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FORECASTING OF ECONOMIC INDICATORS OF AGRICULTURAL ENTERPRISES ACTIVITY IN THE SYSTEM OF ENSURING THEIR MANAGEMENT ON THE BASIS OF SUSTAINABLE DEVELOPMENT: A CASE STUDY OF UKRAINE

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Abstract

The article proved that the application of the «AGMEMOD–Ukraine» model allowed conduct forecasting the development indicators of agricultural producers in the context of sustainable rural development, namely: yield, gross harvest and sown areas of major crops, changes in demographic indicators on the basic and optimistic forecast, the results of which allow competitive strategies, the implementation of which will increase the volume of sales, profits, market share, penetration into a new market segment, etc. It is considered that the use of the model «AGMEMOD–Ukraine», which covers the multicriteria measurement of functional components of agricultural producers, provides an opportunity to analyze and predict not only key competitive advantages but also secondary characteristics, which together have a significant impact on solving problems of strategic management of economic efficiency and competitiveness of agricultural enterprises in Ukraine. According to the results of the study, there were substantiated in the article the main strategic goals and priority areas for the development of agricultural producers.

***Key words*:** *forecasting, agricultural enterprises, management, «AGMEMOD–Ukraine» model, sustainable development*

INTRODUCTION

An important feature of agriculture in the socio-economic aspect is not only the financial efficiency of enterprises, but also the fact that it largely depends on the quality of life of the rural population, and this efficiency depends on food security in general. It should be noted that in addition to those factors related to the technology of production processes, agricultural production is dependent on changes and anomalies of weather conditions, price dynamics in commodity markets, features of government regulation and changes in legislation, and more.

In such conditions, it is very important to make timely and informed decisions to ensure the effective functioning of agricultural enterprises. At the same time, effective management of agricultural enterprises is almost impossible without the use of modern methods of analysis and forecasting. It should be noted that traditional approaches involve the use of correlation-regression analysis to determine the density of the relationship between factor and performance, the relationship between which is random.

However, the intensive development of digital information and communication technologies greatly simplifies the use of special methods of economic and econometric analysis, which also includes forecasting.

Therefore, the study of the process of forecasting economic performance of economic entities operating in the agricultural sector, based on the use of economic and mathematical formulary tools becomes particularly relevant, especially in terms of forming a strategy for sustainable development of such producers.

In the realities of today, new technologies of social forecasting and prediction have become widespread. Such technologies include the Forsyth method, Data Mining, etc.

The problem of forecasting the economic activity of enterprises is not new in economics and is widely disclosed in specialized studies. In particular, in our opinion, it is expedient to highlight the works of such scientists as O. Agres [1], O. Binert [5], L. Brovko [7], N. Chukhray [9], O. Gudz [17], A. Marcuta [20], I. Nademianov [21], T. Shmatkovska [34-36], N. Vavdiiuk [45-46], Y. Yanyshyn [49], and others.

However, the specifics of the functioning of the agricultural sector require special approaches to assessing performance indicators of enterprises.

Economic research in this area requires the use of multifactor analytical models to ensure the reliability of the data.

The researched problems were reflected in the scientific achievements of O. Apostolyuk [2], I. Atamanyuk [3]. A. Boiar [6], M. Dziamulych [10-16], R. Sodoma [37-39], V. Stechel [44], O. Vovchak [47], O. Yatsukh [50] and others.

It is also necessary to note the relevance of research on the use of mathematical and analytical-static tools for evaluating and forecasting the activities of agricultural producers, which are presented in the works of I. Balaniuk [4], Y. Chaliuk [8], V. Fenyves [18], R. Lopatiuk [19], R. Ostapenko [22], A. Popescu [23-32], N. Samarets [33], O. Stashchuk [40-42], I. Yakoviyk [48], I. Zhurakovska [51] and others.

