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**VECTOR GUIDELINES FOR ADAPTIVE DEVELOPMENT  
OF AGRICULTURAL ENTERPRISES IN RURAL AREAS  
IN THE CONTEXT OF ACTIVATING INNOVATION PROCESSES**

*The study is based on the importance of adaptive development of rural areas, in terms of determining the impact on the overall socio-economic development of our state, given that the rural population of Ukraine makes up a third of the existing one, and agricultural lands – 70% of its land fund. The need to manage the multifunctional agrarian economy of rural areas that have rich resource potential is substantiated, providing for its rational use in order to ensure sustainable multi-sectoral development of production, full employment of the rural population and high quality of life. The potential for adaptive development is determined, which contributes to the implementation of a number of the most important national functions: production, demographic, resource, labor, socio-cultural, environmental, recreational and agro-recreational, residential, spatial and communication, social control in terms of the restoration of rural areas in the context of the activation of innovation processes. Key indicators of adaptive development of agricultural enterprises in rural areas have been formed, based on the results of the analysis, a toolkit for activating innovative development of rural areas is provided using the example of the Vinnytsia region in accordance with the concept of rural development. The vector guidelines for adaptive development of agricultural enterprises given in this study can serve as the basis for the development of rural areas, will contribute to the implementation of entrepreneurial initiatives, and the formation of a multi-structured rural economy. It is noted that the mono-sectoral nature of adaptive development of rural areas leads to unsystematic and disproportional use of local development potential, deformation of the qualification structure of supply in the labor market, and modernization of agricultural production.*

**Keywords:** *adaptive development; agricultural enterprises; innovations; investment processes; resources; rural areas; sustainable development.*

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**ВЕКТОРНІ ОРІЄНТИРИ АДАПТИВНОГО РОЗВИТКУ  
АГРАРНИХ ПІДПРИЄМСТВ СІЛЬСЬКИХ ТЕРИТОРІЙ У КОНТЕКСТІ  
АКТИВІЗАЦІЇ ІННОВАЦІЙНИХ ПРОЦЕСІВ**

*Дослідження ґрунтується на важливості адаптивного розвитку сільських територій, в частині визначення впливу на загальний соціально-економічний розвиток нашої держави, зважаючи що сільське населення України складає третину від наявного, а сільськогосподарські угіддя – 70% її земельного фонду. Обґрунтовано необхідність управління поліфункціональною аграрною економікою сільських територій, що володіють багатим ресурсним потенціалом, передбачаючи його раціональне використання з метою забезпечення стійкого багатогалузевого розвитку виробництва, повної зайнятості сільського населення і високої якості життя. Визначено потенціал до адаптивного розвитку, який сприяє виконанню цілої низки найважливіших загальнонаціональних функцій: виробничої, демографічної, ресурсної, трудової, соціально-культурної, природоохоронної, рекреаційної та агрорекреаційної, житлової, просторово-комунікаційної, соціального*

контролю в частині відновлення сільських територій у контексті активізації інноваційних процесів. Сформовано ключові індикатори адаптивного розвитку аграрних підприємств сільських територій, за результатами аналізування наведено інструментарій активізації інноваційного розвитку сільських територій на прикладі Вінницького регіону у відповідності до концепції розвитку сільських територій. Векторні орієнтири адаптивного розвитку аграрних підприємств наведені в даному дослідженні можуть слугувати основою для дорожньої розвитку сільських територій, сприятимуть втіленню підприємницьких ініціатив, формуванню багатокладності сільської економіки. Зазначено, що моносекторальний характер адаптивного розвитку сільських територій призводить до несистемності та диспропорційності використання місцевого потенціалу розвитку, деформації кваліфікаційної структури пропозиції на ринку праці, модернізації агропромисловості.

**Ключові слова:** адаптивний розвиток; аграрні підприємства; інновації; інвестиційні процеси; ресурси; сільські території; сталий розвиток.

**Problem statement.** The study of innovation processes of agricultural enterprises of the Vinnytsia region with the definition of strategic guidelines for the development of investigated enterprises in rural areas in the context of the activation of innovation processes is relevant in the conditions of post-war reconstruction of the state.

