УПРАВЛІННЯ НАЦІОНАЛЬНИМ ГОСПОДАРСТВОМ
GOVERNANCE OF NATIONAL ECONOMY

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ЗАСТОСУВАННЯ МОЖЛИВОСТЕЙ НЕЧІТКОЇ ЛОГІКИ ДО ПРОГНОЗУВАННЯ ТЕХНОГЕННОЇ ШКОДИ В НАЦІОНАЛЬНОМУ ГОСПОДАРСТВІ

З метою дослідження теоретичних основ та прикладних проблем прогнозування техногенних збитків у національному господарстві та методів управління ними на рівні держави в статті узагальнено теоретичні засади застосування нечітких множин як ефективного математичного інструменту за умов неповноти даних та невизначеності майбутнього. Відповідно до поставлених завдань виділення концептуальних рис моделі нечіткої експертної системи для встановлення взаємозалежностей між обсягами забруднення довкілля (викиди, скиди, відходи) та погіршенням стану здоров'я населення України, а також побудови моделі прогнозування техногенних збитків у національному господарстві та її перевірки на прикладі встановленої взаємозалежності між обсягами скидів (відведених забруднених вод без очищення), викидів діоксину сірки, оксиду азоту та кількістю вперше зареєстрованих новоутворень в Україні отримано такі результати.

Модель нечіткої експертної системи для встановлення взаємозалежностей між обсягами забруднення довкілля (викиди, скиди, відходи) та погіршенням стану здоров'я населення України повинна містити базу знань із 27 логічних висловлювань типу "якщо – тоді, інакше".

Запропоновано модель прогнозування техногенних збитків в національному господарстві та встановлено її відповідність під час дослідження взаємозалежності між обсягами скидів (відведених забруднених вод без очищення), викидів діоксину сірки й оксиду азоту та кількістю вперше зареєстрованих новоутворень на 1000 осіб населення України. Встановлено, що вплив викидів і скидів забруднювальних речовин на кількість захворювань є нагромаджувальним і проявляється із часовою затримкою, тому взаємозв'язок між результатами має містити часовий лаг та показники повинні бути усереднені за значеннями обсягів впливів у визначений час.

Ключові слова: техногенні збитки, національне господарство, нечітка логіка, нечітка експертна система, техногенна шкода, прогнозування.

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THE APPLICATION OF FUZZY LOGIC TO FORECASTING OF TECHNOGENIC DAMAGE IN THE NATIONAL ECONOMY

In order to study the theoretical foundations and applied problems of predicting man-made damage to the national economy and methods of management at the state level in paper there is summarizes the theoretical foundations of the application of fuzzy sets as an effective

mathematical tool under conditions of incomplete information and uncertainty of the future. According to the allocation of tasks in the conceptual model features a fuzzy expert system to establish interdependencies between the amount of pollution (emissions, effluents, waste) and deterioration of health of Ukraine, as well as building prediction models of man-made damage to the national economy and its verification by the example of the set interdependence between the amount of discharges (drained polluted waters without treatment), and emissions of sulfur dioxide and nitric oxide and the number of newly registered tumors in Ukraine returned the following results.

Model of fuzzy expert system for establishing interdependencies between the amount of pollution (emissions, effluents, waste) and deterioration of health of Ukraine shall include a knowledge base with 27 logical statements such as "if – then otherwise".

The model prediction of man-made damage to the national economy and established its compliance with established interdependence between the amount of discharges (drained polluted waters without treatment), and emissions of sulfur dioxide and nitric oxide and the number of newly registered tumors in Ukraine. It was established that the impact of emissions and discharges of pollutants into the incidence is cumulative in nature and appears to the time delay, because the relationship between the results must include the time lag and indicators should be averaged over a specified period of time hence volume effects.

Key words: man-made damage the national economy, fuzzy logic, fuzzy expert system, a technological sorry forecasting.

Statement of the problem. In conditions permanent destructive impact of business enterprises on the environment and society mechanism of management of the national economy requires not only improvement, but also a deep restructuring to address natural resources management, nature conservation and social responsibility towards future generations. This requires a search for new effective method for determining amounts of man-made damage and methods of economic evaluation of man-made damage from them at the level of the national economy. Solving these problems involves not only forecasting amounts of environmental impact, but also determine their effects on the scale societies and the quality of life (incidence, life expectancy, mortality).

Of particular relevance is the problem of forecasting in the national economy of man-made damage, which is manifested in the calculation of anthropogenic pollution (emissions, effluents, waste) and study their impact on public health, as general description of the notion of man-made damage at the national economy.

