Original scientific paper
UDC 334.722:631.11]:658.18(477)

FORECASTING THE EFFICIENCY OF THE MANAGEMENT OF RESOURCE-SAVING DEVELOPMENT OF AGRICULTURAL ENTERPRISES

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Abstract

The complexity of forecasting resource-saving development of enterprises and the variety of factors that determine the effectiveness of the implementation of resource-saving agri-food sector, require new innovative approaches in the field of business management. At the present stage of development of the world economy there have been changes in the paradigm of management of resource conservation and greening of production. In addition to the changes in the principles and methods of resource conservation management, there have been changes in the methods of forecasting resource conservation management at the enterprise. Given the lack of tools for assessing the effectiveness of management of resource-saving development of agri-food enterprises in the scientific world, there is a need to intensify further research in this area. The aim of the article is to model the forecasting of the efficiency of management of resource-saving development of agri-food enterprises in today's conditions.

The materials for forecasting the effectiveness of resource-saving development management were statistical data of agricultural enterprises of Poltava, Zaporizhia and Luhansk regions. In order to model the forecasting of the effectiveness of management of resource-saving development of agri-food enterprises, we used adaptive models. These models have the ability to adjust their parameters according to the dynamics of the indicators for which they are used to predict. A dynamic regression model was used to predict integrated assessments of the effectiveness of resource-saving development management of agri-food enterprises in Ukraine. The dynamic regression model was used to determine forecasts of integrated assessments of economic efficiency of material, human, financial, intangible, informational, time resources, financing of resource-saving measures, social and environmental efficiency of resource-saving development management. The results of modeling the forecasting of the effectiveness of management of resource-saving development of agri-food enterprises were tested on a group of Ukrainian enterprises (according to the data of 2011 - 2020).

The study revealed common problems of resource-saving development management for groups of enterprises in Poltava, Zaporizhia and Luhansk regions. Negative trends in the use of material resources are a decrease in capital efficiency, lower profitability of fixed assets, reducing the turnover ratio of inventories. There are no positive trends in the dynamics of most financial indicators, which reduces the efficiency of financial resources. There are also no positive trends

in the dynamics of the coefficient of completeness of information, which negatively affects the management decision-making process. Our forecast of integrated assessments of the effectiveness of management of resource-saving development of agri-food enterprises showed that most of the studied enterprises need to improve the management system of resource-saving development. This necessitates the development of recommendations for organizational and personnel support, the formation of resource-saving behavior of staff, a comprehensive assessment of the effectiveness of this area of management.

The proposed modeling of forecasting the effectiveness of resource-saving development of agri-food enterprises will be appropriate for practical use in the current activities of market participants in order to save production and improve its environmental friendliness.

***Key words**: Resource-saving development, Management; Agri-food enterprises, Forecasting.*

1. Introduction

For science-based planning of resource-saving development of enterprises in the agri-food sector of Ukraine, it is important to assess with sufficient accuracy the probable value of its indicators in future periods. It is advisable to carry out such an assessment with the help of economic and mathematical modeling, which ensures the objectivity of the results obtained. The choice of model for forecasting is determined by the nature of the phenomena and processes studied using this model. The need for economical use of resources was raised in the numerous works of scientists. As an example, Tang *et al*., [1], Semenov *et al*., [2], Gupta and Seth, [3], Hnatenko *et al*., [4], Kee *et al*., [5], and Hu *et al*., [6], emphasized the need for resource efficiency in agricultural enterprises and development waste-free production. In the works of Petryk *et al*., [7], Sinha and Talati [8], Gryshchenko *et al*., [9], Ren *et al*., [10], Berbel and Mateos, [11], Zos-Kior *et al*., [12], and Khodakivska *et al*., [13], an innovative methodology was used that can be adapted to predict the resource-saving development of an agri-food enterprise. Jiang *et al*., [14], due to the integration of the two-level optimization model, offer savings of water and land resources and assess their current state. Yuan *et al*., [15], propose a methodology for estimating the energy budget and identify areas for efficient use of energy in wheat production in the management of Chinese crops. The works of Mazur et al., Hnatenko *et al*., Mayovets *et al*., and Rossokha *et al*., [16-19] propose various methods of enterprise management that should be used in the process of forecasting and improving the work of agricultural enterprises in the direction of resource conservation. Raut *et al*., [20], offer the indicators needed to implement green management practices in India's agricultural sector. The position of the authors on the recombination of the proposed indicators is quite interesting. Emphasizing the need for these studies to implement forecasting the effectiveness of resource-saving development of agricultural enterprises should point to the fragmentary nature of certain areas of research.

In addition, many works of scientists are outdated in time. Thus, there is a need for an uninterrupted study of the problems of predicting the effectiveness of managing the resource-saving development of agricultural enterprises, and the aim of the article is to model the forecasting of the efficiency of management of resource-saving development of agri-food enterprises in today's conditions.

