Abstract

The article provides a theoretical and conceptual study of the concept of "sustainability of the agricultural sector in the region" which is completed by "intellectual innovative" component. The factors of influence on the sustainability of Vinnitsa regional agricultural sector are defined. For the first time an economic and mathematical forecasting model of sustainability of the agricultural sector in the region based on the theory of fuzzy logic was developed. An interactive decision support system for managing sustainability of the agricultural sector in the region is developed.

Key words: *sustainability, agricultural industry, model, control, fuzzy logic, decision support system.*

Rapid dynamics of modern living in a market system of coordinates generates new research problems, activates methodological searches and forms new paradigms in research of economic processes. Among these allocated problem of sustainability management and development of the agricultural sector in Ukrainian region through the use of innovative methods of economic and mathematical modeling. The necessity and actuality of modeling and forecasting of sustainability of the agricultural sector development in the region is caused by the fact that during the market reforms underestimation of the economy regulation process was found out and, as a result, inadequate with potential possibilities using by the state management system. This underlines the great importance of this problem that actually caused the subject of this study.

The aim of this work is a theoretical research of the concept of "sustainability of the agricultural sector development in the region" and construction of economic and mathematical model for determining and forecasting the level of sustainability of the agricultural sector of Vinnitsa region based on the theory of fuzzy logic.

Currently, in the economic literature, there is no single and generally accepted definition of sustainability of the agricultural sector, because of the inconsistency and underdevelopment the concepts of sustainability of economic systems development, lack of sufficient information for quantitative measurement of the sustainability degree. Some authors understand sustainability (including agriculture) as the ability of the agricultural sector to counteract negative influences, mainly elemental forces of nature, and also its ability to prevent or weaken the production decline [10,17].

Other researchers consider the sustainability of the agricultural sector development as the sustainability of the average level dynamic row of production volumes and crop yields [15], others - as sustainability of evolution, development of investigated phenomenon [3]. However, in our view the concept of sustainability is not limited by only these features. Sustainability of agrarian development - is not only an opportunity to overcome the adverse effects for agricultural production, but also the ability to use them with the highest effect.

Without denying the contribution of mentioned scientists in the development of the theory of agrarian production sustainability, it should be noted, that recent reforms conducted in the agri-food sector largely were aimed at the regionalization of the economy, its orientation on self-providing. Therefore, the reproductive processes which are being occurred now in the agricultural sector, it is better to consider at the regional level. Furthermore, assessment of sustainability of the agricultural sector development will not be complete due to the magnitude of dynamic rows fluctuation, because it does not allow taking into account social, economic and environmental consequences of sustainable (or unsustainable) development of the agricultural sector. It is necessary to understand that the sustainability of the agricultural sector development achieved not only by meeting the needs (demand) of the population in food through its mass production. The sustainability of the agricultural sector development should be seen as a category of reproduction, therefore sustainable can be such a variant of development that, allowing fluctuations of production output in some years, providing full compensation of recurring food shortages at the expense of previously established reserves and stocks. However, this applies not to all types of products (for example, grain) since the bulk of agricultural products has limited period of storage.

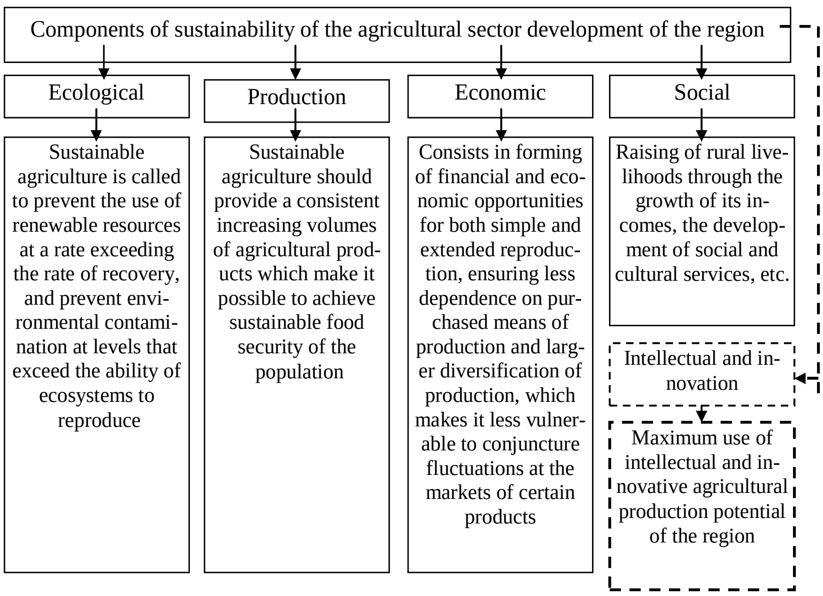
The variety of approaches to determine sustainability of agricultural production caused by both the versatility of this problem and the extraordinary complexity of tasks solved agrarian industry as a whole and its components. The searching for new directions and ways of the development of agricultural sector, that reduces its negative impact on the environment, led to the emergence of a new interpretation of agricultural production sustainability as production oriented to increasing the quality of food and quality of life, to ensuring the safety of the environment and stabilization of the food supply of population in a long term. This approach, which can be called environmental [2], the notion of "sustainability of the agricultural sector development of the region" distinguishes the following components: ecological, production, economic and social. Supplement existing components of sustainability of the agricultural sector development (see picture 1) with "intellectual innovation" component is offered.

