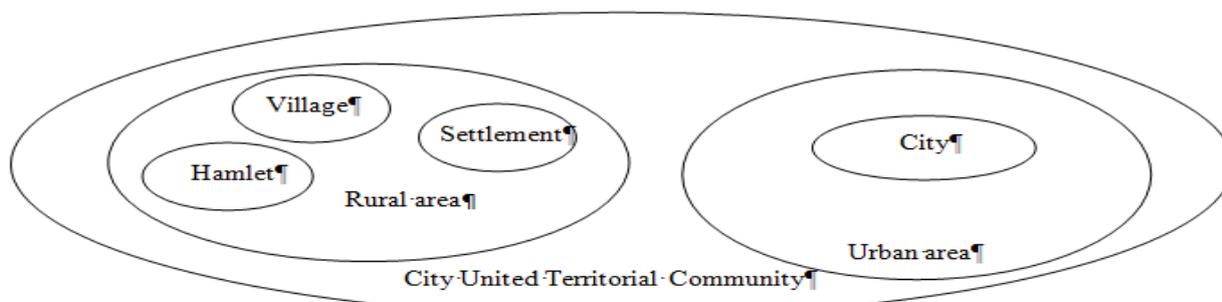


Fig. 1. Correlation of the concepts «rural territory» and «urban united territorial community»
 Source: built by the authors.

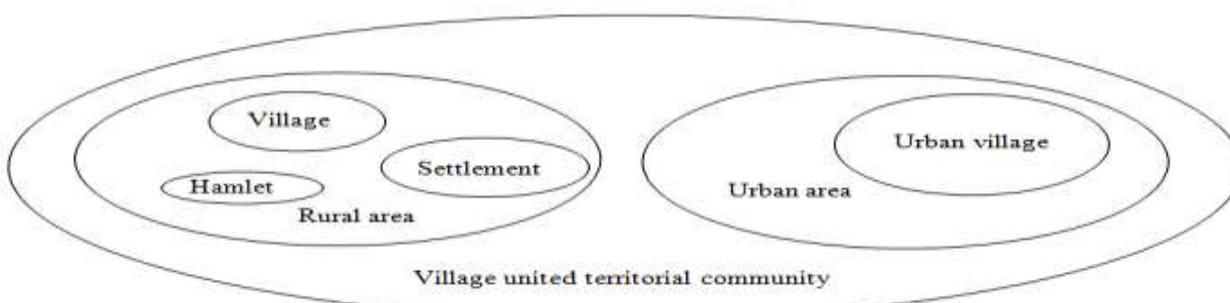


Fig. 2. The relationship between the concepts of «rural area» and «settlement united territorial community»
 Source: built by the authors.

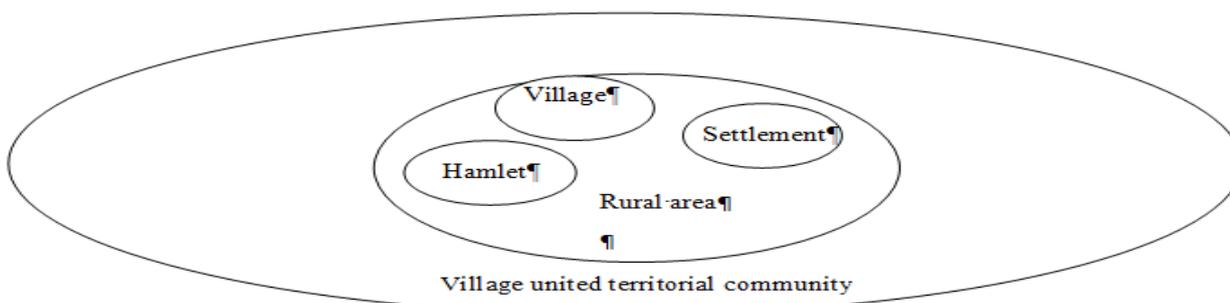


Fig. 3. The relationship between the concepts of «rural area» and «rural united territorial community»
 Source: built by the authors.

According to our reckoning, a rural united territorial community is an administrative unit which, as a result of voluntary association of several villages, settlements and hamlets, is able to provide an appropriate level of service provision (educational, cultural, health care) independently or through relevant local governments, taking into account the relevant

resources for the development of the infrastructure of this unit.

Rural communities formed as a result of decentralization contribute to rural development, which depends primarily on the villagers and the extent to which rural communities can maintain local infrastructure at the appropriate level, have access to a wide

range of services, and work to intensify business and economic opportunities. .
 As of November 1, 2019, 28,377 rural settlements were registered in Ukraine, which is 468 less than in 1991. Most of these villages disappeared in Kyiv, Kharkiv, Poltava, and Zhytomyr oblasts. Along with the decrease in the number of rural

settlements, there is a decrease in the total number of rural population. During 1990–2018, the rural population decreased by 3.8 million people (from 32.4% to 30.7% of the total population). The dynamics of the rural population number and the share of rural population in the total population of Ukraine is shown in Fig. 4.