Analysis of recent research and publications. On the theory of damage and losses caused by the economic activity of enterprises many scientists and researchers from around the world have worked. His research publications confirms that a significant contribution in this direction made by Ukrainian scientists [1 – 4]. O. Amosha, A. Balatskiy, B. Burkyns'kyi, J. Vytvytsky, V. Geyets, B. Danilishin, S. Doroguntsov, S. Illyashenko, A. Zagorodniy, O. Kuzmin, L. Melnyk, E. Mishenina, I. Nyedin, Soloviev, Yu. Stadnitskii, V. Trehobchuk, Yu. Tunytsya, A. Fedoryscheva, L. Fedulova, S. Kharichkov, Ye. Khlobystov, M. Hvesyk, V. Shevchuk, N. Shpak and many others.

Conducted the analysis of scientific sources and publications indicates that scientists in Ukraine and the world paid little attention to methods of economic evaluation of man-made damage to the national economy and their prediction at the state level. The problem of predicting of man-made damage to the level of the national economy goes beyond the purely economic problem, as the needs of the modern mathematical tools to solve it. Investigation of completion of outstanding scientists in the field of prediction and simulation of socio-economic and ecological-economic systems [5–7], including: D. Belenko, N. Kizim, T.Klebanov, Yu. Lysenko, V. Kravchenko, O. Panasenko, V. Ponomarenko, L. Chagovets, et al., shows that the unresolved part of the general aspects of the research the effects of anthropogenic impact on the recipient of the environmental, economic and social systems are improvement of the forecasting process as well as its mathematical tools.

Modern mathematical toolkits which allow to predict importance of the phenomenon under incomplete information and under uncertainty of the future, which is a characteristic feature of the management of national economics are a method, model, fuzzy sets theory, means and neural networks. Fundamental contributions to the theory of fuzzy logic and its application in practical application problems have domestic and foreign scholars [8 – 20]: A. Blyschun, D. Dubois, L. Zade, G.Klier, L. Konisheva, D. Nazarov, A.Nedosekin, B. Nowak, I. Perfilieva, M. Syavavko, I. Turksen, H. Ueno, H. Zimmerman, D. Shapiro and others.

Goal Setting. The theoretical foundations and applied problems of predicting man-made damage to the national economy and methods of management at the state level setting causes the following purposes:

– justify the application of theoretical principles of fuzzy logic as an effective mathematical tool under conditions of incomplete information and uncertainty of the future;

– outline the conceptual model features a fuzzy expert system for establishing interdependencies between the amount of pollution (emissions, effluents, waste) and deterioration of health of Ukraine;

– propose a model predicting man-made damage to the national economy and to test its efficacy in established interdependence between the amount of discharges (drained polluted waters without treatment), and emissions of sulfur dioxide and nitric oxide and the number of newly registered tumors in 1,000 citizenships in Ukraine.

The main material. In previous works of the author of [21 – 23], there were the essence of concepts man-made damage and man-made losses, built concept of economic evaluation of man-made damage to the national economy and the necessity and need for the application of fuzzy sets as an effective mathematical tool for economic evaluation of man-made damage to the national economy.

The advantages of fuzzy systems is that they allow you to get “acceptable” results for reasons that are close to human in the sense of the absence of an exact match between the requirements of the input data (the so-called left side of the rule) and the appropriate state (right side). These systems are based on a linguistic description of the relationships between variables. The use of linguistic variables allow approximately describe phenomena that are so complex that defy description in conventional quantitative terms. Another, in our opinion, is extremely significant advantage of expert systems, fuzzy particular, is that they are able to process a dialogue with experts receive, store and correct knowledge held by experts of the subject area and provide a basis to solve practical problems.

At this stage in expert systems for knowledge representation formalism is the most widely used type of productive model “If A, then B”. Characteristic features of modern expert systems belonging to second generation is the presence of both the fuzzy knowledge representation, and the fuzzy conclusions [15, 18]. An example of the fundamental problem of inference for the living conditions of fuzziness is the following problem (1):

Given a (fuzzy) production rules "if A then B".
There is A '(A- as certain extent). What should be B? (1)

For adoption fuzzy-inference form of comclusion we will build the fuzzy knowledge bases consisting of formalized fuzzy conditional rules for converting existing in the first stage fuzzy data in fuzzy action (control actions) on the basis of “if-then”. Getting fuzzy set of conclusions that fuzzy decision-making, in this case, by using the table of decision rules of fuzzy knowledge from the knowledge base. To find the solution of the problem in real terms (specific numerical value) we will conduct defuzzification that is the process of converting fuzzy conclusions into distinct variables (quantitative or qualitative) used in the economics, which is carried in the opposite direction to the process fuzzification) for input linguistic variables.