Let’s consider intellectually innovative component of sustainability of the agricultural sector development of the region in more details.

The first component - is intellectual potential. Unambiguous and generally accepted definition of "intellectual potential" does not exist. Availability of intellectual potential suggests primarily mental capabilities of people and intellect capabilities. A widespread definition is the following: intellectual potential - is the unity of creative and individual labor potentials of workers which characterize their ability to produce material goods using materialization of knowledge and their adequacy to management requirements [8].

The second component – is innovative potential. Currently, the economic activity requires so-called innovative potential, which is interpreted as collection of all kinds of information resources, including technological documentation, patents, licenses, business plans, innovative programs, etc. The state of innovative potential affects the choice of one or another development strategy therefore innovative potential in this case can be interpreted as "measure of readiness" of the economic system to accomplish the objectives of development [8].

Thus, the essence of a systematic approach to the interpretation of sustainability of the agricultural sector development of the region consists of the analysis a balanced production achievement, economic, social, ecological and intellectual-innovative goals facing the agricultural sector of the region.



Picture 1. Components of "sustainability of the agricultural sector development of the region"

For modeling sustainability of the agricultural sector development of Vinnitsa region is proposed to use the most advanced mathematical apparatus - the theory of fuzzy logic which is successfully used in other fields of human activity [5,7,8, 9,11]. The theory of fuzzy logic in technical systems is investigated by L. Zadeh, O. Rotshtein, S. Shtovba and others [14,16] in economic systems by S. Kozlovskyi, A. Matviichuk, Y. Gerasymenko, G. Pchelyanska, B. Kozlovskyi [8, 11], but for modeling sustainability of the agricultural sector development of Vinnitsa region, it is proposed for the first time. Advantages of the theory of fuzzy logic over other mathematical apparatus are given in [6 p. 53], which are the basis for using the theory of fuzzy logic for solving the problem.

Basic methodology of modeling is based on the theory of fuzzy logic envisages a phased solution of such problems [8]: a definition of main factors of influence which characterize the sustainability of the agricultural sector of the region and formalizing the relationships between them in generalized form; definition and formalization of linguistic estimates of factors; construction of fuzzy knowledge base of the interactions between factors; output of fuzzy logic equations based on fuzzy linguistic assessments and knowledge base; optimization of fuzzy model parameters.

Taking into account the basic principles for modeling the sustainability of the agricultural sector development of the region and conceptual apparatus of the theory of fuzzy logic, input factors of model for determining the sustainability of the agricultural sector of the region is given in table 1.

Table 1

Input factors (variables) of model and its linguistic assessment

Input factor (variable)	Name of the input parameter (of variable)	Range of the input parameter	Linguistic assessment of input parameters (terms)
1	2	3	4
x_1	Gross agricultural output in the region	10-30 billion UAH	Low, 10-15 billion UAH, (H) Average, 15-25 billion UAH, (C) High, more than 25 billion UAH, (B)
x_2	Grain and leguminous crops production in the region	20-70 million quintal	Low, до 20-30 million quintal (H) Average, 30-40 million quintal, (C) High, 40 -70 million quintal, (B)
x_3	Sugar beet production in the region	15-50 million quintal	Low, till 15-20 million quintal, (H) Average, 20-35 million quintal, (C) High, 35-50 million quintal, (B)
x_4	Rapeseed production in the region	1-8 million quintal	Low, 1-2 million quintal, (H) Average, 2-4 million quintal, (C) High, 4-8 million quintal., (B)
x_5	Meat production (slaughter weight) in the region	150-400 thousand tons	Low, 150-200, (H) Average, 200-300, (C) High, 300-400, (B)
x_6	Milk production in the region	800-950 thousand tons	Low, 800-850, (H) Average, 850-900, (C) High, 900-950, (B)
x_7	Profitability whole enterprises activities of the agricultural sector in the region	3-50 %	Low, 3-5%, (H) Average, 5-20%, (C) High, 20-50%, (B)
x_8	Average prices of grain and leguminous crops in the region	1-4 thousand UAH per ton	Low, 1-2, (H) Average, 2-3, (C) High, 3-4, (B)
x_9	Average prices of animal husbandry in the region	2-8 thousand UAH / ton	Low, 2-3 thousand UAH / ton, (H) Average, 3-6 thousand UAH / ton, (C) High, 6-8 thousand UAH / ton, (B)
x_{10}	Average prices for milk and dairy products in the region	1-7 thousand UAH / ton	Low, 1-2 thousand UAH / ton, (H) Average, 2-4 thousand UAH / ton, (C) High, 4-7 thousand UAH / ton, (B)
x_{11}	Balance of foreign trade in Vinnitsa region	30-50 million U.S. $	Negative -30-0 million U.S., (HH) Low, 0-10 million U.S., (H) Average 10-30 million U.S., (C) High, 30-50 million U.S., (B)
x_{12}	Investments in agriculture of Vinnitsa region	500-3000 million UAH	Low, 500-1000 million UAH, (H) Average, 1000-2000 million UAH, (C) High, 2000-3000 million UAH, (B)
x_{13}	The amount of subsidies in agriculture from the state budget	50-300 million UAH	Low, 50-100 million UAH, (H) Average 100-200 million UAH, (C) High, 200-300 million UAH, (B)
x_{14}	The inflation rate in Ukraine	0-50 %	Low, 0-2 %, (H)