2. Materials and Methods

The materials for forecasting the effectiveness of resource-saving development management were statistical data of agricultural enterprises of Poltava, Zaporizhia and Luhansk regions. A dynamic regression model was used to predict integrated assessments of the effectiveness of resource-saving development management of agri-food enterprises in Ukraine (on the example of Poltava, Zaporizhzhia and Luhansk oblasts). In this model, the forecast for each year of the retrospective period is determined using the parameter α, which changes dynamically depending on the forecast error for the previous year. Forecasting is performed according to the following algorithm:

1) The forecast value $W^p(1,q)$ of the integrated assessment of resource-saving development of agri-food enterprises for the q-th region for the first year of the retrospective period is taken equal to the actual value of this assessment, i.e. $W^p(1,q) = W(1,q)$, parameter α is accepted equal to 0.

2) The forecast value of the integrated assessment for the next year is determined by the formula (1):

$$W^p(t,q) = \alpha W(t,q) + (1-\alpha)W^p(t-1,q) \quad (1)$$

we take t = t + 1.

3) The parameter α varies according to the formula (2):

$$\alpha = \frac{\sum_{r=1}^{t-2}(W^p(r-2,q) - W(r,q))((W^p(r-2,q) - W(r-1,q))}{\sum_{r=1}^{t-2}(W^p(r-2,q) - W(r,q))^2} \quad (2)$$

4) Repeat the previous two steps to reach the value of t = T, where T is the duration of the retrospective period.

5) We determine the forecast for T + 1 year using the formula (3):

$$W^p(T+1,q) = \alpha W^p(T,q) + (1-\alpha)W^p(T-1,q) \quad (3)$$

6) If necessary, we determine forecasts for the coming years (4):

$$W^p(T+\varepsilon,q) = \alpha W^p(T+\varepsilon-1,q) + (1-\alpha)W^p(T+\varepsilon-2,q) \quad (4)$$

The dynamic regression model was used to determine forecasts of integrated assessments of economic efficiency of material, human, financial, intangible, informational, time resources, financing of resource-saving measures, social and environmental efficiency of resource-saving development management. Based on the forecasts, the expected values of integrated assessments of economic, environmental and social efficiency of resource-saving development management and general integrated assessments of its effectiveness were calculated. To do this, use the weights calculated in determining these integrated estimates.

3. Results and Discussion

The forecast values of the integrated assessment of the efficiency of resource-saving development of agri-food enterprises and components of this assessment for Poltava, Zaporizhzhia and Luhansk oblasts are given in Table 1. In addition, the projected growth rates of these indicators for 2012-2021 were calculated.

Table 1. Forecast values of the integrated assessment of the efficiency of resource-saving development of the group of agri-food enterprises of Poltava, Zaporizhzhia and Luhansk oblasts for 2023

Indicator	Region	Significance in 2021	Forecast for 2023	Projected growth rate
Efficiency of use of material resources	Poltava	0.494889	0.503989	1.018387
	Zaporizhzhia	0.446217	0.454317	1.018153
	Luhansk	0.479105	0.48234	1.006752
Human resource efficiency	Poltava	0.823271	0.725195	0.880871
	Zaporizhzhia	0.75789	0.765758	1.010382
	Luhansk	0.645333	0.584019	0.904989
Efficiency of use of financial resources	Poltava	0.53271	0.553528	1.03908
	Zaporizhzhia	0.328602	0.348762	1.06135
	Luhansk	0.645333	0.54108	0.838451
Efficiency of use of intangible assets	Poltava	0.532234	0.511123	0.960334
	Zaporizhzhia	0.214638	0.232588	1.08363
	Luhansk	0.406573	0.411574	1.012299
Efficiency of use of information resources	Poltava	0.934976	0.974421	1.042188
	Zaporizhzhia	0.546626	0.516972	0.94575
	Luhansk	0.551138	0.597529	1.084172
Time efficiency	Poltava	0.825261	0.720043	0.872504
	Zaporizhzhia	0.342543	0.305368	0.891476
	Luhansk	0.551138	0.530832	0.963156
Financing of resource-saving measures	Poltava	0.832436	0.838305	1.00705
	Zaporizhzhia	0.594034	0.588803	0.991194
	Luhansk	0.826497	0.826404	0.999887
Economic efficiency of resource-saving development management	Poltava	0.844665	0.82622	0.978159
	Zaporizhzhia	0.519144	0.50152	0.966055
	Luhansk	0.650812	0.649752	0.998371
Social efficiency of resource-saving development management	Poltava	0.970467	0.98472	1.014686
	Zaporizhzhia	0.906644	0.915161	1.009394
	Luhansk	0.590172	0.599162	1.015231
Environmental efficiency of resource-saving development management	Poltava	0.886367	0.89975	1.01510
	Zaporizhzhia	0.894087	0.90533	1.012575
	Luhansk	1.000000	0.995603	1.004416
Integral assessment of the effectiveness of resource-saving development management	Poltava	0.905413	0.912916	1.008288
	Zaporizhzhia	0.825557	0.830334	1.005786
	Luhansk	0.798004	0.802553	1.005700

Source: calculated by the authors.

Thus, a slight increase in the integrated assessment of the effectiveness of resource-saving development management is forecast for the studied regions (Figure 1).