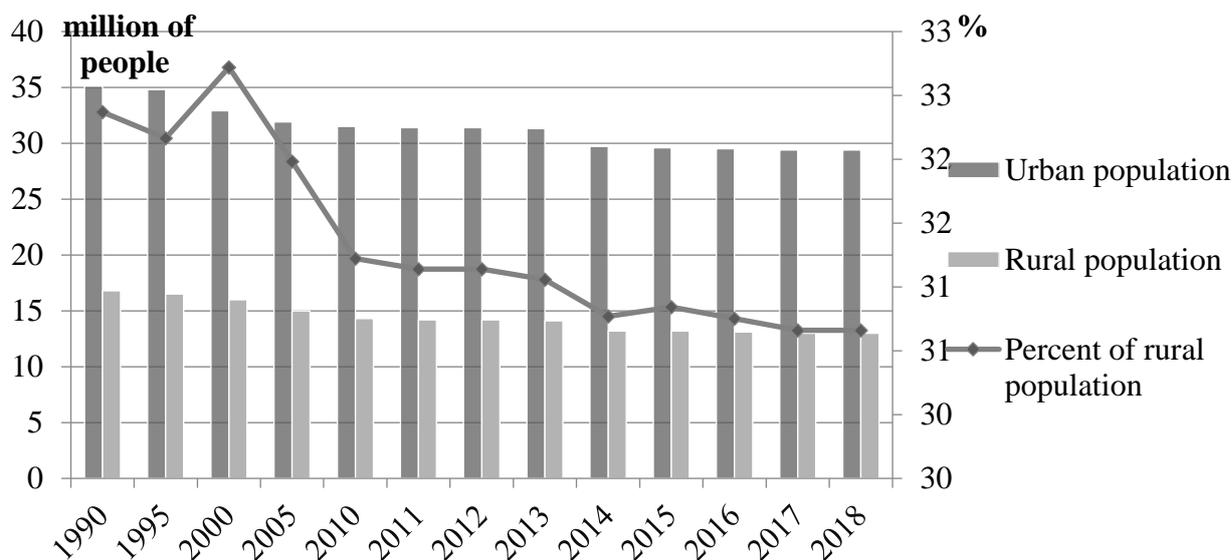


Fig. 4. Dynamics of the number of rural and urban population and the share of rural population in the total population of Ukraine, 1990 – 2018
 Source: based on data [32, p. 29].

In 2018, the largest number of rural population per rural settlement was observed in Zakarpattia (1,368 persons), Chernivtsi (1,291 persons) and Ivano-Frankivsk (1,002 persons) regions.

An important social parameter of rural development is the general increase (decrease) of the rural population. In 2018, there was a total reduction of the rural population in Ukraine by 118.9 thousand people due to natural (108.2 thousand people) and migration (10.7 thousand people) reduction. The problem of migration outside territorial communities for all their types (urban, settlement, rural) is extremely relevant. The problem of population migration is especially acute for territorial communities that are located far from large cities and important highways.

The decrease in the number of rural residents is also due to a natural reduction, i.e. a

reduction in the number of people of working age.

The main problem of rural residents' life is that their financial situation is more difficult than that of the urban population. The low standard of living of rural residents of Ukraine is evidenced by such an indicator as the share of the population with per capita equivalent cash income per month below the statutory subsistence level: in 2018 it was 4.3% nationwide, while in rural areas – 7.1 %. In 2018 the share of the population with per capita equivalent cash income per month below the actual subsistence level for Ukraine as a whole was 38.6%, and in rural areas – 48.4%. As of January 1, 2019, 4,465 thousand pensioners lived in rural areas, i.e. 38.9% of the number of all those registered at the Pension Fund of Ukraine, which is 775 thousand more pensioners than in 2017.

In rural areas, there is a rapid decline in the employment of active population, especially in the share of the employees working at agricultural enterprises. The decline in employment at agricultural enterprises is not offset by the expansion of rural population employment in other areas, as well as self-employment.

An important prerequisite for sustainable development of rural areas is the improvement of living conditions of peasants (because in addition to agriculture, rural development covers other areas, such as education, health, environment, infrastructure etc.). In general, only 41% of rural children of the corresponding age are covered by preschool

education in Ukraine. There is not only a decrease in the number of preschool institutions and treatment and prevention facilities, but also in the number of libraries and clubs. The dynamics of reducing the number of commissioned residential premises in rural areas is observed.

We calculated the integrated index of sustainable development of rural territories I_{rur} . We determined the indicators of development of the social sphere, economic situation and ecological situation.

The indicators of the development of the social sphere of rural territories in Ukraine and their dynamics in 2014–2018 are revealed in Table 1.