**Undetermined parts of the problem.** It is advisable to conduct research using economic and mathematical methods and models to understand the innovative, economic and financial state of business entities from a mathematical and statistical perspective. Using linear and nonlinear multiple production regressions, we will conduct further research, analysis, comparison, modeling and forecasting of strategic guidelines of innovation potential based on the activities of real enterprises and in real time, namely the impact of the main factors of diversification of innovation processes on the level of profitability of leading agricultural enterprises of the Vinnytsia region.

**Analysis of literary sources of the study.** Taking into account the analysis of scientific sources [1, 7–13], rural areas are understood as administrative-territorial formations (localities) outside cities, which include the territories of rural settlements and inter-village territories (localities located outside rural settlements, villages, settlements, farms, etc.) with a predominant share of rural population.

Ensuring the country's food security is directly related to the adaptive development of rural areas. A system-forming role in the development of rural areas in terms of the implementation of their functions and tasks, the main of which is the task of achieving food independence of the country, as well as in terms of solving a number of problems of the development of domestic rural areas, in addition to state bodies and the rural population, is played by agricultural enterprises of rural areas. Without the normal functioning of agricultural enterprises of various organizational and legal forms of ownership, which provide employment to rural residents, create jobs, and which support and largely finance the development of rural communities through budget revenues, local taxes, and various rural assistance funds, as well as which, in fact, create and supply agricultural products, equipment, and provide various agricultural services to the market, it is impossible to even imagine the adaptive development of rural areas.

**The purpose research** is to study the adaptive development of investigated enterprises in rural areas.

**Presentation of the main research** To study the strategic guidelines of agricultural enterprises, we choose the well-known multiple linear production function, as well as:

- exponential:

$$\hat{Y} = e^{a+b_1x_1+b_2x_2}; \quad (1)$$

- semi-logarithmic function:

$$\hat{Y} = a_0 + a_1 \ln x_1 + a_2 \ln x_2 + \dots + a_p \ln x_p + U, \quad (2)$$

where  $a_0, a_1, \dots, a_p$  are the parameters of the functions.

As previously noted, all nonlinear functions are intrinsically linear, meaning they can be transformed into linear form. The estimation of the parameters of intrinsically linear functions is carried out by applying the Least Squares (LS) method to the linearized form of the nonlinear function.

Linearization consists of the following transformations:

- exponential:

$$\hat{Y} = e^{a+b_1x_1+b_2x_2} \quad (3)$$

after linearization by introducing additional variables  $Z$ :  $Z_1 = EXP(x_1)$ ;  $Z_2 = EXP(x_2)$  and  $Z_n = EXP(x_n)$  and using the built-in statistical function EXP of Microsoft Excel spreadsheets, it looks like:

$$\hat{Y} = a_0 + a_1 Z_1 + a_2 Z_2 + \dots + a_n Z_n; \quad (4)$$

- semi-logarithmic function (5) after linearization by logarithmization takes the form:

$$\ln \hat{Y} = \ln a_0 + a_1 \ln x_1 + a_2 \ln x_2 + \dots + a_p \ln x_p + U. \quad (5)$$

When introducing new variables for logarithmizing quantities:

$$\ln \hat{Y} = \hat{Y}; \ln a_0 = a_0; \ln a_1 = a_1; \ln x_1 = x_1; \ln a_2 = a_2; \ln x_2 = x_2; \ln x_p = x_p;$$

as a result of transformations and reduction of the multiple nonlinear semi-logarithmic production function to a multiple linear function, we obtain the expression:

$$\hat{Y} = a_0 + a_1 X_1 + a_2 X_2 + \dots + a_n X_n. \quad (6)$$

In the further calculation, econometric analysis of nonlinear functions: estimation of parameters and their significance, importance of the function as a whole, forecasting, calculation of indicators of closeness of connection is carried out using linearized regression forms.

The choice of the analytical form of the model study can be carried out on the basis of a priori information about the dependence of factor characteristics and the effective indicator [1].

We take into account the end-to-end research, study, modeling and forecasting of innovation processes of selected agricultural enterprises, we choose as factor characteristics: the integral indicator of the implementation of innovative potential, the production concentration index and the Herfindahl-Hirschman index. The effective indicator in the study is the level of profitability of selected business entities, as a guideline for the strategic development and functioning of agricultural enterprises. The dynamics of the level of profitability of agricultural enterprises of Vinnytsia region is demonstrated in Table 1.

Table 2 presents, based on financial statements, the main indicators of production activity and strategic management of agricultural enterprises in Vinnytsia region.