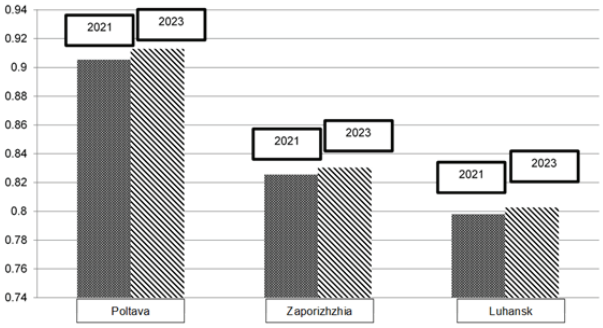

Figure 1. Dynamics of the integrated indicator of management efficiency of resource-saving development of Ukrainian agri-food sphere enterprises for 2021 - 2023 taking into account forecast value
Source: calculated by the authors

In Poltava oblast, the integrated indicator is expected to grow by 0.83%, in Zaporizhzhia oblast - by 0.58%, in Luhansk oblast - by 0.57%. At the same time, the assessment of economic efficiency of resource-saving development management is expected to decrease - by 2.2% in Poltava oblast, 3.4% in Zaporizhzhia oblast, and 0.2% in Luhansk oblast.

In Poltava oblast, it is projected to increase the efficiency of the use of material, financial and information resources and reduce the efficiency of the use of human resources, intangible and temporal resources; the assessment of the financing of resource-saving measures remains in fact at the level of 2021. In Zaporizhzhia oblast, it is projected to increase the efficiency of the use of material, human, financial and intangible resources and reduce the efficiency of the use of information and time resources; the assessment of the financing of resource-saving measures remains in fact at the level of 2021. In Luhansk oblast, it is projected to increase the efficiency of material, intangible and information resources and reduce the efficiency of human, financial and time resources; the assessment of the financing of resource-saving measures remains in fact at the level of 2021. Thus, the general tendency for groups of enterprises of the considered areas is to increase the efficiency of material resources and reduce the efficiency of time resources.

In addition, a slight increase in estimates of social and environmental efficiency of resource-saving development management is forecast for groups of enterprises in Poltava, Zaporizhzhia and Luhansk oblasts, which makes it possible to predict a certain increase in the overall assessment of their effectiveness.

For a detailed assessment of the prospects of resource-saving development, it is necessary to identify trends in the dynamics of primary indicators, on the basis of which the integrated assessment was performed. To determine these trends, we write the equations of the pairwise linear regression, which has the form (5):

$$\begin{aligned} x_{1ij}(t,q) &= \eta_{1ijq}t + \theta_{1ijq} \\ x_{2j}(t,q) &= \eta_{2jq}t + \theta_{2jq} \\ x_{3j}(t,q) &= \eta_{3jq}t + \theta_{3jq} \end{aligned} \quad (5)$$

The coefficients η_{1ijq}, η_{2jq}, η_{3jq}, θ_{1ijq}, θ_{2jq} and θ_{3jq} are determined by the method of least squares, for which we find solutions of systems of equations (6 - 8):

$$\begin{cases} \eta_{1ijq}\sum_{t=1}^{T} t^2 + \theta_{1ijq}\sum_{t=1}^{T} t = \sum_{t=1}^{T} t x_{1ij}(t,q) \\ \eta_{1ijq}\sum_{t=1}^{T} t + \theta_{1ijq}T = \sum_{t=1}^{T} x_{1ij}(t,q) \end{cases}$$

$$\begin{cases} \eta_{2jq}\sum_{t=1}^{T} t^2 + \theta_{2jq}\sum_{t=1}^{T} t = \sum_{t=1}^{T} t x_{2j}(t,q) \\ \eta_{2jq}\sum_{t=1}^{T} t + \theta_{2jq}T = \sum_{t=1}^{T} x_{2j}(t,q) \end{cases} \quad (6)$$

$$\begin{cases} \eta_{3jq}\sum_{t=1}^{T} t^2 + \theta_{3jq}\sum_{t=1}^{T} t = \sum_{t=1}^{T} t x_{3j}(t,q) \\ \eta_{3jq}\sum_{t=1}^{T} t + \theta_{3jq}T = \sum_{t=1}^{T} x_{3j}(t,q) \end{cases}$$

Where: T is the duration of the retrospective period.

The adequacy of the obtained equations of paired linear regression to the initial data is checked by the Fisher criterion, for which we determine the coefficient of determination and the actual value of this criterion.

For equations $x_{1j}(t,q) = \eta_{1ijq}t + \theta_{1ijq}$, the coefficient of determination is determined by equality (7):

$$R^2_{1ijq} = 1 - \frac{\sum_{t=1}^{T}(x_{1ij}(t,q) - \eta_{1ijq}t - \theta_{1ijq})^2}{\sum_{t=1}^{T}(x_{1ij}(t,q) - \overline{x_{1ij}(q)})^2} \quad (7)$$

Where: $\overline{x_{1j}(q)}$ is the average value of x_{1ij} in the q-th region for the retrospective period.

The actual value of the Fisher criterion is calculated by the formula (8):

$$F_{1ijq} = \frac{R^2_{1ijq}}{1 - R^2_{1ijq}}(T-2) \quad (8)$$

If the value obtained exceeds the critical value of the Fisher test $F(\alpha, k_1, k_2)$ where α is the confidence probability (assumed to be 0.95), k_1=1 and k_2=T-2=8 are degrees of freedom, then the regression equation is considered adequate.

