ATLANTIS PRESS

Advances in Economics, Business and Management Research, volume 105

1st International Scientific and Practical Conference on Digital Economy (ISCDE 2019)

Mathematical tools for assessing rural development by separate components

Demyanov D.G.
The Russian Presidential Academy of National Economy and Public Administration, Chelyabinsk branch,
Chelyabinsk, Russia
viola_1_49@mail.ru

Semin A.N.
Ural State Mining University
Yekaterinburg, Russia
aleks_ural_55@mail.ru

Nemykina Yu.S.
The Russian Presidential Academy of National Economy and Public Administration, Chelyabinsk branch,
Chelyabinsk,Russia
irina_vikt@rambler.ru

***Abstract* — The authors justify the main points of the theory and methodology of assessing the potential for sustainable developing rural areas on the basis of systematizing factors which affect the dynamics and structure of changes in their potential. The authors use modeling methods to determine the projected values of significant indicators of the Perm Kray rural territories.**

Keywords — rural territories, modeling, rural territories

I. INTRODUCTION

Digital agriculture is considered as a new area focused on developing agricultural production and rural areas through using digital technologies.

The main advantages of introducing digital agriculture are [1] possibility to exchange information and possibility for agricultural producers to have an access to it, formation of effective food markets by increasing information accessibility and transparency of markets; reduction of links in the intermediary chain; decreasing risks by reducing uncertainty in making managerial decisions, increasing readiness for climate changes, and natural disasters; increasing investments into innovative developments, digital infrastructure, and human capital.

Developing digital technologies in the agricultural sector makes it possible to reduce production losses (according to the Ministry of Agriculture of Russia, they make up about 40%), which is very important in the context of food shortages. The agri-food sector of the socio-economic system determines territorial identity, which requires substantiating the prospects for structural and digital transformation of this segment.

Digitalization of the economy is ensured by 2024 provided that a number of target indicators are achieved [2]:

a) as regards the digital economy system (operation of at least 10 leading companies competitive in world markets; operation of at least 10 industry digital platforms in the main subject areas of the economy; operation of at least 500 small and medium enterprises in the field of creating and using digital technologies and providing digital services);

b) as regards the education system and personnel potential (the number of graduates of higher educational institutions in the areas of training related to information and computer technologies is 120 thousand people per year; the number of graduates of higher and secondary vocational educational institutions with competencies in the field of information and computer technology - 800 thousand people per year; the proportion of citizens having skills to use digital technologies - 40%);

c) as regards the research and development system (the number of projects of at least 100 million rubles that are implemented in the field of digital economy is 30 units; the number of organizations implementing large projects of $ 3 million under international scientific and technical cooperation agreements in the field of economics digitalization - 10);

d) as regards the digital infrastructure (the proportion of households with broadband Internet access is 97%; stable coverage with 3G networks and more in all large cities);

e) as regards the information security (the share of business entities using standards for safe information interaction is 75%; the share of internal network traffic of the Russian Internet routed through foreign servers is 5%).

To harmoniously implement all possible areas of digitalization, it is necessary to create certain conditions: firstly, to create a regulatory framework adequate to the requirements of digital economy; secondly, to develop and implement a system of stimulators for using digital technologies at various levels of management; thirdly, to create a digital platform that will make it possible to concentrate the resources necessary for digitalization, as well as systematize and harmonize the activities of a particular sector and the territorial economic system as a whole.

Creating a digital platform of the agro-industrial complex involves increasing the efficiency of organizing and

managing agricultural production as a result of the large-scale introduction of digital technologies (creating and developing infrastructural, organizational, financial and other conditions).

Digital economy is represented by three levels: 1) markets and sectors of the economy (suppliers and consumers of goods, works, services); 2) platforms and technologies (the formation of competencies for developing digital economy); 3) the environment necessary for implementing these two requirements.

The digital platform will make it possible for all its participants, namely, authorities, business, scientific and educational institutions, etc., to adapt their activities to the requirements of the present-day context and quickly make effective management decisions in the interests of the region development [3].