Table 1. The indicators of the development of the social sphere of rural territories in Ukraine in 2014–2018

Indicator	2014	2015	2016	2017	2018
Share of rural population, %	30.88	30.81	30.77	30.71	30.59
Number of rural population per rural settlement, persons on average	467	464	462	459	454
Provision of living space, sq. m for 1 person	28.51	28.94	29.30	29.61	30.07
Share of apartments in residential buildings and non-residential buildings in rural areas, equipped with % running water	28.9	29.8	30.6	31.5	32.3
hot water supply	16.9	17.5	18.1	19.1	19.5
sewerage	25.2	26.1	26.9	27.7	28.5
central heating	1	1.1	1.2	1.2	1.3
heating from individual installations	48.1	48.8	48.9	49.5	49.9
stove heating	44.2	44.2	44	44.2	44
natural gas	53.2	53.5	53.7	53.8	54.1
Total increase, decrease (-) in the rural population, per 1,000 people	-75.9	-80.6	-73.3	-86.8	-118.9
Economically active population aged 15-70, thousand people	5,850.6	5,667.5	5,648.7	5,602.2	5,604.7
Economically inactive population aged 15-70, thousand people	3,615.9	3,647.7	3,633.7	3,674.1	3,644.9
Rate of economic activity, %	61.8	60.8	60.9	60.4	60.6
Employment rate, %	55.9	55.1	54.9	54.4	55
Unemployment rate, %	9.5	9.4	9.7	9.9	9.2
Coverage of children by preschool educational institutions, % to the number of children of the appropriate age	40	40	41	41	41
Number of rural settlements with 1 library	2.10	2.07	2.10	2.12	2.13
Number of rural settlements that have one club-type cultural institution	1.86	1.82	1.83	1.83	1.84
Provision of the population with hospital beds, thousand people per 1 bed	3.92	4.21	4.73	4.76	4.73
Share of households with access to the Internet at home, %	15.6	27.2	30.6	38.6	40.6

Source: formed on the basis of data from the State Statistics Service of Ukraine.

*Excluding the temporarily occupied territories of the Autonomous Republic of Crimea, Donetsk and Luhansk regions.

We calculated the normalized indicators of the development of the social sphere of rural territories in Ukraine in 2014–2018 and the

partial index of the development of the social sphere of rural areas in Ukraine $I_{\text{fur}}^{\text{soc}}$ (Table 2).

Table 2. Partial index of development of the social sphere of rural territories in Ukraine, 2014 – 2018

Year	2014	2015	Increase to the previous year, %	2016	Increase to the previous year, %	2017	Increase to the previous year, %	2018	Increase to the previous year, %
$I_{\text{fur}}^{\text{soc}}$	0.2817	0.2817	0	0.2812	-0.1910	0.2830	0.6690	0.2855	0.8580

Source: calculated by the authors.

At present, the agricultural sector is the foundation of a sustainable economy, filling budgets and space for attracting investment. The territory of Ukraine consists of 95% of lowlands and hills, 5% of it is mountainous, which is extremely favorable for the development of agricultural production. Ukraine ranks first in Europe in terms of agricultural land and arable land.

The area of agricultural lands of Ukraine as of January 1, 2019 amounted to 41,329 thousand hectares or 68.5% of the total land fund, of which arable land accounted for 32,544.3 thousand hectares or 78.74%.

The area of the plowed land in Ukraine is almost the largest in the world and is equal to 53.9%. High percentage of the plowed land is threatening, because it is the reason for the reduction of the natural potential of rural areas.

Agricultural development of Ukraine in 2018 was 71.3%, and the share of arable land in the total area of agricultural land was 78.7%.

For comparison - in the countries of the European Union plowing of agricultural lands is 25.6%, and in highly developed countries worldwide – 11.8% [14, p. 82].

A significant aggravation of the economic crisis can be seen in the sphere of agriculture - the main productive sphere of rural areas. Large agricultural holdings are mainly engaged in the cultivation of grain and industrial crops using advanced technologies, which virtually monopolizes arable farming. The largest area of agricultural land (3,977.6 thousand hectares) is concentrated in

enterprises that owned and used more than 10,000 hectares.

As a result, enterprises practically monopolized the processing of agricultural raw materials and sales of marketable products.

Monopolization of land leads to the decline of small and medium-sized businesses in rural areas, farming.

The most important branch of the food sector in rural areas in Ukraine is grain production. This is due to favorable soil and climatic conditions, which are suitable for growing almost all types of cereals. Grain production plays an important role not only in the socio-economic and political development of the economy, but also in ensuring food security of the state. Ukraine ranks seventh in the world rating of grain producers.

Ukraine has been a world leader in the production and export of sunflower oil for several years in a row. At the same time, exports of seeds and fruits of oilcrops increased by +525 million US dollars (where rapeseed and soybeans hold key positions), and grain exports – by +428 million US dollars (mainly due to corn). The main market for Ukrainian agricultural products remains the Asian market, which slightly reduced its share in the structure of Ukrainian exports in 2017 to 45%, from 48% in 2016.