The adequacy of the equations $x_{2j}(t,q) = \eta_{2jq} t + \theta_{2jq}$ and $x_{3j}(t,q) = \eta_{3jq} t + \theta_{3jq}$ is similarly checked.

If the regression equation is an adequate initial data, then there is a trend in the dynamics of the indicator corresponding to this equation. If the coefficient for the variable t is positive, then there is an increasing trend, and if negative - then declining. If the equation is not adequate, the trend in the dynamics of this indicator is not detected.

At the next stage of the study, it is advisable to determine the predictive trends in the dynamics of primary indicators of the economic efficiency of the management of resource-saving development of the group of enterprises in Poltava oblast (Table 2, next page).

Thus, based on the calculations, we can conclude that the indicators of efficiency of material resources by the group of enterprises of Poltava region tend to gradually decrease. Primary indicators of human resource efficiency according to the forecast for 2023 have a positive upward trend. For indicators of efficiency of use of financial resources as a result of calculation of forecast value the tendency is not revealed. Most indicators of the efficiency of information, intangible and time resources are characterized by a positive upward trend.

The same trend is observed for the vast majority of funding for resource-saving measures. For all indicators of social efficiency of management of resource-saving development of the group of enterprises of agri-food sphere of Poltava oblast on the calculation basis of forecast values the tendency to increase is observed (Table 3).

The exception is an indicator of the formation of value-oriented unity of the team, for which the forecast calculations did not show a trend.

Various tendencies were revealed for the indicators of ecological efficiency of resource-saving development management for the group of agro-food enterprises of Poltava oblast (Table 4).

Thus, for the coefficient of nature and resource intensity of the process there is a tendency to decrease, which is

Table 3. Forecast trends of indicators of social efficiency of resource-saving development management of the group of enterprises of Poltava oblast

Indicator	Coefficient at t in the regression equation	Free member of the regression equation	Coefficient of determination	The actual value of the Fisher test	Tendency
x_{21}	-0.00145	0.016	0.484848	7.529412	decrease
x_{22}	0.008485	0.693333	0.571096	10.65217	increase
x_{23}	0.008	0.696	0.507692	8.25	increase
x_{24}	0.020606	0.726667	0.796143	31.24324	increase
x_{25}	0.018545	0.644	0.66858	16.13857	increase
x_{26}	0.022061	0.618667	0.673469	16.5	increase
x_{27}	0.02	0.58	0.654933	15.1839	increase
x_{28}	0.018909	0.602	0.052185	0.440465	not detected
x_{29}	-0.00709	1.198	0.431568	6.073814	increase
x_{210}	0.004364	0.912	0.484848	7.529412	increase

Source: calculated by the authors.

Table 4. Forecast tendencies of indicators of ecological efficiency of management of resource-saving development of group of the enterprises of Poltava oblast

Indicator	Coefficient at t in the regression equation	Free member of the regression equation	Coefficient of determination	The actual value of the Fisher test	Tendency
x_{31}	-0.00467	0.138667	0.497692	7.926471	decrease
x_{32}	0	0.01	1	∞	constant
x_{33}	-0.00327	0.064	0.71261	19.83673	decrease
x_{34}	0.056545	1.414	0.973914	298.6752	increase
x_{35}	0.005455	0.826	0.552826	9.89011	increase

Source: calculated by the authors.

Table 2. Forecast trends of indicators of economic efficiency of resource-saving development management of the group of enterprises of Poltava oblast