II. RESEARCH METHODOLOGY

Analyzing domestic and foreign studies on the problem of rural development management makes it possible to talk about the necessity for in-depth development and justification of a methodological approach to forecasting indicators of territorial development, to developing and using the principles of the scenario method for implementing the mathematical approach to determining prospective vectors of socio-economic territorial development [4].

The aim of the study is to develop scientific and methodological recommendations how to form and use a system of assessment indicators for sustainable development of rural areas.

In accordance with the tasks to be solved, the authors use a set of methods and techniques of organizing and conducting economic research: monographic, computational-constructive, economic-statistical, comparative analysis, and abstract-logical methods.

The scientific novelty of the study consists in working out proposals to form and improve the system of target indicators for assessing programs to develop agricultural sector and rural areas.

In order to build a model for assessing the level of rural territories development, in addition to the interrelating factors of socio-economic development, vectors and conditions for ensuring the territory economic growth should be determined.

The methodology for assessing the organizational and economic potential of rural development is determined by a structurally oriented approach to justifying and selecting development alternatives.

A systemic analysis of determining the main factors, which affect changes in the development potential of rural territories, establishes the most characteristic technical and economic interconnections not only for monitoring the factors influence on changes in the resulting indicators of rural territories, but also for developing forms, methods and tools of current and future management of rural territories [5].

The functional model of socio-economic development, focused on improving the life quality and livelihoods of the population, involves operational accounting, assessing, analyzing the rural areas development, and adopting reasoned management decisions.

The problem-oriented analysis of rural territories development makes it possible to determine a set of measures aimed at forming, distributing and effective implementation of the resource potential of rural territories; interactions of institutional environment elements; forming and effective functioning of social and industrial infrastructure objects; developing all types and forms of organizing and managing the territory, and the life quality of the population [5].

Forecasting the development of production and social infrastructure of rural areas makes it possible to objectively choose the optimal scenario for changing organizational and economic potential of rural areas on the basis of implementing indicative planning and forecasting tools [5].

Digital economy places specific requirements on the quality of using all factors of production. Obtaining only positive results from implementing state programs in the agribusiness of Russia's territories seems insufficient because it does not take into account the organizational and managerial component of the agro-industrial complex potential [6].

A great number of recent publications indicate the necessity to use tools for forecasting the economy development in combination with economic regulation (using the main traditional economic categories) and on this basis to change priorities and goals to develop the territories, to change the paradigm of the economy.

III. RESEARCH RESULTS

Forming a system of evaluating indicators for sustainable development of rural areas required the following areas of development assessment - production activities, social development, social infrastructure and finance.

The following indicators are used for the area of production - production output in accordance with branches of production (livestock agriculture and crop production, as well as total production), production costs against sectors of agriculture, profit from agricultural production, against sectors and in general.

To determine the social development of the Perm Kray, the following criteria were used: the number of the rural population, the average wage of rural workers, and the productivity of workers in municipal areas.

The following indicators were used to determine the life quality in the village of the Perm Kray: the number of non-gasified settlements, the number of rural settlements equipped with a telephone, the number of gas stations, the total length of streets, travel directions, embankments, the number of educational institutions, and the number of rural settlements served by postal service.

The following criteria were established for the "finance" area: profitability of agricultural products in general, profitability of livestock agriculture and crop production in particular, investments made by organizations located in the territory of the municipal district and at the expense of the municipal formation budget.

The proposed indicators of rural development directions are aggregated into an indicator of a multicomponent assessment of rural territories development and represent the conceptual content of this indicator.

There are several stages of implementing the methodology of multicomponent assessment of the development of rural territories and the agricultural sector.

The first stage is preparatory [7], it consists in forming a system of indicators, quantitative assessment of factors, the whole of rural territorial entities functions.

In general, in the economy of sustainable development, the following assessment work is necessary [8]:

- systemic socio-ecological-economic assessments of resources, potential, social security;
- systemic assessments of natural resources limits and their potential;
- assessment of the natural and production potential of the territories.

Each individual indicator or several selected indicators characterize a certain group of factors for assessing the development of rural territories and the agricultural sector. The process of data accumulation is carried out as part of the first stage. The choice of indicators is influenced by their statistical accessibility.