In order to calculate the integrated index of sustainable development of rural areas, the main indicators of economic development in rural areas in Ukraine and their dynamics in 2014-2018 have been identified, which is presented in Table 3.

Table 3. The main indicators of the economic situation in rural areas in Ukraine in 2014 – 2018

Indicator	2014	2015	2016	2017	2018
GRP for 1 person, UAH	33.473	36.904	46.413	55.899	70.233
Level of agricultural land development, %	71.66	71.66	71.65	71.62	71.34
The level of plowing of the territory, %	56.16	56.18	56.18	56.18	56.18
The level of plowing of agricultural land, %	78.37	78.4	78.41	78.44	78.74
Provision of agricultural land per hectare per rural inhabitant	3.13	3.15	3.17	3.19	3.22
Number of business entities in agriculture, forestry and fisheries, thousand items	75.8	79.3	74.6	76.6	76.3
Share of economic entities in agriculture, forestry and fisheries in total, %	3.92	4.02	4.00	4.24	4.15
The level of profitability of agricultural, forestry and fisheries enterprises, %	42.30	41.70	32.40	22.40	17.90
Share of agricultural, forestry and fisheries enterprises that suffered losses, %	11.3	11.5	12.2	13.8	13.8
Share of the population employed in agriculture, forestry and fisheries, %	17.10	17.46	17.61	17.71	17.96
Average monthly nominal salary of full-time employees in agriculture, UAH	2,476	3,140	3,916	5,761	7,166
Production of agricultural products, UAH million	371.189	544.206	637.791	707.792	847.587
Volumes of capital investments in agriculture, UAH million	18.388	29.310	49.660	63.401	65.059
Share of capital investments in agriculture to total volumes, %	8.38	10.73	13.82	14.14	11.24
The share of transported products of agriculture, forestry and fisheries in the structure of all the goods transported by motor transport enterprises	12.93	13.51	12.78	13.94	12.42
Total resources of households in rural areas, on average per month per household	4.455	5.238	6.258	8.065	9.455
Income from the sale of agricultural activities	409.86	497.61	506.93	661.31	680.77
The cost of consumed products obtained from personal farms	494.51	639.04	725.97	798.42	907.70

Source: formed on the basis of data from the State Statistics Service of Ukraine.

*Excluding the temporarily occupied territories of the Autonomous Republic of Crimea, Donetsk and Luhansk regions of Ukraine.

The results of calculations of the partial index of economic development in rural areas in Ukraine $I_{\text{rur}}^{\text{econ}}$ are presented in Table 4.

Table 4. Partial index of economic situation development in rural areas in Ukraine, 2014 – 2018

Year	2014	2015	Increase to the previous year, %	2016	Increase to the previous year, %	2017	Increase to the previous year, %	2018	Increase to the previous year, %
$I_{\text{rur}}^{\text{econ}}$	0.1201	0.1202	0.0463	0.1202	0	0.1214	0.9379	0.1210	-0.2975

Source: calculated by the authors.

In order to calculate the integrated index of sustainable development of rural areas, the main indicators of the development of the ecological situation in rural areas in Ukraine and their dynamics in 2014 – 2018 are highlighted (Table 5).

Table 5. The main indicators of the development of the ecological situation in rural areas in Ukraine in 2014–2018

Indicator	2014	2015	2016	2017	2018
Emissions of pollutants into the atmosphere from stationary sources of pollution of agriculture, forestry and fisheries, thousand tons. Their share in the overall structure of emissions, %	2.4	2.7	2.7	3.1	3.1
Emissions of carbon dioxide into the atmosphere from stationary sources of pollution of agriculture, forestry and fisheries, thousand tons. Their share in the total structure of emissions, %	0.5	0.8	0.6	0.9	0.9
The share of fresh water intake by agricultural enterprises from the total intake, %	36.08	32.81	33.84	37.01	43.89
The share of the area fertilized with mineral fertilizers, %	82	81	87	89	91
The share of the area fertilized with organic fertilizers, %	2	3	3	3	4
Share of generated waste from agriculture, forestry and fisheries in total, %	2.38	2.80	2.95	1.69	1.69
Share of forest reproduction areas to deforestation areas, %	15.16	15.13	16.36	15.44	11.56
Share of capital investments in environmental protection from agriculture in the volume of total capital investments, %	0.29	0.24	0.31	0.44	0.06
Share of current investments in environmental protection from agriculture in the volume of total capital investments, %	1.07	1.03	0.40	0.38	0.29

Source: formed on the basis of data from the State Statistics Service of Ukraine.

We presented the results of the calculations of the partial index of the development of the ecological situation in rural territories in Ukraine $I_{\text{rur}}^{\text{ecol}}$ in Table 6.