Conduct the formalization of the problem under consideration in the form of an object in n – inputs and one output (2):

$$y = f(x_1, x_2, ..., x_n), \tag{2}$$

where $x_1, …, x_n$ – A set of input variables; $\boldsymbol{y}$ – the output variable.

To construct the mathematical model of quantitative variables are converted into linguistic terms (3) – (4) [16]:

$$U_i = \left[\underline{u_i}, \overline{u_i}\right], \;\; i = \overline{1,n}, \tag{3}$$

$$Y = \left[\underline{y}, \overline{y}\right], \tag{4}$$

where $\underline{u_i}, \overline{u_i}$ is the smallest and the largest possible value of variable x_i; $\underline{y}, \overline{y}$ is the smallest and the largest possible value of the output variable $\boldsymbol{y}$.

For the solving of the task (2) we should apply decision method by which a fixed vector of input variables $x^* = \left(x_1^*, x_2^*, ..., x_n^*\right), \;\; x_i^* \in U_i$ clearly be treated in compliance solution $y^* \in Y$ [16]. For the formal solution of this dependence we will consider input $x_i, \;\; i = \overline{1,n}$ and output $\boldsymbol{y}$ parameters as linguistic variables defined on the universal set (3), (4). For evaluation of linguistic variables $x_i, \;\; i = \overline{1,n}$ and $\boldsymbol{y}$ we will use qualitative terms such term-sets: 1) $A_i = \left\{a_i^1, a_i^2, ..., a_i^{p_i}\right\}$ – a therm-set of input variable $x_i, \;\; i = \overline{1,n}$; 2) $D = \left\{d_1, d_2, ..., d_m\right\}$ – a term-set of the output variable $\boldsymbol{y}$. For the construction of the term-sets we can apply, for example, the method proposed in the works [9].

For each therma of the each linguistic variable we will build membership function $\mu_{a_i^p}(x)$ and $\mu_{d_j}(y)$ (trapezoidal, triangular, etc. [19]) based on expert knowledge, where $\mu_{a_i^p}(x)$ – the item measure of belonging $x \in U_i$ to terms $a_i^p \in A_i, \;\; i = \overline{1,n}; \;\; p = \overline{1, p_i}$; $\mu_{d_j}\left(y\right)$ – the item measure of belonging $y \in Y$ to terms $d_j \in D, \; j = \overline{1,m}$.

The definition of the linguistic evaluation of variables and required to formalize their membership function is the first step in building a fuzzy model of the object. In the literature on fuzzy logic [13] it is called fuzzyfication of the variables [13].

The next step is creating a fuzzy knowledge base [20]. Suppose that for item (2), we know N rules that bind its inputs and output via vectors such as (5):

$$V_k = \left(x_1, x_2, ..., x_n, y\right), \;\; k = \overline{1,N}\,, \text{ And } N = k_1 + ... + k_j + ... + k_m\,, \tag{5}$$

where k_j is the number of experimental data corresponding to the same value d_j of the therm-set output variable $\boldsymbol{y}$; m is the total number of terms of a target variable, and in general case, $k_1 \neq ... \neq k_m$.

The base of knowledge, in this case, as a table of decision rules of fuzzy knowledge is presented in formalized form in Table 1 [11].

After building the knowledge base we should be carefully checked in Table 1 the presence of opposing lines, where rules for the same input variables have different output values. The knowledge matrix in the form of (6) defines a system of logical statements such as “If – then, otherwise” that bind the values of input variables $x_1, ..., x_n$ with one of the possible values of the output $d_j, \;\; j = \overline{1,m}$:

$$\bigcup_{p=1}^{k_j}\left[\bigcap_{i=1}^{n}\left(x_i = a_i^{jp}\right)\right] \rightarrow y = d_j, \;\; j = \overline{1,m}\,. \tag{6}$$

Rules of the described fuzzy conclusions are active if they have a degree of nonzero truth consider.

In [11] it was suggested method is to use fuzzy logic equations, which are based on a matrix of knowledge or isomorphic to it of logical expressions (6) and allow you to calculate the value functions of the output variable for fixed values of the input object.

Linguistic evaluation a_i^{jp} variables $x_1, ... x_n$ included in the logical expression (6), will be considered as fuzzy sets defined on the universal set (3). We introduce the following notation: $\mu^{a_i^{jp}}(x_i)$ is function of the parameter x_i to the fuzzy terms $a_i^{jp}, \;\; i = \overline{1,n}, \;\; j = \overline{1,m}, \;\; p = \overline{1,k_j}$; $\mu^{d_j}\left(x_1, x_2, ... x_n\right)$ is function of the vector of input variables $x = \left(x_1, x_2, ... x_n\right)$ of the therm output variable $y = d_j, \; j = \overline{1,m}$.