Indicator	Coefficient at t in the regression equation	Free member of the regression equation	Coefficient of determination	The actual value of the Fisher test	Tendency
Indicators of efficiency of material resources use					
x_{111}	-0.70412	8.798667	0.741552	22.95399	decrease
x_{112}	12.80903	1.793333	0.928508	103.901	increase
x_{113}	-0.02842	0.709333	0.923069	95.98996	decrease
x_{114}	-0.00218	0.036	0.377622	4.853933	not detected
x_{115}	-0.44891	5.626	0.585882	11.31817	decrease
x_{116}	0.100606	2.662667	0.269361	2.949322	not detected
x_{117}	-1.55527	16.482	0.766472	26.25711	decrease
x_{118}	0.005758	0.827333	0.294386	3.337648	not detected
Indicators of human resource efficiency					
x_{121}	72.12952	53.34267	0.658265	15.40997	increase
x_{122}	0.004485	0.941333	0.455877	6.70257	increase
x_{123}	-0.00255	0.114	0.534545	9.1875	decrease
Indicators of efficiency of use of financial resources					
x_{131}	0.001697	0.262667	0.019537	0.159414	not detected
x_{132}	-0.24	5.482	0.103781	0.926393	not detected
x_{133}	-0.08127	1.844	0.376073	4.822014	not detected
x_{134}	0.183455	5.104	0.15984	1.521997	not detected
x_{135}	0.042848	4.571333	0.186261	1.831163	not detected
x_{136}	0.453515	6.298667	0.114166	1.031042	not detected
x_{137}	0.008121	0.781333	0.052199	0.440589	not detected
x_{138}	0.160545	5.792	0.015935	0.129543	not detected
x_{139}	0.012242	2.044667	0.001805	0.014466	not detected
x_{1310}	0.001515	0.572667	0.008896	0.071806	not detected
x_{1311}	0.061333	1.212667	0.620942	13.10493	increase
x_{1312}	-0.00455	0.194	0.130217	1.1977	not detected
x_{1313}	0.003212	0.019333	0.470283	7.102402	increase
Indicators of efficiency of use of intangible resources					
x_{141}	0.006182	0.026	0.716529	20.22157	increase
x_{142}	0.065576	0.017333	0.704793	19.09967	increase
x_{143}	0.914303	25.35333	0.255645	2.747564	not detected
x_{144}	1.363152	16.31467	0.929723	105.836	increase
Indicators of efficiency of information resources use					
x_{151}	-0.00406	0.543333	0.160224	1.526352	not detected
x_{152}	0.005152	0.504667	0.341559	4.149914	not detected
x_{153}	0.009333	0.370667	0.297461	3.387274	not detected
x_{154}	0.009394	0.663333	0.927427	102.234	increase
x_{155}	0.008727	0.654	0.484848	7.529412	increase
x_{156}	0.006788	0.038667	0.754209	24.54795	increase
x_{157}	0.01097	0.034667	0.810414	34.19729	increase
Indicators of time use efficiency					
x_{161}	0.003091	0.928	0.426044	5.938356	increase
x_{162}	0.005879	0.736667	0.300444	3.435823	not detected
x_{163}	0.005091	0.89	0.636364	14	increase
Indicators of financing resource-saving measures					
x_{171}	0.014242	0.086667	0.907038	78.05654	increase
x_{172}	0.008	0.01	0.846154	44	increase
x_{173}	0.000667	0.035333	0.05314	0.44898	not detected
x_{174}	-0.00073	0.02	0.181818	1.777778	not detected
x_{175}	0	0.01	1	∞	constant
x_{176}	0.002606	0.020667	0.448242	6.499121	increase
x_{177}	0.000242	0.010667	0.030303	0.25	not detected
x_{178}	0	0.01	1	∞	constant

Source: calculated by the authors.

positive in the activities of the group of enterprises of Poltava region. According to the forecast data for 2023, the environmental intensity ratio remains unchanged. The indicators of environmental friendliness of the facility and production tend to increase, which also positively characterizes the activities of agri-food enterprises, as these indicators are stimulants.

As a result of calculation of forecast values of primary indicators of efficiency of resource-saving development of agro-food enterprises of Zaporizhzhia oblast it is revealed that the vast majority of indicators of efficiency of use of material resources tends to decrease, which indicates the need to improve resource-saving measures (Table 5).

Trends in the dynamics of efficiency of financial resources as a result of calculations were not identified. At the same time, the indicators of the efficiency of the use of human, intangible, informational, time

Table 5. Forecast trends of indicators of economic efficiency of resource-saving development management of the group of enterprises of Zaporizhzhia oblast

Indicator	Coefficient at t in the regression equation	Free member of the regression equation	Coefficient of determination	The actual value of the Fisher test	Tendency
Indicators of efficiency of material resources use					
x_{111}	-0.62188	8.379333	0.819672	36.36368	decrease
x_{112}	11.43703	1.599333	0.928516	103.9125	increase
x_{113}	-0.03606	0.633333	0.927629	102.5416	decrease
x_{114}	-0.00218	0.036	0.377622	4.853933	not detected
x_{115}	-0.40048	5.020667	0.584935	11.27408	decrease
x_{116}	0.091273	2.424	0.266695	2.909512	not detected
x_{117}	-2.0457	20.49933	0.799323	31.8651	decrease
x_{118}	0.024121	0.671333	0.838596	41.56494	increase
Indicators of human resource efficiency					
x_{121}	62.8857	46.50467	0.658267	15.41007	increase
x_{122}	326255.4	169372.5	0.455877	6.70257	increase
x_{123}	0.001659	0.001981	0.534545	9.1875	increase
Indicators of efficiency of use of financial resources					
x_{131}	-0.00067	0.250667	0.00251	0.020128	not detected
x_{132}	-0.21964	5.026	0.103302	0.921622	not detected
x_{133}	-0.07727	1.756	0.37311	4.761413	not detected
x_{134}	0.588848	3.799333	0.127856	1.172792	not detected
x_{135}	-2.23024	24.38933	0.179764	1.753295	not detected
x_{136}	-0.13309	3.11	0.094485	0.834751	not detected
x_{137}	-0.00776	0.836667	0.017225	0.140213	not detected
x_{138}	-0.80533	11.71533	0.162564	1.552966	not detected
x_{139}	-0.19721	2.704667	0.274915	3.033187	not detected
x_{1310}	-0.01467	0.230667	0.162218	1.549025	not detected
x_{1311}	0.056606	1.114667	0.623998	13.27645	increase
x_{1312}	-0.00394	0.176667	0.122517	1.116986	not detected
x_{1313}	0.002061	0.014667	0.243266	2.571746	not detected
Indicators of efficiency of use of intangible resources					
x_{141}	0.004667	0.023333	0.418803	5.764706	increase
x_{142}	0.056	0.012	0.523725	8.797008	increase
x_{143}	-0.6957	28.77933	0.01794	0.146145	not detected
x_{144}	0.400667	19.04533	0.03951	0.329084	not detected
Indicators of efficiency of information resources use					
x_{151}	-0.00127	0.416	0.029763	0.245409	not detected
x_{152}	0.006727	0.4	0.414388	5.660924	increase
x_{153}	0.013212	0.453333	0.458054	6.761613	increase
x_{154}	0.012848	0.525333	0.672895	16.45698	increase
x_{155}	0.004242	0.650667	0.167969	1.61503	not detected
x_{156}	0.007455	0.018	0.900697	72.56115	increase
x_{157}	0.007091	0.036	0.588395	11.43609	increase
Indicators of time use efficiency					
x_{161}	0.004727	0.914	0.709091	19.5	increase
x_{162}	0.003758	0.563333	0.571004	10.6482	increase
x_{163}	0.004	0.888	0.825	37.71429	increase
Indicators of financing resource-saving measures					
x_{171}	0.012667	0.019333	0.877181	57.13669	increase
x_{172}	0.002485	0.003333	0.835072	40.50602	increase
x_{173}	0.00297	0.008667	0.692929	18.05263	increase
x_{174}	0.000727	0.008	0.272727	3	not detected
x_{175}	0.001515	-0.00333	0.757576	25	increase
x_{176}	0.001758	0.007333	0.621582	13.14063	increase
x_{177}	0.001758	-0.00267	0.621582	13.14063	increase
x_{178}	0.001455	-0.002	0.727273	21.33333	increase