			Average, 2-10 %, (C) High, 10-50 %, (B)
x_{15}	The level of disposable income per capita in the region	10-70 thousand UAH / year	Low, 10-20 thousand UAH / year, (H) Average, 20-40 thousand UAH / year, (C) High, 40-70 thousand UAH / year, (B)
x_{16}	The average wage in the region	1-7 thousand UAH / month	Low, 1-2 thousand UAH / month, (H) Average, 2-4 thousand UAH / month, (C) High, 4-7 thousand UAH / month, (B)
x_{17}	The average number of workers employed in agricultural production in the region	25-50 thousand people / year	Low, 20-30 thousand people / year, (H) Average, 30-40 thousand people / year, (C) High, 40-50 thousand people / year, (B)
x_{18}	The number of agricultural enterprises in the region	1-3 thousand units / year	Low, 1-1,5 thousand units / year, (H) Average, 1,5-2 thousand units / year, (C) High, 2-3 thousand units / year, (B)
x_{19}	Indices of consumer prices of goods and services in the region	50-150 %	Low, 50-90 %, (H) Average, 90-110 %., (C) High, 110-150%., (B)
x_{20}	The volume of sown areas of basic agricultural crops in the region	1-2 million hectares	Low, 1-1,2 million hectares, (H) Average, 1,2-1,7 million hectares, (C) High, 1,7-2 million hectares, (B)
x_{21}	Yields of grain and leguminous crops in the region	30-70 quintals per hectare	Low, 30-40 quintals per hectare, (H) Average, 40-50 quintals per hectare, (C) High, 50-70 quintals per hectare,(B)
x_{22}	Yields of sugar beet	200-700 quintals per hectare	Low, 200-300 quintals per hectare, (H) Average, 300-400 quintals per hectare, (C) High, 400-700 quintals per hectare, (B)
x_{23}	Yields of rapeseed	10-40 quintals per hectare	Low, 10-15 quintals per hectare, (H) Average, 15-30 quintals per hectare, (C) High, 30-40 quintals per hectare, (B)
x_{24}	Emissions of polluting substances into the air of the region	30-200 thousand ton	Low, 30-80 thousand ton, (H) Average, 80-120 thousand ton, (C) High, 120-200 thousand ton, (B)
x_{25}	Natural disasters in the region	0-100 points	Low, 0-25, (H) Average, 25-50, (C) High, 50-100, (B)
x_{26}	Intellectual potential of the region	0-100 points	Low, 0-30, (H) Average, 30-60, (C) High 60-100, (B)
x_{27}	Innovative potential of the region	0-100 points	Low, 0-30, (H) Average, 30-60, (C) High 60-100, (B)
x_{28}	The level of political stability in the country	0-100 points	Low, 0-30, (H) Average, 30-60, (C) High 60-100, (B)

For establishing the hierarchical relationships between the factors that affect the sustainability of the agricultural sector of the region group them into the following groups: production (a); economic and financial (e); social (s); natural and environmental (p); expert and intellectual factors (i). These groups of factors are given in the form of an "output tree" (see pictures 2-6).

According to pictures 2-6 linguistic variables factors a, e, s, p, i are defined using the following correlations:

$$a = f_a(x_1, x_2, x_3, x_4, x_5, x_6, x_7), \quad (1)$$

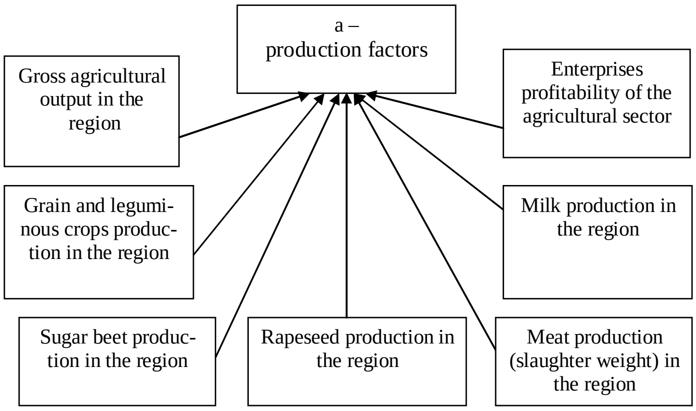
$$e = f_e(x_8, x_9, x_{10}, x_{11}, x_{12}, x_{13}, x_{14}), \quad (2)$$

$$s = f_s(x_{15}, x_{16}, x_{17}, x_{18}, x_{19}), \quad (3)$$

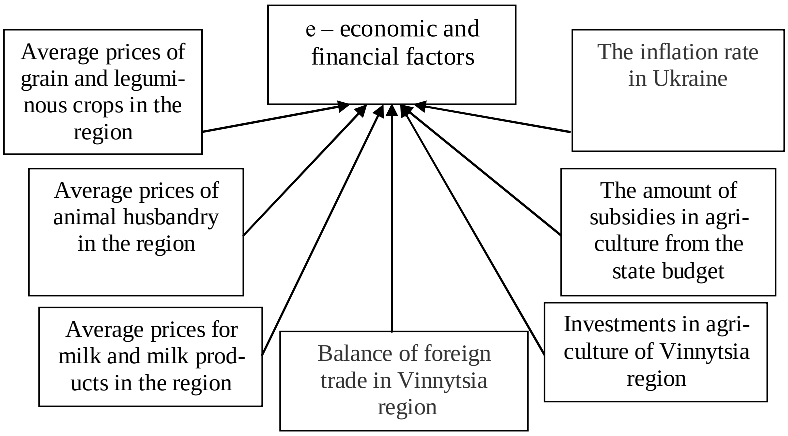
$$p = f_p(x_{20}, x_{21}, x_{22}, x_{23}, x_{24}, x_{25}), \quad (4)$$