Table 1

General view of the decision rules base of the fuzzy knowledge *

Number of input combinations	Input variables				Weight	Output variable
	x_1	x_2	$...x_i...$	x_n	w	y
11	a_1^{11}	a_2^{11}	a_i^{11}	a_n^{11}	w_{11}	d_1
12	a_1^{12}	a_2^{12}	a_i^{12}	a_n^{12}	w_{12}	
…	…	…	…	…	…	
$1k_1$	$a_1^{1k_1}$	$a_2^{1k_1}$	$a_i^{1k_1}$	$a_n^{1k_1}$	w_{1k_1}	
…	…	…	…	…	…	…
j_1	a_1^{j1}	a_2^{j1}	a_i^{j1}	a_n^{j1}	w_{j1}	d_j
j_2	a_1^{j2}	a_2^{j2}	a_i^{j2}	a_n^{j2}	w_{j2}	
…	…	…	…	…	…	
jk_j	$a_1^{jk_j}$	$a_2^{jk_j}$	$a_i^{jk_j}$	$a_n^{jk_j}$	w_{jk_j}	
…	…	…	…	…	…	…
m_1	a_1^{m1}	a_2^{m1}	a_i^{m1}	a_n^{m1}	w_{m1}	d_m
m_2	a_1^{m2}	a_2^{m2}	a_i^{m2}	a_n^{m2}	w_{m2}	
…	…	…	…	…	…	
mk_m	$a_1^{mk_m}$	$a_2^{mk_m}$	$a_i^{mk_m}$	$a_n^{mk_m}$	w_{mk_m}	

* Built and collectived by author by sources [18–20].

Thus, we have two kinds of functions that define the relationship between the fuzzy knowledge base (6), from which we can derive a system of logical equations (7) [11]:

$$\mu^{d_j}(x_1, x_2, ..., x_n) = \bigvee_{p=1}^{k_j}\left(w_{jp}\left[\bigwedge_{i=1}^{n}\mu^{a_i^{jp}}(x_i)\right]\right),\ j = \overline{1.m}. \tag{7}$$

Decision-making $d^* \in D\{d_1, d_2, ..., d_m\}$, which corresponds to a fixed vector of input variables $x^* = \left(x_1^*, x_2^*, ..., x_n^*\right)$, will be carried out according to the fuzzy conclusions by Mamdani constructed using fuzzy logic. So, first find the minimum values of membership functions in each rule, and then between is we will elect largest value among all the membership function of rules for each value d_j, $j = \overline{1,m}$ that assigns to the output variable y. Thus, obtain the conclusion of belonging output variable y to terms d_j^*, whose membership function is maximum.

The proposed algorithm uses the idea of identifying linguistic terms, the maximum membership function and generalize this approach to the entire matrix of knowledge. Computational part of this algorithm is easily realized by simple operations maximize (**Max**) and minimize (**Min**) application [15].

To obtain accurate numbers from the interval $[\underline{y}, \overline{y}]$, corresponding fuzzy output, we apply the operation defuzzyfication. Identify it clear number $\boldsymbol{y^*}$ is offered at the center of gravity method (8):

$$y^* = \frac{\int_{Min}^{Max} y\mu(y)dy}{\int_{Min}^{Max} \mu(y)dy}, \tag{8}$$

where ***Min*** and ***Max*** are the left and right points of the interval carrier fuzzy set output variable ***y***.

The main sources for the analysis of man-made damage as a result of human interaction with nature and in Ukraine and worldwide, there is evidence of statistical studies of the impact of human activities on the environment, collected relevant departments (State Statistics Committee of Ukraine, the Ministry of Environment and Natural Resources, etc.).

In statistical reports for the period 1990-2012 there are quantitative data on the dynamics of anthropogenic stress, such as emissions of sulfur dioxide, nitrogen oxides, carbon dioxide and other pollutants into the atmosphere by business entities (stationary sources) and by road, rail, aviation, water transport and production equipment (mobile sources), the dynamics of key indicators of the using and protecting of water resources and also the dynamics of the first reported cases of the population of Ukraine and others. Present with an array of technogenic stress we can choose those statistical series and that according to experts, have a direct impact on quantitative quality of life. Among the analyzed Data according to the recommendations of the experts the most significant impact on the number of newly reported cases of tumors are large volume discharges untreated polluted water, total release and emissions of sulfur dioxide and nitric oxide from stationary and mobile sources (Table 2).