Source: calculated by the authors.

resources and financing of resource-saving measures tend to increase.

All indicators of social efficiency of resource-saving development management of the group of enterprises of agri-food sphere of Zaporizhzhia region have a tendency to increase, which positively characterizes the activity of the studied economic entities (Table 6).

As a result of calculating the predicted values of the primary indicators of environmental efficiency of resource-saving development management of a group of enterprises in the agri-food sector of the Zaporizhzhia oblast, it was found that the coefficients of nature and resource intensity of the process have a positive tendency to decrease (Table 7).

Trends in changes in the environmental intensity have not been identified, and the coefficients of environmental friendliness of the facility and production according to forecasts will increase, which has a positive impact on the activities of agri-food enterprises in Zaporizhzhia oblast.

As a result of forecast calculations, it was found that the vast majority of indicators of economic efficiency of resource-saving development management of the group of agri-food enterprises of Luhansk region tend to increase (Table 8).

Thus, the vast majority of indicators of efficiency of use of financial, intangible, information resources and financing of resource-saving measures tend to increase. There are no trends for significant changes in indicators of efficiency of material and time resources. The efficiency of the use of tangible assets tends to decrease, which negatively affects the performance of agri-food enterprises.

As a result of calculation of forecast values of indicators of social efficiency of management of resource-saving development of group of the enterprises of the Luhansk area it is revealed that the majority of indicators or have a tendency to growth, or such tendency is not revealed at all (Table 9).

Table 6. Forecast trends of indicators of social efficiency of resource-saving development management of the enterprises group of Zaporizhzhia oblast

Indicator	Coefficient at t in the regression equation	Free member of the regression equation	Coefficient of determination	The actual value of the Fisher test	Tendency
x_{21}	-0.00194	0.022667	0.554113	9.941748	decrease
x_{22}	0.011879	0.650667	0.430518	6.047859	increase
x_{23}	0.009212	0.677333	0.575758	10.85714	increase
x_{24}	0.028182	0.66	0.870734	53.88785	increase
x_{25}	0.015152	0.648667	0.538663	9.340906	increase
x_{26}	0.013333	0.626667	0.539216	9.361702	increase
x_{27}	0.02	0.58	0.673469	16.5	increase
x_{28}	0.020606	0.592667	0.77776	27.99709	increase
x_{29}	0.036364	0.872	0.044332	0.37111	not detected
x_{210}	0.005515	0.890667	0.645088	14.54083	increase

Source: calculated by the authors.

Table 7. Forecast tendencies of indicators of ecological efficiency of management of resource-saving development of the enterprises group of Zaporizhzhia oblast

Indicator	Coefficient at t in the regression equation	Free member of the regression equation	Coefficient of determination	The actual value of the Fisher test	Tendency
x_{31}	-0.00339	0.122667	0.659933	15.52475	decrease
x_{32}	-0.00091	0.016	0.23511	2.459016	not detected
x_{33}	-0.00364	0.068	0.699301	18.60465	decrease
x_{34}	0.056788	1.492667	0.922988	95.87955	increase
x_{35}	0.008667	0.793333	0.805808	33.19643	increase

Source: calculated by the authors.