$$i = f_i(x_{26}, x_{27}, x_{28}), \quad (5)$$

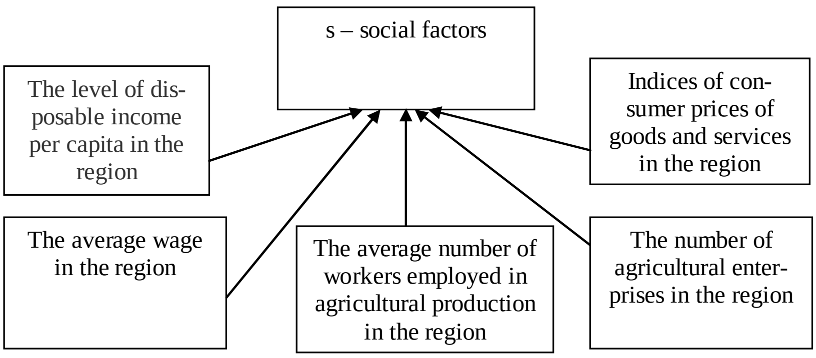
where $x_1 \div x_7$ – production factors; $x_8 \div x_{14}$ – economic and financial factors; $x_{15} \div x_{19}$ – social factors; $x_{20} \div x_{25}$ – natural and environmental factors; $x_{26} \div x_{28}$ – expert and intellectual factors.



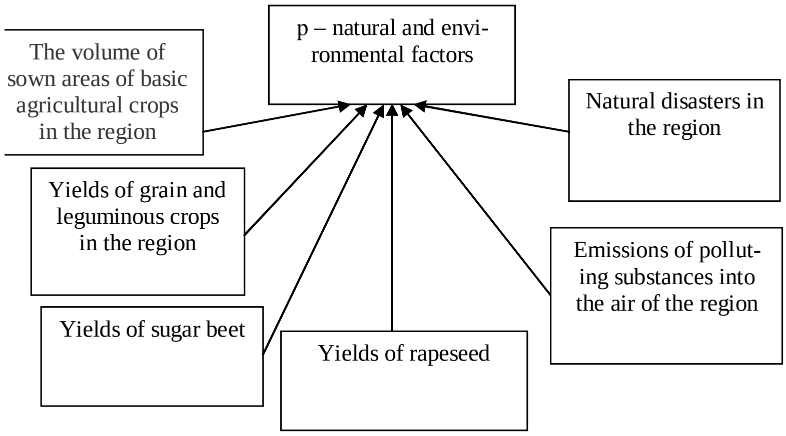
Picture 2. Classification of production factors



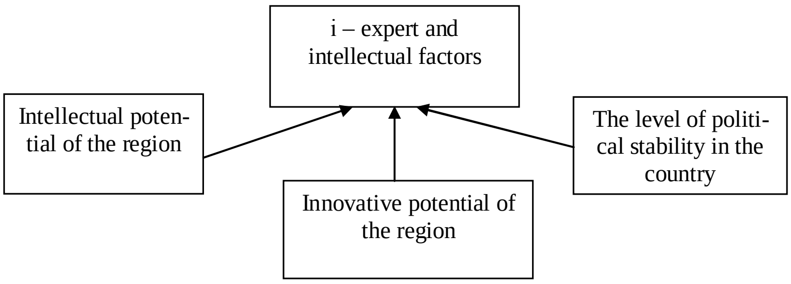
Picture 3. Classification of economic and financial factors



Picture 4. Classification social factors



Picture 5. Classification of natural and environmental factors



Picture 6. Classification of expert and intellectual factors

The output magnitude, that is sustainability of the agrarian sector of Vinnitsa region Y, is defined by the formula:

$$Y = f_Y(a, e, s, p, i, t), \quad (6)$$

where a,e,s,p,i and t – linguistic variables describing respectively industrial, economic and financial, social, natural and ecological, expert-intellectual factors and forecasting period (1M, 6M, 1P, 2P, 3P, where letters M and P indicate a month and a year).
According to the economic situation and the accepted principles of modeling possible changes of sustainability of Vinnitsa regional agrarian sector the following levels are defined (on a scale from 0 to 100):

– Y_1 (85-100) – excellent sustainability (class A or 1);
– Y_2 (66-84) – good sustainability (class B or 2);
– Y_3 (51-65) – satisfactory sustainability (class C or 3);
– Y_4 (31-50) – unsatisfactory sustainability (class Д or 4);
– Y_5 (0-30) – absolute sustainability (class E or 5).