Table 2

Dynamics of volumes of input and output variables in the period 1990-2012 years*

Years	Volume discharges million m^3.	Emissions of sulfur dioxide, t	Emissions of nitrous oxide, t	The incidence of neoplasms was first recorded in 1000 people[1]
1990	470	2782.30	760.80	...
1991	701	2537.90	989.80	...
1992	951	2376.20	830.20	6.397
1993	1196	2194.00	700.10	6.355
1994	1053	1715.00	567.60	6.294
1995	912	1639.10	530.30	6.321
1996	980	1292.60	466.60	6.531
1997	763	1132.40	455.20	6.848
1998	813	1023.00	444.50	7.385
1999	748	1026.10	436.60	7.653
2000	758	984.80	440.60	7.728
2001	746	992.10	452.00	8.053
2002	782	1032.60	435.70	7.883
2003	804	1046.30	477.90	8.229
2004	758	988.50	471.90	8.525
2005	896	1132.80	523.90	8.629
2006	1427	1347.20	515.10	8.822
2007	1506	1342.60	641.90	8.725
2008	616	1320.60	642.00	8.755
2009	270	1262.70	562.10	8.820
2010	312	1235.20	603.70	9.094
2011	309	1363.40	633.00	9.240
2012	292	1430.30	634.60	9.489

1 Data are calculated taking into account the migration flows in Ukraine (... – There are no data for the calculation)

* Built and designed by author according to the State Statistics Committee of Ukraine.

Thus, we propose to establish interdependencies between the magnitude of discharges (drained polluted waters without treatment), and emissions of sulfur dioxide and nitric oxide and the number of tumors per 1,000 population at Ukraine to apply the model of fuzzy expert system.

According to the conditions specified by our task we establish the effect of the discharge x_1 (removal of untreated polluted water by millions m^3), emissions of sulfur dioxide x_2 (total emissions from stationary and mobile sources in tonnes) and emissions of nitrogen oxide by x_3 (the total amount of emissions from stationary and mobile sources in tonnes) by the number of fixed tumors (1,000 citizens of Ukraine) $\boldsymbol{y}$. Using the statistical data presented in Table 2, we will define the universal set of input variables described for x_1, x_2, x_3 and output $\boldsymbol{y}$,respectively (9):

$$U_1 = [0;1600],\ U_2 = [500;1500],\ U_3 = [100;800], U_4 = [4;10]. \quad (9)$$

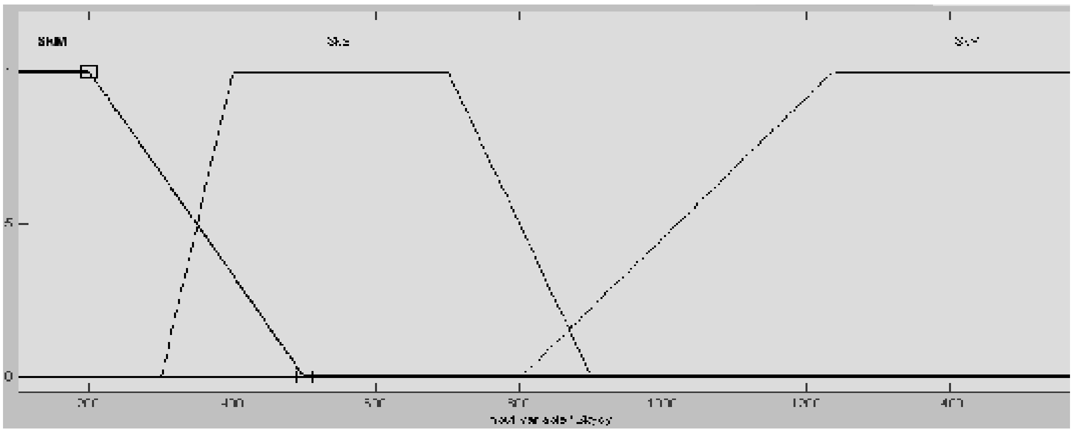

*Fig. 1. The view of the membership function of linguistic variable “Discharges” **
** Own development*