Table 6. Partial index of ecological situation development in rural territories in Ukraine, 2014 – 2018

Year	2014	2015	Increase to the previous year, %	2016	Increase to the previous year, %	2017	Increase to the previous year, %	2018	Increase to the previous year, %
$I_{\text{rur}}^{\text{ecol}}$	0.4162	0.4209	1.1132	0.4222	0.3089	0.4166	-1.3134	0.4053	-2.7150

Source: calculated by the authors.

The results of the calculations of the integrated index of sustainable development of rural areas (I_{rur}) are presented in Table 7.

Table 7. Integrated index of rural development in Ukraine, 2014 – 2018

Year	2014	2015	Increase to the previous year, %	2016	Increase to the previous year, %	2017	Increase to the previous year, %	2018	Increase to the previous year, %
I_{rur}	0.2727	0.2743	0.5868	0.2745	0.0972	0.2737	-0.3157	0.2706	-1.1206

Source: calculated by the authors.

The basis for making management decisions on the development and implementation of the guidelines for achieving strategic prospects for sustainable development of rural areas in Ukraine are the results of our modeling. The initial data for the correlation-regression analysis of the relationship between the integrated indicator of rural development I_{rur} and partial indices of social development $I_{\text{rur}}^{\text{soc}}$, economic $I_{\text{rur}}^{\text{econ}}$ and environmental $I_{\text{rur}}^{\text{ecol}}$ situation in rural areas are presented in Table 8.

Table 8. Initial data for the construction of a correlation-regression model of rural development in Ukraine, 2014 – 2018

Year	Integral index	Index of social sphere development	Index of economic situation development	Index of ecological situation development
	Y	X ₁	X ₂	X ₃
2014	0.2727	0.2817	0.1201	0.4162
2015	0.2743	0.2817	0.1202	0.4209
2016	0.2745	0.2812	0.1202	0.4222
2017	0.2737	0.2830	0.1214	0.4166
2018	0.2706	0.2855	0.1210	0.4053

Source: calculated by the authors.

The existence of a correlation between the features X₁ I_{rur}^{soc}, X₂ I_{rur}^{econ}, X₃ I_{rur}^{ecol} and Y I_{rur} is checked by the graphical method and the

method of analytical grouping, which is presented in Fig. 5, Fig. 6, Fig. 7.

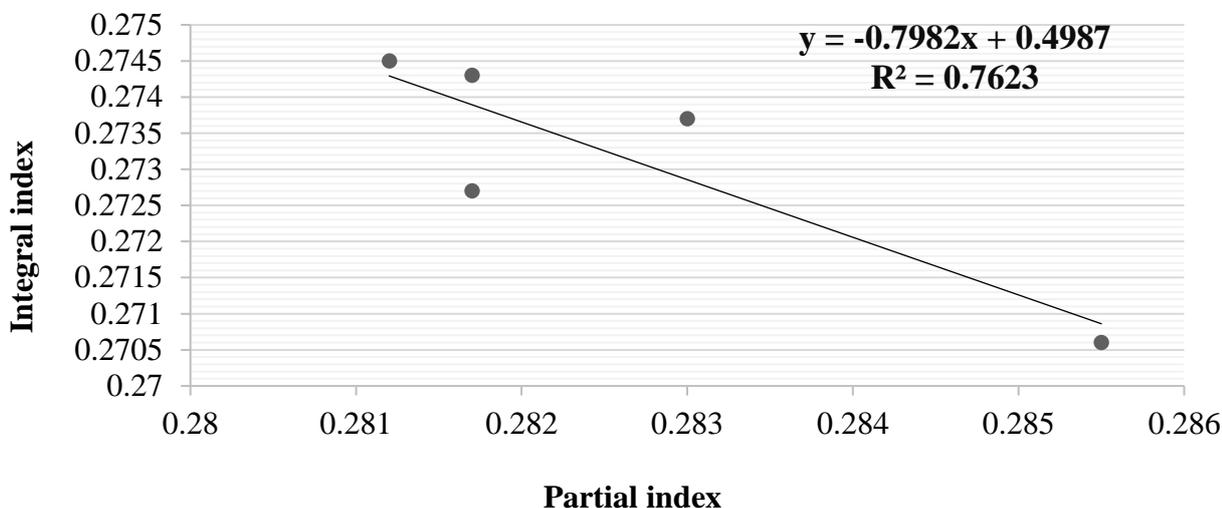


Fig. 5. Correlation field of dependence between the partial index of development of the social sphere and the integrated index of sustainable development of rural areas in Ukraine
 Source: built by the authors.