Table 1 shows the universal sets and estimated terms of impact factors $x_1 \div x_{28}$, an assessment of the generalized indicators a,e,s,p,i will implement by a single point scale with a range from "0" to "100" points, using the terms "Low" 0-30 (H), "Medium"30-50 (C), "Above average" 50-75 (BC), "High"75-100 (B). Denote forecast period by t and select the following periods: t_1=1 month; t_2=6 months; t_3=1 year; t_4=2 years; t_5=3 years.

The structure of the economic model of sustainable development management of the agrarian sector of Vinnitsa region is presented in the form of so-called "logical conclusion tree." Logical conclusion tree – is a graph which shows logical connections between forecasting indicator Y and factors $\{x_1 \ldots x_{28}\}$, that affect this forecasting indicator Y compliance with correlations given in formulas (1)-(5).

The structure of economic-mathematical model of sustainable development management of the agrarian sector of Vinnitsa region will have the form shown in Picture 7.

The analysis of the given model of sustainable development management of the agrarian sector of Vinnitsa region, indicates that this model actually consists of five other interrelated models: a model of sustainability of production branch in the region; a model of sustainability of economic and financial system in the region; a model of sustainability of social system in the region; a model of sustainability of natural-ecological system of the region; a model of sustainability of expert-intellectual level of the region.

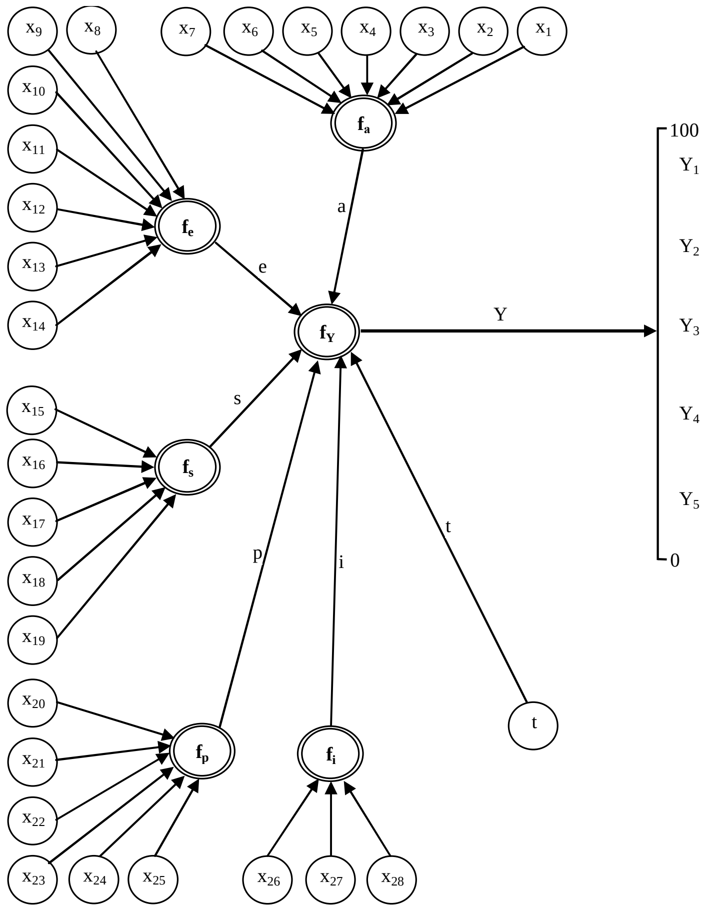
While constructing the model input quantitative and qualitative parameters are operated simultaneously. The input parameters $\{x_1 \ldots x_{24}\}$ are quantitative, and to describe them statistical data are used; parameters $\{x_{25} \ldots x_{28}\}$ – are qualitative, therefore to describe them a conditional point scale assessments from "0" to "100" points is used.

The theory of fuzzy sets presupposes the levels' definition (terms) of the output indicator changes. Each term is submitted by fuzzy set with the appropriate membership function.

For description of terms proven method is used [5,6,7,8,9,11,14,16], therefore for the construction of terms of all variables of determining and predicting model of sustainability indicator of the agrarian sector of Vinnitsa region the formula is used (7). At the same time the terms presented in the form of fuzzy sets, using the model of membership function (MF):

$$\mu^T(x) = \frac{1}{1 + \left[\frac{x-b}{c}\right]^2}, \qquad (7)$$

where b and c - MF parameters; b - coordinate of the maximum of function; c - concentration factor of stretching.



Picture 7. Structural model of sustainable development management of agrarian sector of Vinnitsa region