MATERIALS AND METHODS

To ensure the implementation of the process of calculating the parameters of the model, a specialized model «AGMEMOD-Ukraine» was used, which is based on the use of complex mathematical tools. In the «AGMEMOD-Ukraine» model, the value of expected profit per unit of output is calculated by Formula 1:

$$AEGM_{i,m,t} = p_{i,k,t-1} - C_{i,m,t} + SPRT_{i,m,t} \quad (1)$$

where:

$AEGM_{i,m,t}$ – the expected total profit of culture i, of the producer m, in region k and year t is specified;

$p_{i,n,t-1}$ – price of culture i, in region k and year t-1;

$C_{i,m,t}$ – production costs of culture i, producer m (in region k), and year t;

$SPRT_{i,m,t}$ – state support for crop i, producer m (in region k) and year t (if any).

It should be borne in mind that the adjusted expected total profit of the crop ***i*** produced by the producer of group ***m*** in region ***k*** is the sum of the previous year`s price, expected costs, and state support for the production of this crop this year.

Production costs ***(C)*** are calculated by Formula 2:

$$C_{i,m,t} = S_{di,m,t} + F_{ei,m,t} + F_{li,m,t} + S_{ri,m,t} + L_{bi,m,t} + A_{mi,m,t} + O_{ti,m,t} + R_{ni,m,t} \quad (2)$$

where:

$S_{di,m,t}$ – costs of sowing material for crop i, producer m, in region k and year t;

$F_{ei,m,t}$ – costs of fertilizer application for crop i, producer m, in region k and year t;

$F_{li,m,t}$ – fuel costs for crop i, producer m, in region k and year t;

$S_{ri,m,t}$ – costs of third party services for culture i, producer m, in region k and year t;

$L_{bi,m,t}$ – labour costs for culture i, producer m, in region k and year t;

$A_{mi,m,t}$ – depreciation costs for crop i, producer m, in region k and year t;

$O_{ti,m,t}$ – other costs for culture i, producer m, in region k and year t;

$R_{ni,m,t}$ – the lease price of producer land m, in region k and year t, estimated for culture i.

The sown area of the crop is calculated in the model using a two-stage procedure. First, the area of cereals was estimated (Formula 3):

$$HA_{j,m,k,t} = f(Trend_t, AEGM_{j,m,k,t}) \times N_{m,k} \quad (3)$$

where:
$HA_{j,m,k,t}$ – the total area of the group of crops j, i.e. grain producers m, in the region k and year t;
$Trend_t$ – logarithmic trend calculated as ln (t-2008) (figure for 2008 is 0);
$AEGM_{j,m,k,t}$ – the expected total profit of grain or oilseeds producer m, in region k and year t;
$N_{m,k}$ – number of producers in group m in region k.

The specific weight of crops in cereal areas in the process of modelling is calculated by Formula 4.

$$SHA_{i,m,k,t} = f(Trend_t, AEGM_{i,m,k,t}) \quad (4)$$

where:
$SHA_{i,m,k,t}$ – the share of crop i in the area of the relevant crop group (cereals or oilseeds), producer of group m, in region k and year t;
$Trend_t$ – logarithmic trend calculated as ln (t-2008) (indicator for 2008 is 0);
$AEGM_{i,m,k,t}$ – the expected total profit of the crop i of the corresponding group of crops (cereals or oilseeds), producer m, in region k, and year t is specified.

In order to form a forecast model of the economic performance of agricultural enterprises, we conducted an econometric assessment of crop yields. The estimation of crop yield was determined using Formula 5:

$$Y_{ieldi,m,k,t} = f(Trend_t, AEGM_{i,m,k,t}) \quad (5)$$

where:
$Y_{ieldi,m,k,t}$ – crop yield and producer of group m, in region k and year t;
$Trend_t$ – logarithmic trend calculated as ln (t-2008) (indicator for 2008 is 0);
$AEGM_{i,m,k,t}$ – the expected total profit of the crop i of the corresponding group of crops (cereals or oilseeds), producer m, in region k, and year t is specified.