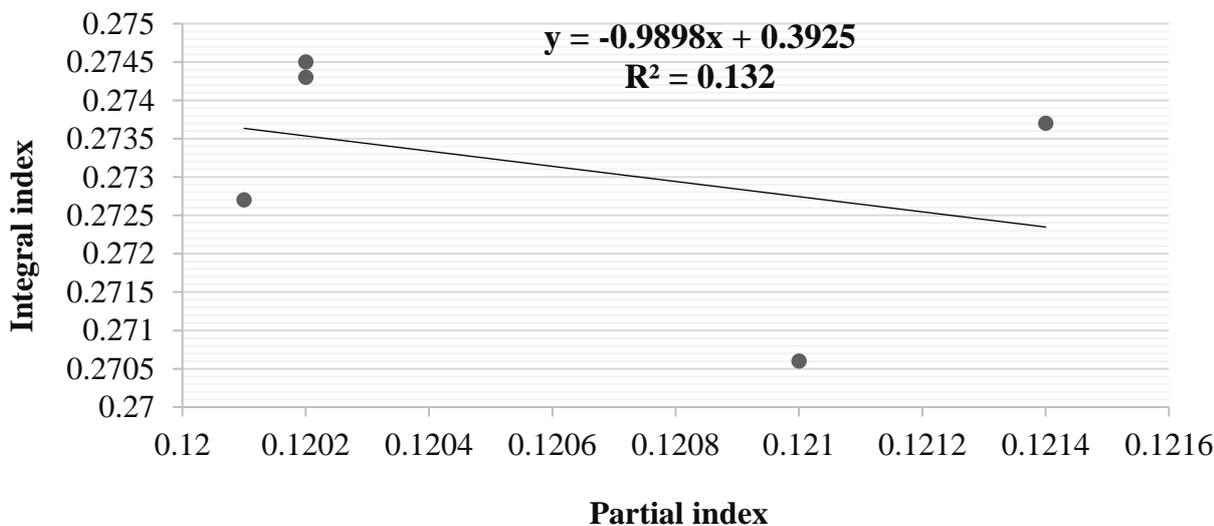


Fig.6. Correlation field of dependence between the partial index of economic situation development and the integrated index of sustainable development of rural areas in Ukraine
 Source: built by the authors.

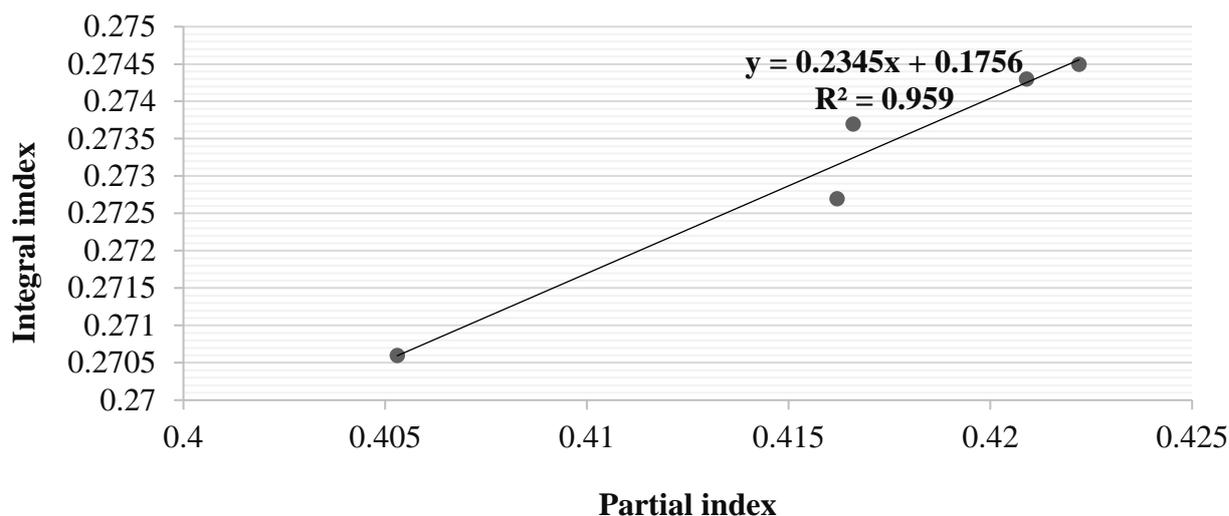


Fig. 7. Correlation field of dependence between the partial index of ecological situation development and the integrated index of sustainable development of rural areas in Ukraine
 Source: built by the authors.

We can see the highest level of dependence between the index of environmental development and the integrated index of sustainable development of rural territories.

In the case of the index of development of ecological situation, we can say about the direct nature of the relationship according to the location of points from the lower left to the upper right corner, and the inverse relationship in the case of the index of social and economic development. Thus, the determining factor for the sustainable development of rural areas is the development of the environmental sphere. That is, in the formation and development of economic potential and actions aimed at improving the social situation in rural areas, it is necessary to take into account what impact such actions

will have on the environmental situation. In addition, the issue of the existing impact of the economic sphere on the environmental situation is important. On the other hand, this trend is explained by the traditionally insignificant negative impact on the environmental situation as compared to cities, where industrial production is usually concentrated. In addition, the population density factor is important, which allows rural areas to be in closer contact with the natural environment.