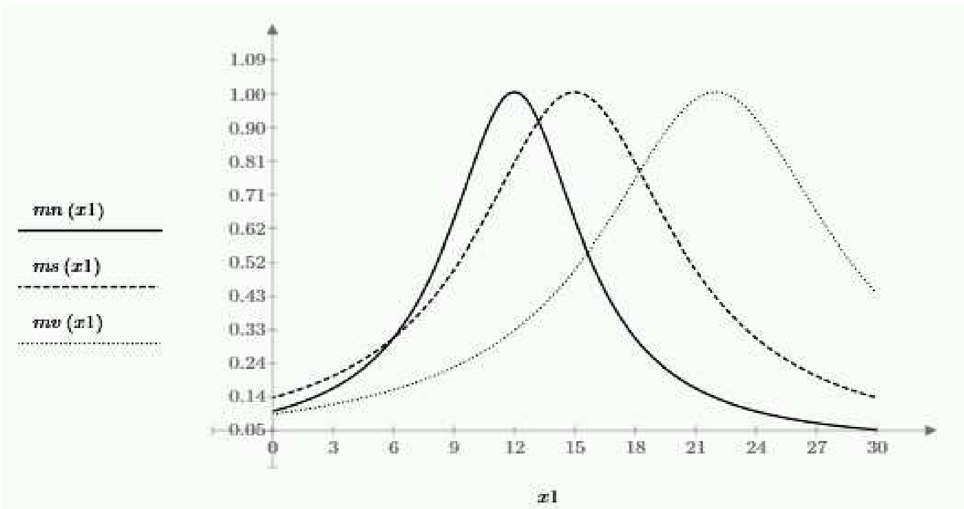
Value of the coefficients b and c for the variable x_1 is given in table 2 (for example).

Table 2

Value of the parameters b and c membership functions of variables x_1 and x_2

Input variables (parameter)	Name of the input variable (parameter)	Linguistic assessment of input variables (terms)	b	c
x1	Gross agricultural production in the region, billion UAH	H C B	12 15 22	4 6 7

The choice of membership function (see formula 7) of this type is due to the fact that it is enough flexible and simple, because it is defined by only two parameters, and also is more convenient for the further establishment of the model. For example, the membership function for variable x_1 is presented in picture 8.



Picture. 8. Membership function for variable x_1

The next step of modeling is to formulate a hierarchical knowledge base. For building the knowledge base information obtained from experts of The Department of Agroindustrial Development and the Department of Regional Economic Development of Vinnitsa Regional State Administration and the Main Department of Statistics in Vinnitsa region is used, factographic information of central executive authorities of Ukraine and information of specialists in this branch.

Let's consider the correlation (6). To estimate the importance of linguistic variables which show causal relationship between the sustainability of the agrarian sector of Vinnitsa region Y and production, economic-financial, social, natural-ecological, expert-intellectual factors the term-set system is used, that is suggested above. Then the knowledge base for the variable Y, which characterizes the sustainability of the agrarian sector of Vinnitsa region, will have the form shown in table 3.

Table 3

Knowledge base of variable Y

a	e	s	p	i	t	Y	w
H	H	H	H	H	1M	Y_5	w_1
H	C	C	H	H	6M	Y_5	w_2
C	H	C	H	H	1P	Y_5	w_3
H	C	H	C	C	6M	Y_4	w_4
C	C	H	H	C	1P	Y_4	w_5
C	H	C	C	H	3P	Y_4	w_6
C	C	C	C	C	1M	Y_3	w_7
BC	H	C	BC	BC	1P	Y_3	w_8
B	H	B	H	H	2P	Y_3	w_9
C	BC	BC	BC	H	1P	Y_2	w_{10}
BC	C	BC	C	C	2P	Y_2	w_{11}
B	B	B	H	C	3P	Y_2	w_{12}
B	B	B	B	B	6M	Y_1	w_{13}
B	BC	BC	BC	C	2P	Y_1	w_{14}
BC	B	B	BC	B	3P	Y_1	w_{15}

Each rule of knowledge base represents an expression "IF-THEN". Rules with the same output parameter are integrated into the rows of tables by the logical statement "OR". The weight of rules of w expresses a subjective confidence of the expert in this rule. At the stage of formation of fuzzy model structure of all rules weight of knowledge base equal to unity is taken [8].

To implement the fuzzy logic conclusion it is necessary to make the transition from logical expressions to fuzzy logic equations [14]. Such equations are obtained by replacing the linguistic values with the value of membership functions and operations "AND" and "OR" - with fuzzy logic operations of intersection $\wedge$ and union$\vee$. The Weight of rules in the knowledge base is taken into account by multiplying fuzzy expression, which corresponds to each row of base, by the appropriate value of weight.

Linguistic expressions shown in table 3 correspond to the following fuzzy logic equation - see. Formula 8-12.

$$\begin{aligned}\mu^{Y_5}(Y) = w_1 \cdot [\mu^H(a)\cdot\mu^H(e)\cdot\mu^H(s)\cdot\mu^H(p)\cdot\mu^H(i)\cdot\mu^{1M}(t)]\vee \\ w_2 \cdot [\mu^H(a)\cdot\mu^C(e)\cdot\mu^C(s)\cdot\mu^H(p)\cdot\mu^H(i)\cdot\mu^{6M}(t)]\vee \\ w_3 \cdot [\mu^C(a)\cdot\mu^H(e)\cdot\mu^C(s)\cdot\mu^H(p)\cdot\mu^H(i)\cdot\mu^{1P}(t)];\end{aligned} \quad (8)$$

$$\begin{aligned}\mu^{Y_4}(Y) = w_4 \cdot [\mu^H(a)\cdot\mu^C(e)\cdot\mu^H(s)\cdot\mu^C(p)\cdot\mu^C(i)\cdot\mu^{6M}(t)]\vee \\ w_5 \cdot [\mu^C(a)\cdot\mu^C(e)\cdot\mu^H(s)\cdot\mu^H(p)\cdot\mu^C(i)\cdot\mu^{1P}(t)]\vee \\ w_6 \cdot [\mu^C(a)\cdot\mu^H(e)\cdot\mu^C(s)\cdot\mu^C(p)\cdot\mu^H(i)\cdot\mu^{3P}(t)];\end{aligned} \quad (9)$$