RESULTS AND DISCUSSIONS

To assess the development of the agricultural market, the «AGMEMOD» methodology involves the use of a combination of exogenous and endogenous data. Exogenous data on annual indicators of gross domestic product, gross domestic product deflator, and population are taken from the State Statistics Service of Ukraine (SSSU). Data on the national currency exchange rate are taken from the resource of the National Bank of Ukraine. As these data come from official sources, the methodology of their calculation is relatively consistent and reasonable. In addition, the use of official statistics increases the reliability of the forecast model and simulation results. However, there is one important caveat related to the use of SSS data – indicators are frequently reviewed and updated, so the database used to form the model should be updated in a timely manner. Estimates of exogenous data are taken from databases and reports from the US Department of Agriculture, the Organization for Economic Development and Cooperation, the United Nations Food and Agriculture Organization, and the European Commission. In Fig. 1 we present an algorithm for forming a forecasting procedure according to the AGMEMOD method.
Historical data on endogenous variables are taken from SSSU databases, PSO Statistics, and OECD-PSO. If the required data are not available, they are estimated based on the trend of previous years. In order to build a forecast model according to the types of producers, data from relevant statistical forms developed and implemented by official statistical bodies in Ukraine were used. These forms are developed in the form of questionnaires, which is mandatory for agricultural producers, and which is then used by SSSU to calculate aggregate indicators. The database, formed on the basis of relevant statistical forms, includes annual data on the performance of 8,521 agricultural producers during the period 2008 – 2020. It covers all

regions of Ukraine and 70% of crop production. In the «AGMEMOD-Ukraine» model, agricultural producers make decisions based on the value of expected profit per unit of output, which is calculated according to Formula 1. Thus, the adjusted total profit of crop ***i***, produced by the producer of group ***m*** in region ***k*** is the sum of the previous year`s price, expected costs, and state support for the production of this crop this year. The production costs (***C***) are calculated by Formula 2.

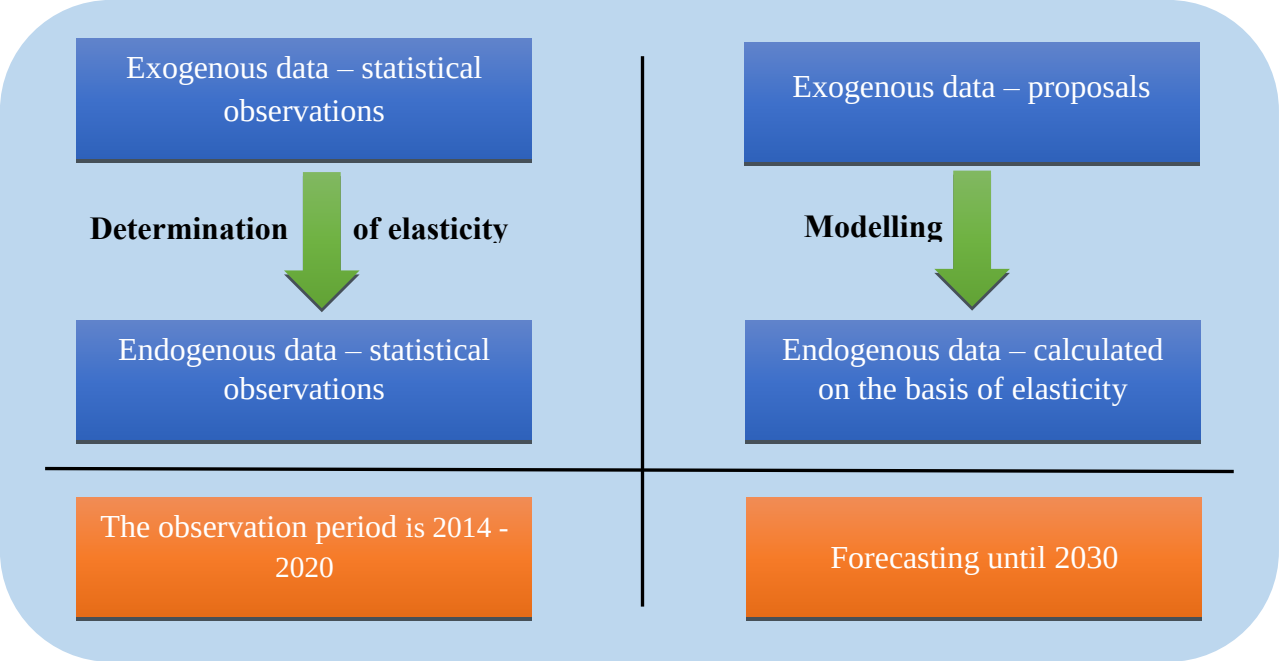

Fig. 1. Algorithm of work and key elements of «AGMEMOD» methodology
Source: systematized by the authors.