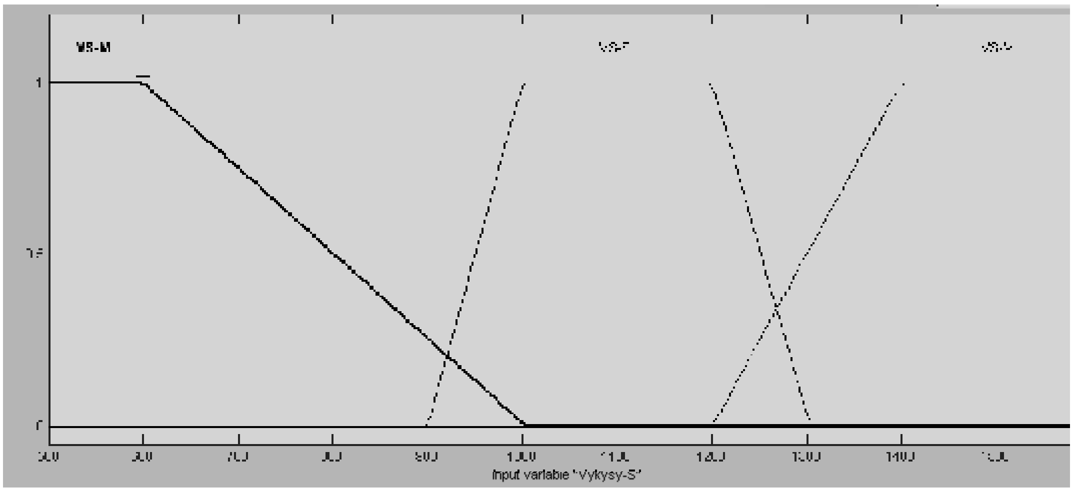

*Fig. 2. The view of the membership function of linguistic variable “Emissions of sulfur dioxide”**
** Own development*

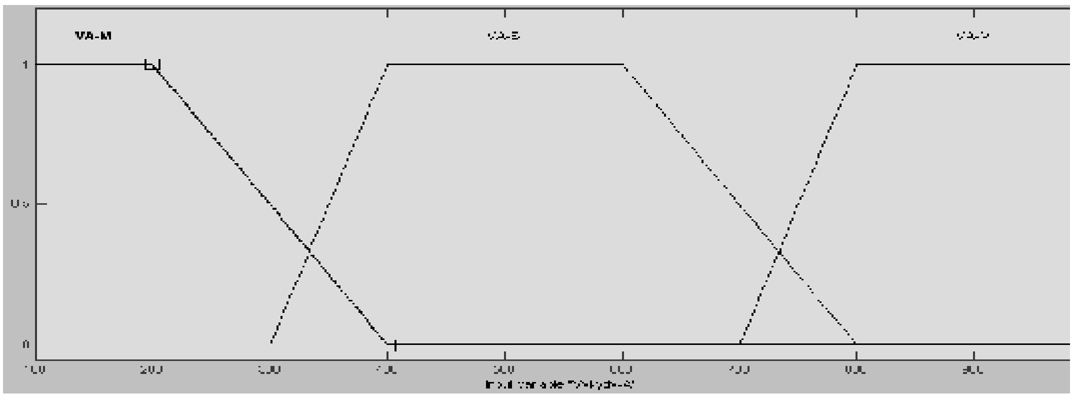

*Fig. 3. The view of the membership function of linguistic variable “Emissions of nitrogen oxide”**
** Own development*

For each input and output variables we will built the term-sets (10) – (13):

$$A_1 = \{\text{"small", "medium", "large"}\} = \{M, C, B\}, \tag{10}$$

$$A_2 = \{\text{"small", "medium", "large"}\} = \{M, C, B\}, \tag{11}$$

$$A_3 = \{\text{"small", "medium", "large"}\} = \{M, C, B\}, \tag{12}$$

$$D = \{\text{"small", "medium", "large"}\} = \{M, C, B\}. \quad (13)$$

We are recommending to select and ratify trapezoidal membership functions for terms of input and output variables, the type of which is shown in Figure 1 – Figure 4.

To solve this problem the experts will build the fuzzy knowledge base presented in Table 3.

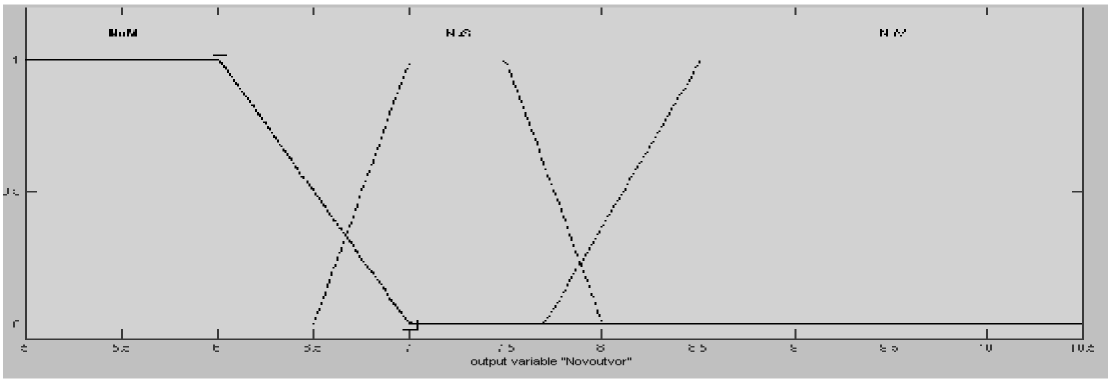

*Fig. 4. The view of the membership function of linguistic variable "Tumors" **
** Own development*