Based on the constructed graphs, to determine the correlation between the features $X_1 I_{rur}^{soc}$, $X_2 I_{rur}^{econ}$, $X_3 I_{rur}^{ecol}$ and $Y I_{rur}$ we obtained the regression dependence equation for each partial and integral index in pairs (Table 9).

Table 9. Correlation relationship based on integrated analysis data

Contents of the relationship	Regression dependence	Components of equation
The impact of the social sphere on the sustainable development of rural areas	$y = -0.7982x + 0.4987$; $R^2 = 0.7623$	y – integral index of rural territories sustainable development (I_{rur}); x – index of social sphere development of rural territories (I_{rur}^{soc})
The impact of the economic situation on the sustainable development of rural areas	$y = -0.9898x + 0.3925$; $R^2 = 0.132$	y – integral index of rural territories sustainable development (I_{rur}); x – index of economic situation of rural territories (I_{rur}^{econ})
The impact of the environmental situation on the sustainable development of rural areas	$y = 0.2345x + 0.1756$; $R^2 = 0.959$	y – integral index of rural territories sustainable development (I_{rur}); x – index of ecological situation of rural territories (I_{rur}^{ecol})

Source: Built by the authors.

However, the analysis of data using the method of constructing correlation fields of dependence between factor features is a preliminary stage of modeling and demonstrates the relationship between only two features.

That is, the reliability of the obtained data can be considered to some extent only partial, but not erroneous. To obtain a more reliable picture and determine the level of interdependence between integral and partial indicators, we should build a multiple regression model.

A matrix of pairwise correlation coefficients has been constructed in order to detect the absence of the phenomenon of multicollinearity between traits (Table 10).

Table 12. Analysis of variance

Components of equation	Coefficient	Standard deviation	t-statistics	P-value	Lower 95%	Upper 95%	Lower 95%	Upper 95%
Y	0.007	0.021	0.3430	0.7896	-0.2653	0.2800	-0.2653	0.2800
X ₁	0.302	0.073	4.1401	0.1509	-0.6242	1.2276	-0.6242	1.2276
X ₂	0.369	0.080	4.6208	0.1357	-0.6451	1.3824	-0.6451	1.3824
X ₃	0.327	0.016	20.2615	0.0314	0.1219	0.5320	0.1219	0.5320

Source: built by the authors.

We built a multiple regression model of sustainable development of rural territories in Ukraine in 2018:

$$I_{\text{rur}} = 0.007 + 0.302I_{\text{rur}}^{\text{soc}} + 0.369I_{\text{rur}}^{\text{econ}} + 0.327I_{\text{rur}}^{\text{ecol}}$$

According to the model, it can be argued that the predominant impact of the economic situation on the process of ensuring sustainable development of rural areas is obvious. At the same time, the significant impact of the environmental situation and the least significant impact of the social sphere development is confirmed.

The validity of the proposed model was verified by constructing its graphical interpretation on the basis of the integrated index of sustainable development of rural areas calculated on its data (Fig. 8).

The coefficient of determination serves as a precaution as to how well the regression describes this system of observations. To

Table 10. Matrix of paired correlation coefficients

	Y	X ₁	X ₂	X ₃
Y	1	-0.8731	-0.3633	0.9793
X ₁	-0.8731	1	0.6996	0.9506
X ₂	-0.3633	0.6996	1	0.5343
X ₃	0.9793	-0.9506	-0.5343	1

Source: Built by the authors.

As we can see, all partial indices of the level of sustainable development of rural areas significantly affect the integrated index and there is no autocorrelation between them (Table 11 and Table 12).

Table 11. Regression statistics

Multiple R	0.9999
R-square	0.9997
Normalized R-square	0.9989
Standard error	0.0001
Observation	5

Source: built by the authors.

analyze the overall quality of the linear multifactor regression equation the multiple coefficient of determination R² is used. The coefficient of determination R² takes values in the range from zero to one: 0 ≤ R² ≤ 1. The larger R², the greater part of the variance of the performance trait (Y) is explained by the regression equation, and the better the regression equation describes the original data. In the absence of a relationship between (Y) and (X), the coefficient of determination R² will be close to zero.

According to the results of calculations it is obtained: R² = 0.9997.

This indicates that 99.9% of the model parameters explain the dependence and change of the resulting factor Y. The obtained result indicates high quality of the proposed model and the accuracy of the regression equation selection.