Table 8. Forecast tendencies of indicators of economic efficiency of management of resource-saving development of the enterprises group of Luhansk oblast

Indicator	Coefficient at t in the regression equation	Free member of the regression equation	Coefficient of determination	The actual value of the Fisher test	Tendency
Indicators of efficiency of material resources use					
x_{111}	-0.65836	8.22	0.738904	22.64005	decrease
x_{112}	11.39982	1.596	0.928486	103.8667	increase
x_{113}	-0.01703	0.754667	0.659344	15.48407	decrease
x_{114}	-0.00267	0.046667	0.333333	4	not detected
x_{115}	-0.34261	5.223333	0.635605	13.95422	decrease
x_{116}	0.111394	2.981333	0.297604	3.389587	not detected
x_{117}	-1.58879	17.29133	0.721925	20.76926	decrease
x_{118}	0.00503	0.803333	0.286362	3.210158	not detected
Indicators of human resource efficiency					
x_{121}	36.93539	76.00733	0.696261	18.33839	increase
x_{122}	0.007091	0.82	0.149808	1.409639	not detected
x_{123}	-0.00491	0.164	0.124184	1.134336	not detected
Indicators of efficiency of use of financial resources					
x_{131}	0.015455	0.136	0.69652	18.36086	increase
x_{132}	0.297091	1.41	0.408601	5.527251	increase
x_{133}	0.047212	1.291333	0.290466	3.275008	not detected
x_{134}	0.122242	3.984667	0.359651	4.493185	not detected
x_{135}	0.067697	3.954667	0.20047	2.005873	not detected
x_{136}	0.255394	4.481333	0.180168	1.758094	not detected
x_{137}	0.015758	0.495333	0.280001	3.111121	not detected
x_{138}	0.100788	0.928667	0.406977	5.490203	increase
x_{139}	0.039939	1.127333	0.050004	0.421086	not detected
x_{1310}	-0.00424	0.485333	0.11283	1.017442	not detected
x_{1311}	0.054909	1.08	0.625977	13.38905	increase
x_{1312}	-0.0043	0.174667	0.137744	1.277982	not detected
x_{1313}	0.002121	0.015333	0.367537	4.648956	not detected
Indicators of efficiency of use of intangible resources					
x_{141}	0.004909	0.02	0.660526	15.56584	increase
x_{142}	0.051939	0.013333	0.704996	19.11831	increase
x_{143}	0.830545	15.094	0.230909	2.401892	not detected
x_{144}	1.016182	10.078	0.697867	18.47843	increase
Indicators of efficiency of information resources use					
x_{151}	-0.00376	0.468667	0.177568	1.727252	not detected
x_{152}	0.004364	0.434	0.344498	4.20438	not detected
x_{153}	0.008061	0.318667	0.311464	3.618863	not detected
x_{154}	0.008424	0.568667	0.936776	118.5337	increase
x_{155}	0.007758	0.561333	0.466621	6.998718	increase
x_{156}	0.005818	0.032	0.767233	26.3691	increase
x_{157}	0.009152	0.030667	0.795097	31.04289	increase
Indicators of time use efficiency					
x_{161}	0.002606	0.852667	0.397378	5.275321	not detected
x_{162}	0.005879	0.676667	0.300444	3.435823	not detected
x_{163}	0.004667	0.821333	0.596899	11.84615	increase
Indicators of financing resource-saving measures					
x_{171}	0.013273	0.084	0.896585	69.35792	increase
x_{172}	0.008	0.01	0.846154	44	increase
x_{173}	0.000667	0.035333	0.05314	0.44898	not detected
x_{174}	-0.00073	0.02	0.181818	1.777778	not detected
x_{175}	0	0.01	1	∞	increase
x_{176}	0.002606	0.020667	0.448242	6.499121	increase
x_{177}	0.000242	0.010667	0.030303	0.25	not detected
x_{178}	0	0.01	1	∞	constant

Source: calculated by the authors.

Table 9. Forecast trends of indicators of social efficiency of resource-saving development management of the enterprises group of Luhansk oblast

Indicator	Coefficient at t in the regression equation	Free member of the regression equation	Coefficient of determination	The actual value of the Fisher test	Tendency
x_{21}	-0.00079	0.013333	0.176594	1.715736	not detected
x_{22}	0.010667	0.541333	0.282731	3.153415	not detected
x_{23}	0.010424	0.540667	0.299227	3.415969	not detected
x_{24}	0.021333	0.564667	0.592593	11.63636	increase
x_{25}	0.01897	0.498667	0.54764	9.685038	increase
x_{26}	0.021939	0.477333	0.642978	14.40756	increase
x_{27}	0.019697	0.452667	0.447721	6.485433	increase
x_{28}	0.018848	0.467333	0.511597	8.379917	increase
x_{29}	-0.00673	1.068	0.059748	0.508355	not detected
x_{210}	0.003818	0.814	0.37007	4.699822	not detected

Source: calculated by the authors.

Table 10. Forecast trends of indicators of ecological efficiency of management of resource-saving development of the enterprises group of Luhansk oblast

Indicator	Coefficient at t in the regression equation	Free member of the regression equation	Coefficient of determination	The actual value of the Fisher test	Tendency
x_{31}	-0.00467	0.128667	0.497692	7.926471	not detected
x_{32}	0	0.01	1	∞	constant
x_{33}	-0.00479	0.077333	0.759523	25.26721	decrease
x_{34}	0.063212	1.583333	0.974463	305.2754	increase
x_{35}	0.005273	0.836	0.472915	7.177809	increase

Source: calculated by the authors.