$$\begin{aligned}\mu^{Y_3}(Y) = w_7 \cdot [\mu^C(a)\cdot\mu^C(e)\cdot\mu^C(s)\cdot\mu^C(p)\cdot\mu^C(i)\cdot\mu^{1M}(t)]\vee \\ w_8 \cdot [\mu^{BC}(a)\cdot\mu^H(e)\cdot\mu^C(s)\cdot\mu^{BC}(p)\cdot\mu^{BC}(i)\cdot\mu^{1P}(t)]\vee \\ w_9 \cdot [\mu^B(a)\cdot\mu^H(e)\cdot\mu^B(s)\cdot\mu^H(p)\cdot\mu^H(i)\cdot\mu^{2P}(t)];\end{aligned} \quad (10)$$

$$\begin{aligned}\mu^{Y_2}(Y) = w_{10} \cdot [\mu^C(a)\cdot\mu^{BC}(e)\cdot\mu^{BC}(s)\cdot\mu^{BC}(p)\cdot\mu^H(i)\cdot\mu^{1P}(t)]\vee \\ w_{11} \cdot [\mu^{BC}(a)\cdot\mu^C(e)\cdot\mu^{BC}(s)\cdot\mu^C(p)\cdot\mu^C(i)\cdot\mu^{2P}(t)]\vee \\ w_{12} \cdot [\mu^B(a)\cdot\mu^B(e)\cdot\mu^B(s)\cdot\mu^H(p)\cdot\mu^C(i)\cdot\mu^{3P}(t)];\end{aligned} \quad (11)$$

$$\begin{aligned}\mu^{Y_1}(Y) = w_{13} \cdot [\mu^B(a)\cdot\mu^B(e)\cdot\mu^B(s)\cdot\mu^B(p)\cdot\mu^B(i)\cdot\mu^{6M}(t)]\vee \\ w_{14} \cdot [\mu^B(a)\cdot\mu^{BC}(e)\cdot\mu^{BC}(s)\cdot\mu^{BC}(p)\cdot\mu^C(i)\cdot\mu^{2P}(t)]\vee \\ w_{15} \cdot [\mu^{BC}(a)\cdot\mu^B(e)\cdot\mu^B(s)\cdot\mu^{BC}(p)\cdot\mu^B(i)\cdot\mu^{3P}(t)].\end{aligned} \quad (12)$$

In these equations, letters „H”, „C”, „BC”, „B” abbreviated form marked the names of terms "Low", "Average", "Above average" and "High".

Significance of levels of membership functions in equations (8) - (12) are determined by fuzzy knowledge bases of production, economic-financial, social, natural-ecological, expert-intellectual factors of development.

Fuzzy Logic Equations (8) - (12) is a mathematical implementation of model of sustainable development management of the agrarian sector of Vinnitsa region.

Defuzzification is the last stage of the modeling and represents an inverse transformation of the found fuzzy expression (conclusion) in the estimated or forecasted output parameter (variable) which is subjected to modeling and forecasting. There are various methods of defuzzification, the selection and application of which depends on an object of modeling [8].

Based on the characteristics of modeling object and the character of output parameter (variable) for solving logical equations defuzzification method is chosen, which is called "expanded method of center of weights" [1]. In this case, when the output parameter (variable) has "n" terms, the calculation of the center of weights is reduced to the solution of equation (13):

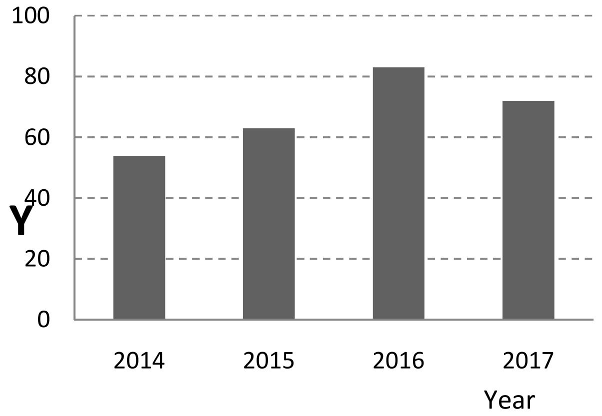
$$Y = \frac{\sum_{i=1}^{n}\left[Y_E + (i-1)\cdot\frac{Y_A - Y_E}{n-1}\right]\cdot\mu^{Yi}}{\sum_{i=1}^{n}\mu^{Yi}}, \qquad (13)$$

where n - number of (discrete values) terms of the variable "Y";

$x_E(x_A)$ - lower (upper) range limit of the variable "Y";

μ^{Yi} - membership function of the variable "Y" to the fuzzy term " Y_i ".

In the mathematical package Matlab 6.1 [4] an experiment, using the foregoing method is performed. Picture 9 shows the results of application the methodology presented above of determining and forecasting the level of sustainability of the agrarian sector of Vinnitsa region to 2017.



Picture 9. Results of determination and forecasting of sustainability of the agrarian sector of Vinnitsa region

According to expert data sustainability of the agrarian sector of Vinnitsa region in 2014-2015 will be classified as class C - "satisfactory sustainability." In 2016-2017, the forecasting class of sustainability of the agrarian sector of the region will improve to class B - "good sustainability".