Analytical characterization is carried out in several stages: presentation of the dynamics of the main factors and the performance indicator, formulation of a mathematical model, analytical characterization and comparison of the obtained results, forecasting for the next period and data visualization.

Table 1

**Profitability level of agricultural enterprises in Vinnytsia region, 2020–2024**

Agricultural enterprise	Years					On average for 2020–2024
	2020	2021	2022	2023	2024	
Archi LLC	35,14%	31,58%	28,21%	23,46%	25,63%	28,80%
Lypivka-Agro LLC	19,05%	16,28%	13,64%	8,70%	12,36%	14,00%
Agro-Etalon LLC	20,48%	18,91%	13,51%	21,80%	21,51%	19,24%
Olgopil AF LLC	18,76%	18,62%	18,48%	22,85%	24,07%	20,56%
Dashkivtsi PJSC	24,38%	23,30%	23,15%	22,70%	23,92%	23,49%
Peredovik LLC	30,04%	29,87%	28,53%	28,37%	30,21%	29,40%

Source: based on [2–8].

Table 2

**Key indicators of production activity and strategic management  
of agricultural enterprises of Vinnytsia region, 2020–2024**

Agricultural enterprise	Net income from the sale of products of agricultural enterprises of Vinnytsia region, 2020–2024, thousand UAH	Cost of production, 2020–2024, thousand UAH	Profitability level, 2020– 2024, %
	7927,40	6172,98	28,80%
Archi LLC	4701,33	4130,67	14,00%
Lypivka-Agro LLC	5271,93	4422,06	19,24%
Agro-Etalon LLC	4133,33	3428,66	20,56%
Olgopil AF LLC	4121,33	3337,43	23,49%
Dashkivtsi PJSC	3590,67	2775,04	29,40%
Peredovik LLC			

Source: based on [2–8].

For further calculation and reduction of production models to a mathematical form, we denote the factors and the indicator as variables (Table 3).

Table 3

**Denoting factors and indicators as variables for formulating linear  
and nonlinear multiple production regression models**

X <sub>0</sub>	– dummy factor (must be used when calculating regression)
X <sub>1</sub>	– integral indicator of innovation potential realization
X <sub>2</sub>	– production concentration index
X <sub>3</sub>	– Herfindahl-Hirschman index
Y	– profitability level, %

Source: author's development based on [1].

Further calculations are carried out using Microsoft Excel spreadsheets, built-in statistical, mathematical functions, arrays, namely CORREL; MDETERM, MINVERSE, CHIINV, TRANSPOSE, MMULT, FINV and LINEST using linear multiple regression and nonlinear multiple regressions: exponential and semi-logarithmic, the characteristics and description of which were presented above. According to the methodology, we linearize nonlinear production functions, as previously described, by introducing additional variables and reducing nonlinear regressions to the form of linear ones for further calculation.

We calculate pair correlation coefficients. Pair correlation coefficients indicate the influence of individual factors on the indicator *Y*, that is, the level of profitability. As for pair correlation coefficients, it is known that the obtained dependencies are evaluated by the level of indicators of the closeness of the connection. If their absolute value is less than 0.3 – the connection is weak;

when it is within 0.3–0.7 – average, if 0.7 – close and when the absolute value is 1 – this indicates a practical-functional connection.

Characterizing the pair correlation coefficients, it should be noted that they are different and indicate the averaged effect of each research factor on the effective indicator – the level of profitability of selected agricultural formations.

Also, in the models of multiple production functions, partial correlation coefficients are determined, which, like even ones, characterize the relationship between variables. But unlike even ones, partial coefficients characterize the closeness of the relationship, provided that other independent variables remain constant.

Next, we calculate the transposed matrix, the product of matrices, and the coefficients of the equations of multiple production functions to determine the theoretical and forecast values of the effective strategic indicator of the studied agricultural enterprises – the level of profitability.

As a result of the calculations, multiple linear and nonlinear production regressions were obtained. The parameters of the equations were calculated by the method of least squares. Each coefficient of the equation indicates the degree of influence of the corresponding factor on the effective indicator with a fixed position of the remaining factors, that is, how the effective indicator changes with a change in a single factor by one unit. The free term of the multiple regression equation has no economic meaning. If we analyze the coefficients of the equations, then when the factor characteristics of innovation processes fluctuate, the effective strategic indicator will also fluctuate, which may indicate dynamic processes in the activities of business entities.