All indicators are calculated by us in monetary terms, in addition, such indicators as price, production costs, and government support are adjusted by the deflator of gross domestic product. They are calculated for each manufacturer, region, and year. These indicators are used for econometric estimation of functions of sown areas, shares of areas of separate cultures, and productivity. For the Baseline Scenario, it is assumed that during the forecast period 2021-2030, the real values of production costs will remain unchanged, i.e. at the level of 2020.

The database used, i.e. the specialized statistical forms used in Ukraine, includes data on the total annual value of leased land. Thus, to determine the cost per hectare of leased land for a particular crop, the following calculations were performed: first, the total value of leased land is divided by the area of leased land to estimate the average lease value per hectare; secondly, to adjust the area of land owned by the producer.

Next, we conducted an econometric assessment of grain areas.

The sown area of the crop is calculated in the model using a two-stage procedure. First, the area of cereals was estimated (Formula 3). According to Formula 3, the area of grain/oil producers of group ***m*** in region ***k*** in year ***t*** (*HAj, m, k, t*) depends on the trend of this indicator (*Trendt*), the adjusted expected total profit from grain/oil (*AEGMj, m, k, t*), calculated, the adjusted expected total profit from the group of substitute crops (*AEGMj, m, k, t*) and the number of producers in group m in the region ***k*** (*Nm, k*). The trend is included due to the clear influence of time on the development of this indicator (i.e., increase or decrease in crop area over time). Producers choose between groups of cereals and oilseeds, taking into account the values of the adjusted expected total profit of both groups. AEGM of crop groups is calculated as the average AEGM of all crops in this group is weighted by their production volumes.

Because the equations were estimated for each producer group in each region, in some cases AEGM was used instead of AEGM or domestic or world prices of certain crops. Note that the number of producers in each group and region is determined by us at the level of 2014.

The share of crops in cereals for modelling purposes is calculated by us according to Formula 4. According to Formula 4, the share of crops ***i*** in the area of the group of crops (cereals or oilseeds), producer of group ***m*** in region ***k*** and year ***t,*** in most cases depends on the trend and values of the adjusted expected total profit of this crop and substitute crops. The latter must belong to the same group of cultures as culture ***i***. In other words, after deciding on the total area of grain and oilseeds, the producer chooses among the crops of each group. The choice of substitute crops in a particular equation is based on the production structure of a particular producer in a given region and the statistical significance of the corresponding coefficient.

For groups of crops, the proportion of one of the crops is a residue, so that the sum of the corresponding shares, in the end, was 100%.

We conducted an econometric assessment of crop yields. The estimation of crop yield is determined based on Formula 5.

Table 1. The results of forecasting the dynamics of some exogenous variables of the «AGMEMOD-Ukraine» model for 2023 – 2030

Macroeconomic factors	2017	2019	2021	2023	2025	2027	2029	2030
Population, million people	42.4	41.8	41.3	40.7	40.1	39.5	38.9	38.6
Real GDP in 2000 prices, UAH billion	241.9	260.1	281.2	303.2	328.2	355.8	385.8	401.7
GDP deflator (2000 = 1), UAH basis	9.9	11.1	12.4	13.5	14.5	15.6	16.6	17.1
Exchange rate, UAH / EURO	33.5	29.7	32.7	28.3	27.9	27.7	27.4	27.2
World prices:								
Wheat, USD per ton	211.7	213.1	224.0	233.2	236.9	239.9	242.9	244.4
Corn, USD per ton	163.0	165.9	175.9	182.2	186.7	192.3	198.2	201.2

Source: [43].

Thus, according to the analysis of Table 1 note that starting from 2027, world prices are own calculations based on the trend and the OECD-PSO. The model takes into account the values of each year from 2017 to 2030. The years listed in Table 1 are chosen based on ease of presentation. That is, based on Table 1, we can graphically display the results of our forecast (Fig. 2).

Note that the blue area in the diagram shows the estimated forecast values (Fig. 2, Table 2).