The second stage is a set of measures aimed at bringing indicators measured in different units to dimensionless correlation. We calculate them in percentage terms in relation to the total amount of indicators throughout the entire calculation period and multiply this value by 10 raised to the 5th power, for the convenience of calculations (1).

$$y_i = \frac{x_i}{\sum_1^n x_i} 10^5, \quad (1)$$

where, y_(i)is the total of the table value

x_i is the actual value of the indicator

n is the number of years, the period which covers the statistics on the estimated indicator

Next, we establish the type of approximated functions in terms of multicomponent estimates. This will make it possible to get ranking of territories according to their development perspectives. Approximation is carried out for all municipal areas.

At the third stage of implementing proposed methodology, aggregating of indicators reduced to dimensionless correlations and forming composite indices are carried out, which are the arithmetic mean value of the indices calculated at the second stage of the proposed methodology.

The composite indices characterize various components of rural territories sustainable development as a whole, adequate to their functions (social development, social infrastructure, finance, and also production). Consolidated indices make it possible to analytically assess the implementation of the four main functions of the organizing activities within the agricultural territories of the Perm Kray as a whole.

At the fourth stage, we approximate the indicators values of the third stage using the least squares method. On the basis of this method, we obtain two approximating functions (quadratic (2) and linear (3)) of the indicator “Estimating population until January 1 of the current year” from the area determining the social development of the Perm Kray.

$$y=13,6014x^2-54\,779,2518x+55\,164\,428,417, \quad (2)$$

$$y=4,5134127x-0,0000066, \quad (3)$$

where x is the year, y is the calculated indicator.

The functions (2) and (3) provide an opportunity to predict the values of rural development indicators in the future and to compile a list of necessary measures to support sustainable rural growth in the Perm Kray as a whole.

At the next stage, the errors of approximating functions are calculated. The error values made it possible to determine which of the functions shows changes in the indicator relative to the sample data more accurately.

The total approximation error for the quadratic function was 0.0360, and for the linear function it was 0.0507. Consequently, the quadratic function describes changes in indicators of the indicators system to assess rural territories sustainable development most objectively.

On the basis of the obtained data, it can be concluded that the prospective value of the indicator "Estimating population until January 1 of the current year" in 2020 will decrease by 3.1583% with an accuracy of 3.6%.

At the fifth stage, the authors range multicomponent indicators for assessing the rural territories and agriculture according to the years within the analyzed period, calculate the corresponding composite indices relative to the data obtained during the previous analysis. As a result, four development sectors of the Perm Kray in municipal districts were obtained.

At the sixth stage, the authors generalize the results of the various factors influence on the rural territories development; make the analysis of the various factors influence on the rural areas development on the basis of the quantitative values of indicators.

It was established that the factors (social, demographic, production) described by indices with low quantitative values show their negative impact on rural development, which requires working out and implementing measures aimed at correcting the current situation (in the format of a program-targeted approach). To clarify management decisions, the authors use the expert assessments methodology.

A multicomponent indicator of rural development, calculated by the proposed methodology, can be determined in terms of qualitative indicators (gross agricultural output; level of profitability of products sold by agricultural organizations of the Perm Kray, level of labor costs, which, according to the authors, most fully characterize the state and development agricultural sector, and rural areas.

Similarly, on the basis of the least squares method, calculations were carried out for all indicators of the system of assessment indicators for rural territories sustainable development. As a result, the following forecasting values of the indicators were obtained:

1. Area "Social development".

1) The indicator “Estimating population until January 1 of the current year”.

The approximating function $y = 13.6014x^2-54779.2518x + 55\,164\,428.4166$.

The growth rate in 2020 is -1.9880.

The calculation error is 3.6%.

2) Indicator "Average monthly salary of agricultural workers."

The approximating function $y = 19.2045x^2$-76355.1288x + 75 892 166.0483.

The growth rate in 2020 is 5.2209.

The calculation error is 6.46%.

3) The indicator "Labor productivity of rural workers."

The approximating function $y = -65x^2$+262799,0009x - 265606014.9522.

The growth rate in 2020 is 1.2260.

The calculation error is 3.17%.

2. Area "Social infrastructure".

1) The indicator “Number of non-gasified settlements”.