Table 3

Fuzzy knowledge base of the problem studied

Number of input combinations (logical rules)	Input variables			Weight	Output variable
1	M	M	M	1	M
2	M	M	C	0.9	
3	M	M	B	0.8	
4	M	C	M	0.9	
5	M	C	C	0.7	
6	M	C	B	0.5	
7	M	B	M	0.4	
8	M	B	C	0.2	
9	M	B	B	0.6	C
10	C	M	M	0.5	
11	C	M	C	0.6	
12	C	M	B	0.7	
13	C	C	M	0.8	
14	C	C	C	0.9	
15	C	C	B	0.8	
16	C	B	M	0.8	
17	C	B	C	0.8	
18	C	B	B	0.7	
19	B	M	M	0.7	
20	B	M	C	0.6	
21	B	M	B	0.5	
22	B	C	M	0.7	
23	B	C	C	0.8	B
24	B	C	B	0.9	
25	B	B	M	0.8	
26	B	B	C	0.9	
27	B	B	B	1	

* Own development

The following calculations are carried out for these technogenical stress of production (Table 2) on 2003 year: x_1 = 804, x_2 =1046.30, x_3 = 477.90. In Figure 5 is shown a graphical representation of active rules for input and output variable and a function of target variable ***y***.

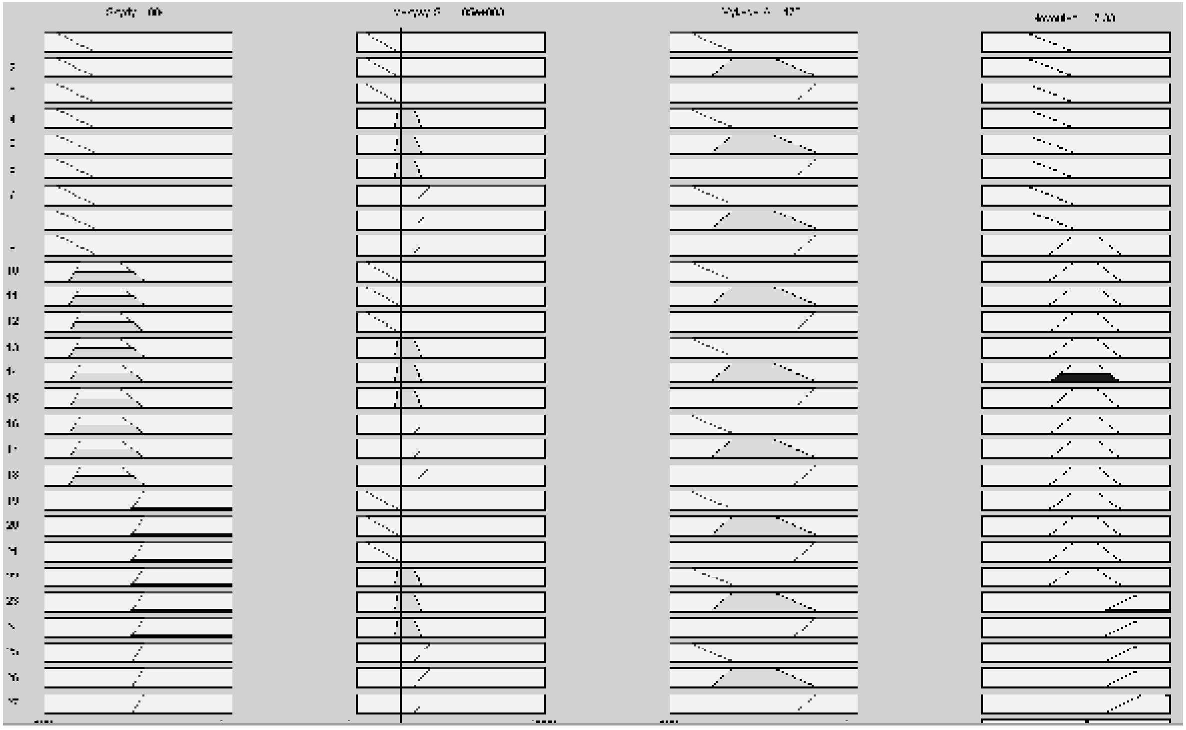

*Fig. 5. The view of the membership function of the linguistic output variable and the active rulers**
**Own development*

As a result of the calculation is active the rule #14, which can be seen from Figure 5. Active rules is at #14 drives to the exit B quantitative value of the output value ***y*** (result defuzzyfication) is 7.333. The real number of cases recorded first tumors in 1,000 people in 2003 year has reached 8.229. These differences of predicted and actual values indicate that the impact of the release of C and C discharge of pollutants to the number of cases is cumulative in nature and appears to the time delay, because the relationship between the results must include the time lag and indicators should be averaged over a specified period of time.