According to the results of the analysis of forecast indicators, we found that in 2030 compared to 2008-2014, the forecast estimates of the model indicate an increase in corn production by 8.3% (up to 21.2 million tons, Fig. 3).

Enterprises with a cultivated area of more than 5,000 hectares and family farms located in the Donbas region are estimated to have the largest increase in production: + 89.4% (up to 96.3 thousand tons) and + 132.9% (up to 233.3 thousand tons), respectively.

Table 2. Results of forecasting for 2030. Area and yield of wheat by producer groups and regions in Ukraine

Producer group	Area, 1,000 hectares Yield, t / ha	Indicator in 2030	Change compared to 2008–2014,%
Mixed forests			
Enterprises ≥ 5,000 ha	Area	134.9	46.2
	Yield	4.6	12
Enterprises < 5,000 ha	Area	631.5	142.6
	Yield	3.8	12.6
Family farms	Area	46.1	1.3
	Yield	4.6	37.4
The region, in general	Area	812.5	104.1
	Yield	4	12.6

Source: adapted from the «AGMEMOD-Ukraine» model

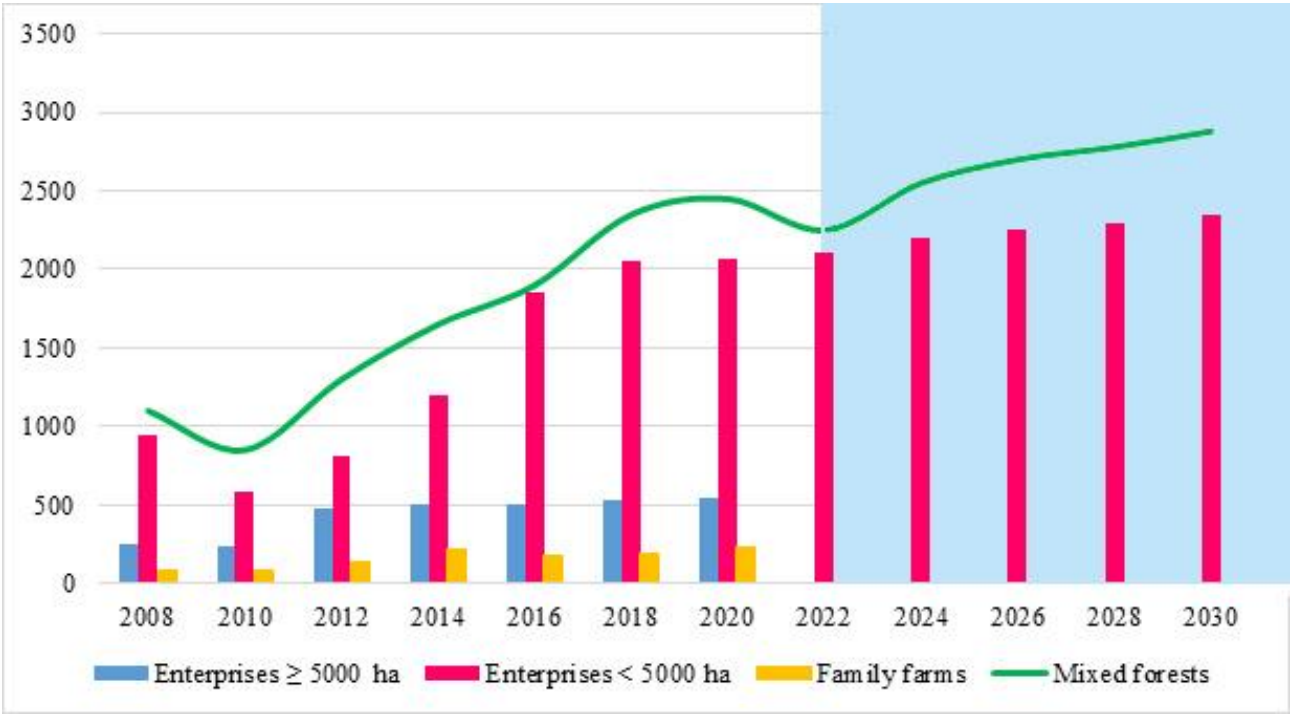

Fig. 2. Results of forecasting wheat production for 2030 by producer groups in the mixed forest zone in Ukraine, thousand tons
Source: adapted from the «AGMEMOD-Ukraine» model.