The approximating function y= 4.1403538x + 0.0000189.

The growth rate in 2020 is 0.8368.

The calculation error is 1.19%.

2) The indicator "The number of rural areas equipped with telephones."

The approximating function $y=-92.1429x^2$+ 371365.0013x-374159497, 056.

The growth rate in 2020 is -4.2630.

The calculation error is 1.32%.

3) The indicator “Number of gas stations”.

The approximating function $y = 56.25x^2$ -226 872.036x + 228 776 075.1206.

The growth rate in 2020 is 1.2133.

The calculation error is 1.63%.

4) The indicator “The total length of streets, driveways, embankments”.

The approximating function $y=20.9715x^2$-84488.7587x + 85103742,426.

The growth rate in 2020 is 1, 5003.

The calculation error is 8.43%.

5) The indicator "The number of educational institutions."

The approximating function $y=55.7093x^2$-224446.4485x + 226074542.9188.

The growth rate in 2020 is 14.6546.

The calculation error is 2,886%.

6) The indicator “The number of rural settlements served by postal service”.

The approximating function $y=-174.2857x^2$+ 702980.0025x-708845573.97.

The growth rate in 2020 is 14.6546.

The calculation error is 2,886%.

3. Area "Production activities".

1) The indicator "The volume of production according to branches of production (livestock agriculture and crop production, as well as the total volume of production)."

The approximating function $y=-64.8485x^2$+ 261355.9395x-263321795.935.

The growth rate in 2020 is -2.5504.

The calculation error is 3.189%.

2) The indicator "Costs of production according to the sectors of agriculture."

The approximating function $y=-1135x^2$+ 4573263.0164x-4606745392.5153.

The growth rate in 2020 is 14.8039.

The calculation error is 3.026%.

3) The indicator "Profit from agricultural production, according to industries and in general."

The approximating function $y=-434.39x^2$+ 1749670.878x-1761836530,453.

The growth rate in 2020 is -16.0177.

The calculation error is 8.33%.

3. Area "Finance".

1) The indicator "Profitability of agricultural products in general (livestock agriculture, crop production)."

The approximating function $y=-1375.714x^2$+ 5544030.02x-5585486708.59.

The growth rate in 2020 is -10.6118.

The calculation error is 3.503%.

2) The indicator "Investments made by organizations located in the territory of the municipal district".

The approximating function $y=-25.3602x^2$+ 102333.0281x-103219990, 517.

The growth rate in 2020 is 0.0229.

The calculation error is 6.61%.

3) The indicator "Investments made at the expense of the municipality budget»

The approximating function $y=-58.5465x^2$+ 235544.6104x-236902770,307.

The growth rate in 2020 is -28.5682.

The calculation error is 4.616%.

The results create the necessary basis for ranking all municipal areas of the Perm Kray. The authors establish the ranking criteria. Provided that the value of the forecasting indicator for a specific municipal district is greater or equal to the average value of the indicator for the Perm Kray as a whole, then the forecast is considered above average. If the condition is not met then the forecasting indicator for a specific municipal district will be below average.

Application of this criterion makes it possible to obtain a set of indicators characterizing positively developing municipal areas and indicators of municipal areas

development, the forecast of which is below average. If the number of positively developing municipal areas is 75% of the total, then the region falls into the sector of maximum development. If the number of positively developing municipal regions falls in the range from 74% to 50%, then the district will fall into the optimal development sector. If the number of indicators whose values are above average falls into the range from 50% to 25%, then the district will be in the zone of a sector of absolutely low development. For the remaining territories we will consider the index of minimal development.

IV. DISCUSSION OF THE RESULTS

Factors (social, demographic, industrial), described by indices with low quantitative values, show their negative impact on rural development, which requires working out development programs aimed at correcting the current situation. To clarify management decisions, it is recommended to use the expert evaluations methodology. A multicomponent indicator of rural development, calculated according to the proposed methodology, is gradually determined in terms of qualitative indicators, which, according to the authors, most fully characterize the state and development of the agricultural sector and rural areas.

