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METHODOLOGY OF ANALYSIS SUSTAINABLE DEVELOPMENT OF UKRAINE BY USING THE THEORY FUZZY LOGIC

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Article objective is analysis of the theoretical and methodological aspects for the assessment of sustainable development in times of crisis. The methodical approach to the analysis of sustainable development territory taking into account the assessment of the level of economic security has been proposed. A necessity of development of the complex methodical approach to the accounting of the indeterminacy properties and multicriterial in the tasks to provide economic safety on the basis of using the fuzzy logic theory (or the fuzzy sets theory) was proved. The results of using the method of fuzzy sets of during the 2002-2012 years the dynamics of changes dynamics of sustainable development in Ukraine were presented.

Keywords: *sustainable development, economic security, indicator, fuzzy logic and fuzzy sets theory, membership function*

Introduction. The sustainable development is a subject of interest for regional policy makers and it needs appropriate assessment based on futile instruments for research, and for practical reasons (planning and decision making). The problem of achieving the sustainable development conditions requires appropriate coordinated actions of many subjects' of the economic-productive activity. Herewith, an important component of this complex action is to provide the acceptable level of the State's economic security (ECS) and its individual areas because achieving the sustainable development conditions requires, above all, rational organization of economic activity.

Namely in the crisis it is quite important to develop integrated methodological approach accounting the properties of uncertainty in problems of ECS. Thus, the given above led us to a necessity of considering the methodological basis of the fuzzy logic theory for Ukrainian's ECS level assessment. The basis of the theory of fuzzy logic is methods of fuzzy sets. Fuzzy numbers and linguistic level based on fuzzy sets theory as a method to overcome vaguely judgment in evaluation.

Analysis of recent researches and publications. In 1965, the LA Zadeh [1] theory of fuzzy sets was introduced. Later work Bellman R. E. and Zadeh L.A. "Decision – Making in Fuzzy Environment" [2, Russian translation – 3] became the basis to using the methodology of fuzzy sets theory. In the general methodology of scientific knowledge Fuzzy sets theory is a mathematical method used to characterize and propagate uncertainty and imprecision in data and functional relationships. In modern world practice, the method of fuzzy sets is widely used for the analysis of SD and business management [4-9 et al.].

Ukrainian and Russian explorers for assessment according to the ECS terms the following methods are mainly used: the indicative analysis method, the scalarization method, the cutting-plane method and the method of discriminant analysis [10-13 et al.]. All the given above approaches have one significant drawback – they require a clear classification of the situation to a particular security class (depending on the security indicators values and their boundary levels). The SD is difficult to define in pure quantitative terms, and during the past decades, the researchers recognize that it bears an imprecise and vague feature of being defined and tackled in many facets, with several ways of collecting data for indicators regarding the efficient and the effective usage of resources.

Previously unsettled problem constituent. Even if the sustainability's attainment is a research topic field for academia and urban planners and managers and, as well, an ambitious goal for any resource administrator, yet there is no precise way of defining and measuring it [7]. Herewith, multicriteriality can be considered as one of the form of displaying the uncertainty of the development conditions and complex systems functioning (purposes' uncertainty). Another feature is the diversity of ratings by the criteria. To solve the problem of ECS it is necessary to the most properly recognize a situation of management decision making [12]. Herewith, information describing the knowledge about the system and the situation is formulated the most adequately by using fuzzy concepts, fuzzy definitions and fuzzy logic.

Main purpose of the article is submitted an analysis approach based on fuzzy sets. The advantages of such approach are derived from taking into account the multi-criteria and uncertainty facets of the phenomenon; also, having in mind that the sustainability remains a non-straight-cut concept, being vaguely defined it implies a non-deterministic character by using the fuzzy set logic. Fuzzy sets are especially

useful when insufficient data exist to characterize uncertainty using standard statistical measures (e.g., mean, standard deviation, and distribution type).

Results and discussions. Fuzzy set theory is a useful tool for dealing with knowledge about SD territory, taking into account uncertainty the interpretation of qualitative evaluation's results (that is, the analysis of statistical measures). This method involves creation of expert systems for pattern recognition. The decision about referring the security indicators to a particular class the experts make on the basis of their understanding of the required security level and the consequences of deviation from this level. In fact, while making a responsible decision the expert usually operates not only with formal concepts, expressed by a number or numerical formula, but also with some logical conclusions that can be expressed as: "If there are certain conditions ..., then the situation can be assigned to the following class". To process this kind of expressions a special system, which is based on the methods of the fuzzy sets theory and fuzzy expressions, is developed. This is achieved by introducing a membership function (MF) of fuzzy parameters, which takes values from 0 to 1. Its approximation to 1 means more confidence in expressions and more significant level of its implementation. It is appropriate to use exponential functions, as follows:

$$f(x) = \exp[b(x-c)^2],$$

where b and c – parameters of the function that determine its form.

The proposed mathematical description corresponds to the information nature and reflects its fuzziness. On the basis of experts' or expert groups' statements a database, that describes the situation classes, is formed for all ECS indicators. Thus, any current or predicted situation can be assigned to a particular class by comparing it with already known data, which was entered into the database. In general fuzzy set characteristic is the MF. Fuzzy set $\overline{A}$ is called the set of ordered pairs or corteges of form $\langle x; \mu_{\overline{A}}(x) \rangle$, where x – element of the universe X, $\mu_{\overline{A}}(x): X \to [0,1]$ – (MF) which assigns to each element $x \in X$ a real number in the interval $[0,1]$, that characterizes the element x grade of membership to fuzzy set $\overline{A}$. The larger the MF value $\mu_{\overline{A}}(x)$, the more universal set element x corresponds to the fuzzy set $\overline{A}$ properties [2, 3]. There are many types of curves to determine the MF. The most common MF is triangular, trapezoid and Gaussian function. Triangular MF is determined by three numbers (a, b, c), and its value at the point x is calculated by the formula:

$$\mu(x)=\begin{cases}\dfrac{x-a}{b-a}, & a\le x\le b\\ \dfrac{c-x}{c-b}, & b\le x\le c,\\ 0, & \text{in other cases}\end{cases}$$

at $(b-a)=(c-b)$ we have a symmetrical triangular MF, which is identically specified by two parameters from the triple (a, b, c).