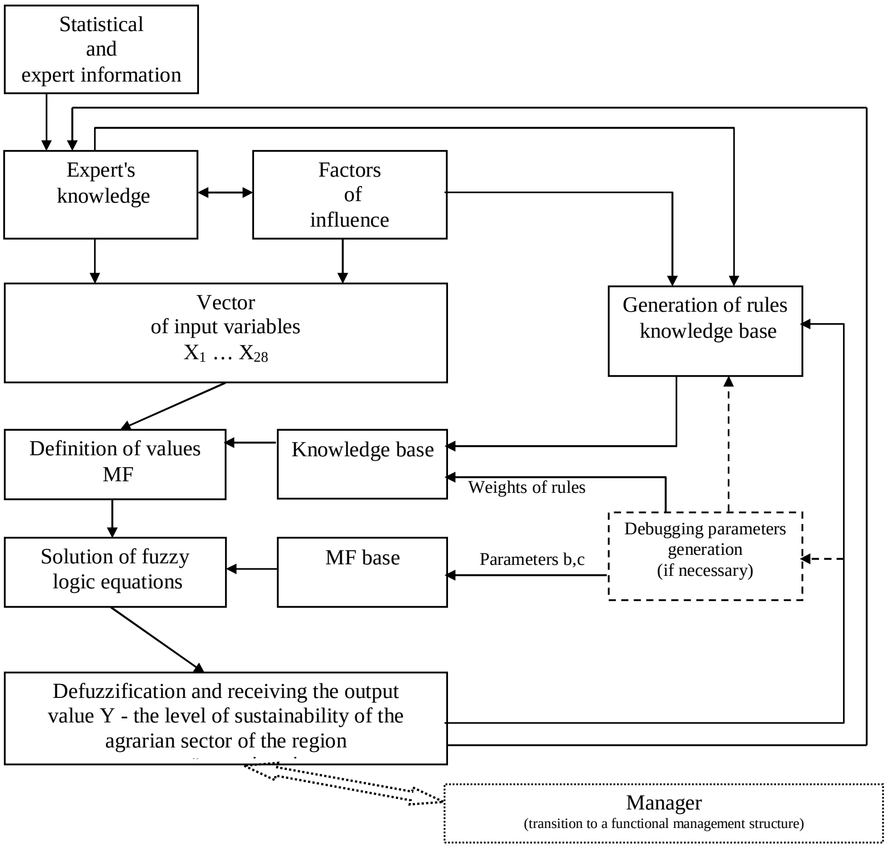
As mentioned earlier, the advantage of macroeconomic models, constructed on the basis of fuzzy logic is the ability to be used as input parameters the linguistic expressions (conclusions) of experts that largely compensate the lack of analytical dependencies between input and output parameters (variables) of prediction object.

However, the application of fuzzy logic apparatus allows to realize another advantage of this method, in particular - enables to influence the process of formation the linguistic expressions (conclusions) of experts that they do on certain issues. Models, constructed with the usage fuzzy logic, have the ability of self-learning, namely the ability to flexible rebuilding according to changes in the structure of causal relationships between input and output parameters (variables) or changes in the character of external factors [4]. This allows to construct an interactive decision support system, with regard to sustainable development of management of the agrarian sector of Vinnitsa region.

The system of decision-making and support SDMS – is an interactive automated system which, while using the appropriate models of decision-making in the agrarian market of the region, provides users with quick and efficient access to appropriate database and gives them a variety of information concerning the forecast level of sustainability of the agrarian sector of the Vinnitsa region [12].

In the database SDMS is captured and stored all the information about changes the factors of management model of sustainable development of the agrarian sector of Vinnitsa region and information about reaction of the control system to these changes (the principle of feedback) and others. The system of decision-making and support is the mechanism which helps to the forecast the level of sustainability of the agrarian sector of the region and prepare appropriate decisions in case of deviations from the desired forecast level of sustainability. Macroeconomic forecasting model of the level of sustainability of the agrarian sector of Vinnitsa region is the most difficult and the most important part of the SDMS.

Taking into consideration the foregoing decision the support system for determining the sustainability of the agrarian sector of the region it can be presented in picture 10.



Picture 10. The process of decision-making and support by using SDMS

According to experts, the process of "decision-making" in complexity and character can be compared directly with the real process of thinking. Under making decisions a single act of choosing some alternatives of their sets is understands. Among the input parameters of developed macroeconomic management model of sustainable development of the agrarian sector of Vinnitsa region are four parameters which take into account the process of human thinking. This is - reflexive parameters x_{25}-x_{28}, which reflect the result of human thinking.

Situations in which decisions are made, regarding to sustainability of agrarian sector of the region, are not always clearly defined. The main difficulties of decision making in uncertain situations lie in the inability to obtain a reliable prediction or estimation of the probability of concrete events, occurred in any given economic situation.

The developed economic-mathematical model of sustainable development management of the agrarian sector of Vinnitsa region can be considered as typical for this class of objects, and developed on its basis modeling methodology can be used for any economic process modeling, which is characterized by fuzzy connection between input and output parameters, difficulties of factors influence formalizing, possibility to attract expert’s linguistic expressions (conclusions) for constructing models and so on.

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