Enterprises with an area of fewer than 5,000 hectares located in the forest-steppe zone will produce the largest amount of corn, 5.5 million tons. In addition, enterprises with less than 5,000 hectares located in the Donbas region of Ukraine will provide the smallest amount of corn – 0.8 thousand tons – 99.3%.

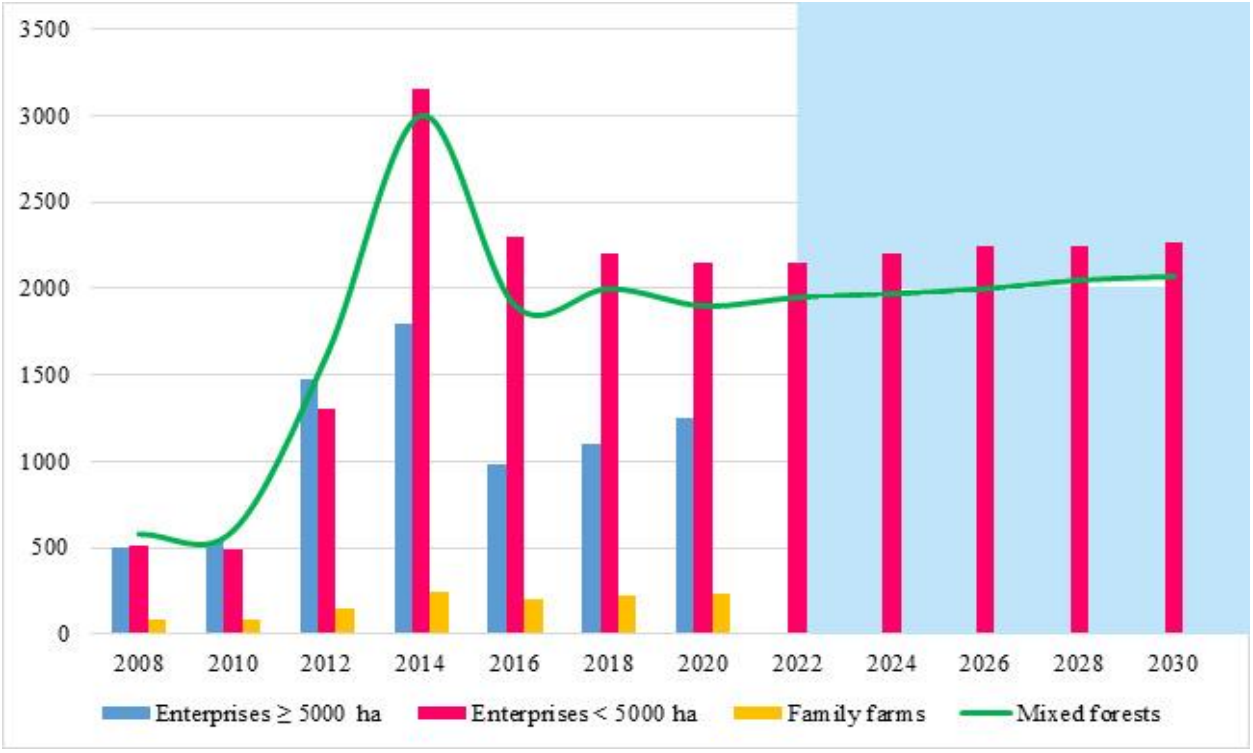

Fig. 3. Expert forecast of corn production by producer groups by regions of Ukraine in 2008–2030, thousand tons
Source: adapted from the «AGMEMOD-Ukraine» model.

It is established that state-owned enterprises are projected to produce 58.7 thousand tons of corn, which is 47.1% less than in 2008–2014. The results of the expert forecast of corn production by producer groups by regions of Ukraine in 2008–2030 are presented in Fig. 3.

It should be noted that the blue area in the diagram shown in Fig. 3 (Table 3), shows the estimated forecast values (namely, the values for 2022–2030).