So, the proposed using of fuzzy sets as an effective mathematical tool for economic evaluation of man-made damage to the national economy is allow to obtain “acceptable” results for reasons that are close to human in the sense of the absence of an exact match between the requirements of the input data (the so-called left side rules) and the appropriate state (right-hand side rules) of the phenomenon. Advantages fuzzy expert s ystem lies in the fact that the using of linguistic variables allow approximately describe phenomena that are so complex that defy description in conventional quantitative terms, moreover, unclear and expert systems are able to process and dialogue with experts receive, store and correct knowledge held by experts of the subject area in order to obtain the real solutions.

In our opinion, the application of fuzzy expert systems proposed method, fuzzy measures of input and output variables of rules for representing acquired knowledge and so allows for Integrated assessment is incurred and projected man-made damage and losses caused by both ordinary and extraordinary economic activity of enterprises for various industries.

Conclusions. The theoretical foundations and applied problems of predicting man-made damage to the national economy and methods of management at the state level allowed for the following conclusions:

1. The purpose of the theoretical foundations of the application of fuzzy sets as an effective mathematical tool under conditions of incomplete information and uncertainty in future in the work there are fuzzy expert system, which is the possibility of approximate mid describe such complex phenomena that can not be described in conventional quantitative terms, and the ability to receive, store and adjust the knowledge possessed by experts in this subject area in the process of dialogue with them in order to get real results.

2. The model of fuzzy expert system for establishing interdependencies between the amount of pollution (emissions, effluents, waste) and deterioration of health of Ukraine is substantiated.

3. The model of forecasting of the man-made damage to the national economy is proposed and fount answer established by the interdependence between the amount of discharges (drained polluted waters without treatment), and emissions of sulfur dioxide and nitric oxide and the number of newly registered tumors in 1,000 citizenships in Ukraine.

4. There was established as a rising idea to use the claim that the impact of emissions and discharges of pollutants to the number of cases is cumulative in nature and appears to the time delay, because the relationship between the results must include the time lag and indicators should be averaged over a specified period time hence volume effects.

Thus, the application of fuzzy sets for forecasting the national economy anthropogenic damage, manifested in the calculation of anthropogenic pollution (emissions, effluents, waste) and study their impact on public health may have practical use in the development in the management of the national economy according methodological model of research, evaluation and regulation of man-made damage to the national economy. The results obtained will improve the efficiency of state regulation of the phenomenon, provide appropriate allocations for their eradication and compensation.

Prospects for future research. The theoretical and practical aspects regarding the economic evaluation of man-made damage will be used in further research on attitude developed under her fuzzy expert system for predicting the study, collecting and analyzing data on the damage, loss and expense in different sectors of the national economy by sector and identifying technological losses (level of man-made damage). The application of the model will form not only an effective system of national economy, but also protection against predictable risks of technogenic emergency situations that may occur in a variety of sectors.

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ТУРИЗМ У СИСТЕМІ НАРОДНОГОСПОДАРСЬКОГО КОМПЛЕКСУ УКРАЇНИ: СУЧАСНИЙ СТАН ТА ПЕРСПЕКТИВИ РОЗВИТКУ

На основі комплексного аналізу проаналізовано сучасний стан туризму в системі народногосподарського комплексу України, висвітлено його особливості та відображено перспективи розвитку в майбутньому. Зокрема, зазначено, що туризм в Україні, як і світі загалом, набуває дедалі більшого значення для розвитку економіки та соціальної сфери. Визначено, що для розвитку туристичної сфери в Україні існують усі передумови. Зокрема, аналіз туристичних потоків свідчить про пріоритетний напрям розвитку в'їзного та внутрішнього туризму, який є важливим чинником підвищення якості життя в Україні, утворення додаткових робочих місць, поповнення валютних запасів держави та підвищення її авторитету на міжнародній арені. Узагальнено те, що незважаючи на значний потенціал, туристична галузь України має низку проблем, нагальне вирішення яких покращить перспективи її розвитку вже в найближчому часі. Перспективи розвитку туристичного бізнесу в Україні тісно взаємопов'язані з формуванням нового державного підходу до туризму як галузі, пріоритетний розвиток якої може позитивно вплинути на економічний та соціальний стан країни, стимулювати важливі галузі економіки, сприяти зміцненню позитивного іміджу України на світовій арені.

Ключові слова: туризм, туристичний бізнес, туристична галузь, туристичний сектор економіки, державна політика, державне регулювання.