We determine the general coefficient of determination, which indicates the close relationship between the studied factors and the indicator and the variation of the indicator. It is quite high and indicates that the factor characteristics introduced into the production models significantly affect the result of production activity – the level of profitability by an average of 97.60%. The models are qualitative.

In order to determine the quality of the calculated models, it is necessary to conduct an analysis of Fisher's F-criterion. If the calculated value of Fisher's F-criterion is greater than its tabular value, then multiple linear and nonlinear econometric models with a reliability of  $P=0.95$  can be considered adequate to the experimental data and on the basis of the adopted models, economic analysis and forecasting of the effective indicator of the level of profitability of selected business entities can be carried out.

To optimize, rationalize research, study, analysis, modeling and forecasting of economic processes, statistical parameters and coefficients of production linear and nonlinear regressions at enterprises, it is proposed to use the built-in statistical function LINEST and the Data Analysis Regression tool, which is an add-in for Microsoft Excel spreadsheets, which significantly simplifies the data processing process.

The use of these tools, in particular the built-in statistical function LINEST and the Data Analysis Regression add-in of Microsoft Excel spreadsheets for automation, comparison, identity, optimization of processing and analysis of the impact of the main factors on the effective strategic indicator of the production activity of business entities of different levels is an alternative optimal solution in economic and mathematical modeling and management decision-making.

Forecasting of the main factor characteristics of innovation processes, these forecast values of the innovative activity of selected agricultural enterprises are used to determine the effective strategic indicator – the level of profitability using selected multiple linear and nonlinear functions [1–9].

We compare the results obtained and select the best function for practical use in real conditions of the business entity.

According to the results of processing, the highest level of profitability of LLC "Peredovik" was obtained at 31.57% using semi-logarithmic multiple nonlinear regression. For other selected

business entities, the most acceptable for the implementation of strategic processes of innovation activity is multiple linear regression and exponential multiple nonlinear regression. At the end of this block of studying the strategic innovation processes of selected agrarian formations of Vinnytsia region, we form a top three enterprise leaders by the forecast level of marketability and level of profitability based on the calculations, which in further studies will allow us to equate the obtained indicators to regional and state performance results (Table 4).

Table 4

**Top three leading enterprises of Vinnytsia region by forecasted level of marketability and level of profitability, 2026**

Agricultural enterprise	1 place		2nd place		3rd place	
	Marketability level, %, 2026	Profitability level, %, 2026	Marketability level, %, 2026	Profitability level, %, 2026	Marketability level, %, 2026	Profitability level, %, 2026
Archi LLC			91,80%			26,26%
Agro-Etalon LLC					90,10%	
Olgopil AF LLC				26,36%		
Peredovik LLC	92,97%	31,57%				

Source: based on [2–9].

**Conclusions and prospects of research** on the use of economic and mathematical methods and models, in particular linear and nonlinear production regressions, in modeling innovation processes and determining strategic guidelines for the development and functioning of agricultural enterprises in rural areas gives a positive result in the complex of possible combinations of resource use for a more technologically and economically efficient production process in the short and long term.

In the Concept of Rural Development until 2030, the main priority is the orientation towards sustainable development of rural areas, as well as the delineation of strategic directions of such development, which include, in particular, innovative support, diversification of the rural economy, the creation of a developed settlement network in rural areas, cooperation, the development of rural small businesses, agrotourism, etc. An important legal development in this document is not only the indication of the goal, objectives and directions of development of rural areas, but also the determination of indicators of such development in each direction.

According to this concept, the criteria for the development of rural areas include:

- an increase of entrepreneurial and social startup projects in rural areas;
- an increase in the number of APs that create and / or introduce innovations;
- a general increase of agricultural enterprises in rural areas, as well as an increase of processed agricultural products by such enterprises;
- growth in the volume of innovative products for agricultural management, other types of activities in rural areas;
- formation and implementation of social innovations;
- high level of capital investments in the production of agricultural products and provision of financial and investment resources to the non-productive sector of rural areas;
- increase of agricultural producers capable of investment;
- growth in employment of the rural population and wages;

- high level of investment in storage and processing of agricultural products in rural areas;  
- high level of innovative material and technical support of the agricultural and non-agricultural rural economy [14].

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