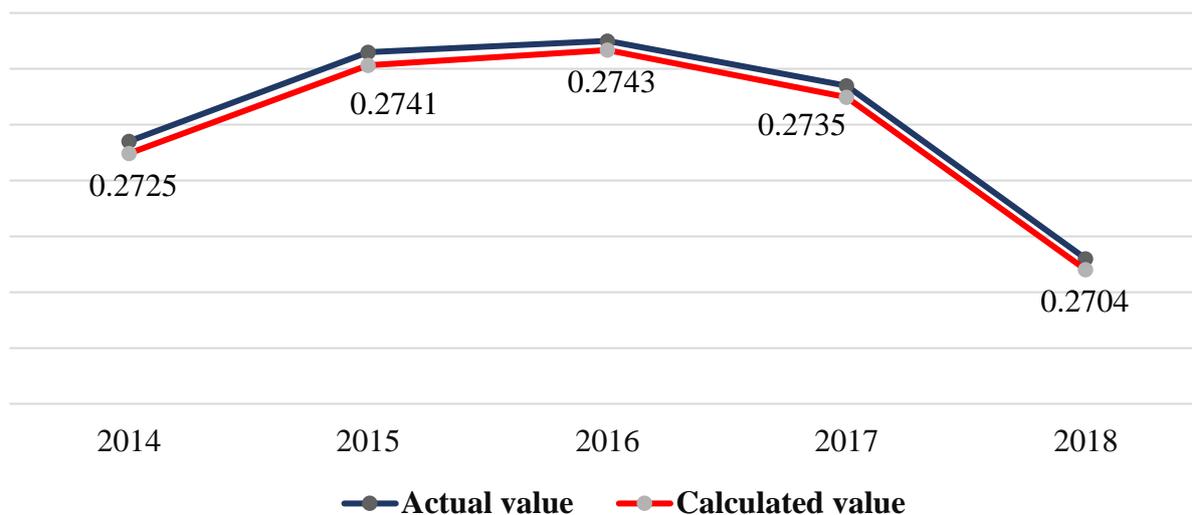


Fig. 8. Comparison of actual and calculated values of the integrated index of sustainable development of rural areas in Ukraine, 2014 – 2018

Source: built by the authors.

The significance of the regression equation was checked on the basis of the calculation of Fisher's F-test, which is used to assess the quality of the regression model as a whole, as well as its parameters.

According to the results of calculations for the proposed model $F_{table} = 590.85$, while F_{act} significantly exceeds its tabular value. Based on this, we can conclude about the statistical significance of the selected factors and the reliability of the constructed regression model. With the number of objects of analysis up to 30 units, it is necessary to check the significance of each regression coefficient. At the same time, they find out to what extent the calculated parameters are characteristic of the display of a set of conditions: whether the obtained values of the parameters are the results of random causes or not. The significance of the coefficients of simple linear regression (for sets in which $n < 30$) is determined using Student's t-test. The actual values of the t-test for the parameters of the equation are calculated.

The calculated values for the variable factors X_1 , X_2 , X_3 significantly exceed the one given in the table. On this basis, it can be stated that the relationship between variables and the results of the regression equation is not accidental.

CONCLUSIONS

The results of the analysis of rural territories development in the conditions of decentralization, obtained by us using economic and mathematical methods, show that the existing strategies of rural development in Ukraine are not effective enough. They do not take into account the full range of problems that are characteristic of the current state of rural development under the influence of local government reform. The problems which need to be addressed include the reduction of rural population and its ageing; external and internal labor migration; low incomes of rural residents; high unemployment rate; insufficient level of competitiveness of agricultural products; reduction of the efficiency of agricultural production; underdeveloped infrastructure; deterioration of the ecological situation in the countryside.

Decentralization is the process of bringing management decisions closer to the public, expanding the rights and powers of local governments. This facilitates the development and implementation of strategies, programs, rural development projects and the provision of services in accordance with the needs of the united territorial communities and the priorities of sustainable growth.

The advantages of decentralization in terms of its impact on rural development are:

- rational decision-making procedure for the development of the rural community;
- transparency of management decisions and quick response to problems to solve them;
- independence of the rural community in the formation of budget revenues and expenditures, based on the available financial and natural resources;
- the opportunity for each villager to participate in the discussion of current issues, which contributes to the formation of public consciousness;
- accessibility of rural residents to qualitative administrative, social and other services;
- promotion of regional development;
- transfer of the budgets of united communities to direct inter-budgetary relations with the State budget;
- transfer of the state-owned agricultural land plots to communal ownership of the united territorial communities;
- increase of tax payments receipts to the budgets of territorial communities;
- growing interest in the diversification of forms of management in the rural community;
- the possibility of receiving grants for rural development.

Analyzing the risks of decentralization that negatively affect or may affect rural development we can mention the following ones:

- strengthening the uneven development of rural areas, including local communities;
- increasing risks of making incorrect management decisions regarding the activities of the rural community due to inadequate qualifications of officials;
- promoting the strengthening of local nationalism and causing interethnic conflicts, especially in border regions;
- creation of too large territorial communities;
- the growth of corruption at the local level through the expansion of the powers of local governments;
- unwillingness of the richer, already established communities to associate with poorer territorial communities;
- loss of state control.

Thus, in the context of the implementation of modern decentralization reform, the main role in managing the sustainable development of

rural areas belongs to local authorities. They coordinate the activities of all economic structures, participate in the development and implementation of strategies, programs, projects, decide on their financing.

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