According to forecast estimates, corn exports in Ukraine by 2030 will decrease by 13.1% (to 9.3 million tons), and imports will remain at a fairly low level – about 18.8 thousand tons.

Due to the increase in poultry production, the use of corn for feed is increasing, thus affecting the volume of exports. In particular, the use of corn for fodder in Ukraine in 2030 will be estimated at about 8.8 million tons, which is 27.1% more than in 2008–2014.

According to the forecast we have substantiated that the use of corn for food in Ukraine will decrease by 14.3% (up to 451.9 thousand tons), which is a consequence of the reduction in per capita consumption and population decline.

Table 3. Results of forecasting for 2030. Area and yield of corn by producer groups and regions in Ukraine

Producer group	Area, 1,000 hectares Yield, t / ha	Indicator in 2030	Change compared to 2008–2014,%
Mixed forests			
Enterprises ≥ 5,000 ha	Area	146.6	-13.4
	Yield	7.5	19.9
Enterprises < 5,000 ha	Area	271.5	34
	Yield	8.1	33.1
Family farms	Area	19.7	-0.2
	Yield	10.6	69.4

Source: developed by the author based on the «AGMEMOD-Ukraine» model.

In the process of forecasting the population, we took into account the assumption that in Ukraine, the population will increase by 1%. Visualization of the results of such forecasting of the population of Ukraine in the baseline and optimistic scenarios is shown in Fig. 4.

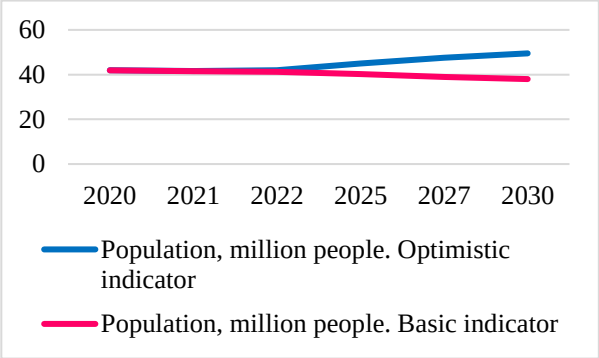

Fig. 4. Results of the population forecast in Ukraine according to the baseline and optimistic scenarios
Source: developed by the author based on the «AGMEMOD-Ukraine» model.

Thus, it is worth concluding that the scenario of development of key performance indicators of agricultural producers in Ukraine according to the «AGMEMOD-Ukraine» model provides for increased yields in all categories of farms, which, in our opinion, includes the import of new varieties and new technologies for plant and crop protection.

CONCLUSIONS

The application of the «AGMEMOD–Ukraine» model allowed conduct forecasting the development indicators of agricultural producers in the context of sustainable rural development, namely: yield, gross harvest and sown areas of major crops, changes in demographic indicators on the basic and optimistic forecast, the results of which allow competitive strategies, the implementation of which will increase the volume of sales, profits, market share, penetration into a new market segment, etc.

We believe that the use of the model «AGMEMOD–Ukraine», which covers the multicriteria measurement of functional components of agricultural producers, provides an opportunity to analyze and predict not only key competitive advantages but also secondary characteristics, which together have a significant impact on solving problems of strategic management of economic efficiency and competitiveness of agricultural enterprises in Ukraine.

According to the results of the study, we have identified the main strategic goals and priority

areas for the development of agricultural producers. In particular, we have grouped and identified the following blocks of strategic goals:

1. Logistics and maintenance unit. The strategic goal here should be the modernization of the material and technical base of enterprises, which is aimed at improving the quality of products and the competitiveness of regional producers. To achieve this goal, the maximum renewal of fixed assets should be identified as a priority area for development.
2. The block of agricultural production, the strategic goals of which, in our opinion, should be to increase crop production; improving the quality of raw materials to ensure its compliance with the technologies of processing enterprises. Increasing the level of productivity and compliance with international quality standards in agricultural production should be a priority to achieve this strategic goal.
3. The infrastructure unit is divided into production, trade, and social infrastructure, each of which has its own strategic objectives. Thus, for the production infrastructure, the strategic goal should be to increase the level of development of storage facilities and warehouses, to store crops in order to sell them at affordable prices.

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