The forecast values of indicators of ecological efficiency of management of resource-saving development of the group of enterprises of Luhansk region have a tendency similar to similar indicators for the group of enterprises of agri-food sphere of Poltava oblast. The coefficient of resource intensity of the process tends to decrease, the environmental friendliness of the object and production - to increase (Table 10). Such projected changes will have a positive impact on the activities of the studied enterprises.

To assess the impact of primary indicators on the relevant integrated assessments, it is advisable to determine the correlation coefficients between indicators x_{1ij}, used to assess the cost-effectiveness of resource management, and integrated estimates v_i of the relevant components of cost-effectiveness. To test the significance of these coefficients, we use the Student's t test. To do this, determine the actual value of this criterion by the formula (9):

$$q_{1tj} = \frac{k_{1tj}}{\sqrt{1-(k_{1tj})^2}}\sqrt{N-2} \qquad (9)$$

Where: k_{1ji} is correlation coefficient between indicators x_{1ij} and v_i, N – the number of known values of the indicator x_{1ij}.

Since 3 regions are considered, and the duration of the retrospective period is 10 years, N = 30. If the obtained values exceed the critical value of the Student's criterion $t(\alpha,k)$ with a confidence level α = 0.95 and the number of degrees of freedom k = N-2 = 28, the corresponding correlation coefficient is considered significant.

As a result of the study it was found that the following indicators have the most significant impact on the integrated assessment of the efficiency of material resources: capital adequacy (correlation coefficient 0.597), disposal ratio of fixed assets (correlation coefficient -0.722) and raw material waste coefficient (correlation coefficient 0.680). The integrated assessment of human resource efficiency is significantly influenced by staff productivity (correlation coefficient 0.804), labor resource utilization coefficient (correlation coefficient 0.892) and staff turnover ratio (correlation coefficient -0.852). The integrated assessment of the efficiency of financial resources use is most significantly influenced by the coverage ratio (correlation coefficient 0.834), equity turnover ratio (correlation ratio 0.873), autonomy ratio (correlation ratio 0.779), and equity ratio. The integrated assessment of the efficiency of use of intangible assets is most significantly influenced

by the coefficients of their renewal (correlation coefficient 0.847), profitability (correlation coefficient 0.684), and return (correlation coefficient 0.796). The integrated assessment of the efficiency of information resources is most significantly influenced by the coefficients of accuracy of information (correlation coefficient 0.935), timeliness of information (correlation coefficient 0.955) and the availability of proprietary software (correlation coefficient 0.716). The integrated assessment of the efficiency of time resources use is most significantly influenced by the downtime utilization factor (correlation coefficient 0.929). The integrated assessment of the efficiency of financing resource-saving measures is most significantly influenced by the coefficients of financing resource-saving development (correlation coefficient 0.856), financing the preservation of intangible resources (correlation coefficient 0.934) and financing improving the efficiency of time resources (correlation coefficient 0.886). The influence of indicators on integrated assessments of economic, social and environmental efficiency of management of resource-saving development of agri-food enterprises was also studied. There is a significant impact on the integrated assessment of economic efficiency of information resources (correlation coefficient 0.888), use of time resources (correlation coefficient 0.884) and financing of resource-saving measures (correlation coefficient 0.882). Assessments of satisfaction with management (correlation coefficient 0.940), psychological climate in the team (correlation coefficient 0.958) and professional development (correlation coefficient 0.944) have the greatest influence on the integrated assessment of social efficiency. The integrated assessment of environmental efficiency is most influenced by the coefficients of resource intensity of the process (correlation coefficient -0.925), environmental friendliness of the object (correlation coefficient 0.847) and environmental friendliness of production (correlation coefficient 0.790).

To assess the impact of efficiency indicators of resource-saving development of agri-food enterprises on agri-food production, correlation coefficients between these indicators and the volume of agricultural production in Poltava, Zaporizhzhia and Luhansk oblasts were determined. It is revealed the relationship between the volume of agricultural production and the use of material resources (correlation coefficient 0.557), the use of human resources (correlation coefficient 0.748), the use of intangible resources (correlation coefficient 0.648), the use of information resources (correlation coefficient 0.719), the use of time correlation 0.524), financing of resource-saving measures (correlation coefficient 0.427) and integrated assessment of economic efficiency of resource-saving development management of agri-food enterprises (correlation coefficient 0.648).

4. Conclusions

- Forecasting the effectiveness of resource-saving development of agri-food enterprises in Ukraine revealed common management problems for groups of enterprises in Poltava, Zaporizhzhia and Luhansk oblasts.
- At the studied enterprises there is no positive trend in the dynamics of the coefficient of accuracy and the coefficient of inconsistency of information, but there are positive trends in the dynamics of human and time resources.
- Most of the indicators of social (except for the growth rate of the average wage) and environmental efficiency of the management of resource-saving development of agri-food enterprises are characterized by positive dynamics. Today, agri-food enterprises of Ukraine operate in conditions of limited resources, fierce competition and increasingly focus on sustainable development.
- All this actualizes the formation of an effective management system for resource-saving development at agri-food enterprises and provides for the solution of a number of tasks, including organizational and personnel support.

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