V. CONCLUSIONS

On the basis of studying and analyzing theoretical and methodological aspects and the practice of organizing and managing the rural territories development with the application of mathematical apparatus and tools, the authors determine measures of influence aimed at maintaining the incomes of the agro-industrial complex and territories, stimulating economic activity, and diversifying the economic mechanism of managing.

The study identified the factors that determine the necessity for sustainable development programs in rural areas (national, technological, commercial factors).

An economic assessment of the level of rural territories development makes it possible to single out the main shortcomings of the existing mechanisms for forming and implementing organizational and economic potential, the lack of state support for agricultural production, additional risks of threats to the agricultural economy development.

Determining the development trends of the agro-industrial complex and rural territories objectively requires developing an algorithm to form a mechanism for managing the sustainable development of the territory, developing a number of legal and scientific-methodological approaches to the organizational and economic mechanism of interaction at the state, economic and local levels of government.

Studying and scientific substantiating the main directions of the forecasting development of the agro-industrial complex and rural territories ensures control, audit, controlling, achievement of strategic macroeconomic tasks taking into account the dynamics of processes in space, as well as the nature and dynamics of development trends of the agro-industrial complex and rural territories.

The project of forecasting socio-economic development of rural areas justifies the directions and principles of forming of a single policy of spatial development.

References

[1] Korchagin S., Polshikov B. Digital economy and transforming public administration mechanisms: risks and prospects for Russia / S. Korchagin, B. Polshikov // Svobodnaya Mysl. - 2018. -- No. 1 (1667). - pp. 23-36.

[2] Decree of the Russian Federation Government of July 28, 2017 № 1632 “On approving the program “Digital economy of the Russian Federation ”.

[3] Izmalkova S.A., Sabinina A.L. Managing the regional economy in the context of its digital transformation / S.A. Izmalkova, A.L. Sabinina // Collection of articles of the International scientific-practical conference. Publishing House of the Federal State Budgetary Educational Establishment of Higher Education “Bryansk State Engineering and Technology University”, 2018. - pp. 191-194.

[4] Velichenko E.A. Improving the tools of indicative planning and forecasting the regions socio-economic development: abstract of the thesis for a Candidate Degree in Economics: defended on 05/30/2018 / E.A. Velichenko. - Makhachkala: Publishing House of FSBEI of HE "Dagestan State Technical University", 2018. - 24 p.

[5] Khilinskaya I.V. Organizational and economic potential of rural development: abstract of the thesis for a Candidate Degree in Economics: defended on October 4, 2018 / I.V. Hilinskaya. - Yekaterinburg: Printing house “Photokhudozhnik”, 2018. - 24 p.

[6] Lovchikova E.I., Pervykh N.A., Solodovnik A.I. Digital economy and personnel potential of agro-industrial complex: strategic relationship and prospects / E.I. Lovchikova, N.A. First, A.I. Malt // Bulletin of Agrarian Science. - 2017. - No. 5 (68). - pp. 107-112

[7] Dykan Yu.A. Priority directions of sustainable development of rural territories: abstract of the thesis for a Candidate Degree in Economics: defended on July 4, 2019 / Yu.A. Dykan. - Voronezh: Voronezh State Agrarian University, 2019 .-- 24 p.

[8] Belov V.V., Lebedev Yu.V., Lebedeva T.A. Strategic priorities and indicators of environmentally sustainable subsoil use / V.V. Belov, Yu.V. Lebedev, T.A. Lebedeva // Bulletin of the Samara Scientific Center of the Russian Academy of Sciences Publishing House of the Samara Scientific Center of the Russian Academy of Sciences (Samara). - 2015. - No. 5. - T. 17. - pp. 251-255.

[9] Chernova S.G. Forming and developing state-indicative agricultural management in the region in market economy environment: abstract of the thesis for a Doctor Degree in Economics: defended on June 28, 2018 / S.G. Chernova. - Novosibirsk, 2018 .-- 59 p.

[10] S.Y. Davydov, A.N. Semin, N.G. Valiev, A.V. Gorbunov, and L.N. Oleinikova, “Energy conservation technologies in the use of a power-driven covering apparatus in industry. refractories and industrial ceramics,” springer New York consultants bureau, № 5, pp. 461- 464, 2016.