To determine the trapezoidal MF four numbers are needed (a, b, c, d), and its value at the point x is calculated by the formula:

$$\mu(x)=\begin{cases}\dfrac{x-a}{b-a}, & a\le x\le b\\ 1, & b\le x\le c\\ \dfrac{d-x}{d-c}, & c\le x\le d,\\ 0, & \text{in other cases}\end{cases}$$

at $(b-a)=(d-c)$ this MF takes symmetrical form.

Generalized MF of the Gaussian's type is described by the formula:

$$\mu(x)=e^{\frac{(x-c)^{2b}}{\sigma^2}},$$

and is determined by three parameters (a,σ,b). The value $b=1$ corresponds to the standard Gaussian function.

This function is preferable due to its three following properties:

1) its similarity to the accumulation;

2) limitation of values that are necessary to comply with the MF properties;

3) infinite definition domain, which greatly simplifies the algorithmic solutions while programming operations on fuzzy subsets.

Therefore, for the MF the Gaussian function is used, and on its basis the evaluating theses, presented in Table 1, are formed.

Table 1. **The list and the content of evaluating theses (**adapted according to the [12])

Name of the thesis	The search key	Formula	Formula interval	Units' interval
1	2	3	4	5
Worse (…)	Worse (	$\exp\left(b*(x-a)^2\right)$	a-1	0-a
Better (…)	Better (	$\exp\left(b*(x-a)^2\right)$	0-a	a-1
Good	Good	$\exp\left(b*(x-1)^2\right)$	0-1	1-1
Bad	Bad	$\exp\left(b*x^2\right)$	0-1	0-0
Medium	Medium	$\exp\left(b*\ (x-0{,}5)^2\right)$	0-1	0.5-0.5
Not bad	Not bad	$\exp\left(b*(x-s)^2\right)$	0-s	s-1
Not good	Not good	$\exp\left(b*(x+s)^2\right)$	1-s-1	0-1-s
Not worse (...)	Not worse (	$\exp\left(b*(x-a-s)^2\right)$	0-a+s	a+s-1
Not better (…)	Not better (	$\exp\left(b*(x-a+s)^2\right)$	a-s-1	0-a-s
Indifferently	Indifferently	1	0-0	0-1

It is assumed that such FS is quite accurately described by MF. The greater the alternative *x* grades of membership to FS, i.e. the higher the value, the higher the achievement's goal grade while choosing alternative as a solution. Fuzzy boundary conditions are also described by the fuzzy subsets. We will define now, what is meant by the solution of the problem of achieving the fuzzy goal. Solving this problem means achieving the goal and satisfying the limitations, moreover, within this setting-up we should talk not only about achieving the goals, but also about the grade of its achievement, taking into account the grade of the limitations accomplishment. The problem mentioned above can be solved by using the Bellman-Zadeh approach. The subject matter of this approach, represented in detail in the works [3, 14] is as follows: let some alternative provides goals' achievement with a grade and satisfy the limitations with a grade. Then it is assumed that the membership grade for this alternative of resolving the problem is the minimum of these values. Thus, the fuzzy solution of the problem of achieving the fuzzy goal is called the intersection of the fuzzy sets of goals and limitations, i.e. MF for the solutions is:

$$\lambda_i = \max_k \left\{ \min_j \left\{ \sup_{x \in X_j} \left(\min \left\{ \mu_j(x), \nu_{ijk}(x) \right\} \right) \right\} \right\},$$

where λ_i – the grade of the considered situation membership to class i; X_j – range of parameter j; $\mu_j(x)$ – MF of the considered situation evaluation by the parameter j; $\nu_{ijk}(x)$ – MF of the k expression in the knowledge base by the parameter j to class i.

In other words, to determine the grade of the situation membership to any class,

it is necessary:

– to determine the exact upper borders of intersection of the MF for the situation evaluation and expressions on the parameters with the sections of expressions of the class;

– to determine the minimum values of exact upper borders by the sections of expressions of the class (grade of the situation membership to the expressions set);

– to determine the maximum grade of the situation membership by the sections of expressions of the class.

It is offered to conduct the Ukraine status assessment according to the ECS level by using the three classes, which are described as follows:

1) normal (n) status – "if all the indicators are better than the threshold values of entering the pre-crisis status, the status is normal";

2) pre-crisis (pc) status – "if at least one of the parameters is worse than the threshold parameter of pre-crisis status, and all other parameters are better than the crisis threshold, the status is considered to be pre-crisis";

3) crisis (c) status – "if at least one parameter is worse than the crisis status threshold, the status is crisis."

All these expressions can be described mathematically by the following statements:

– *normal status*

$$X_1 > X_{PC} \quad and \quad X_2 > X_{PC} \quad and \ldots \quad and \quad Xn > Xpc$$

– *pre-crisis status*

$$Xc < X_1 < Xpc \quad and \quad X_2 > X_C \quad and \ldots \quad and \quad Xn > Xc \quad or$$
$$\ldots \quad X_1 > Xc \quad or \quad X_2 > Xc \, and \quad \ldots and \quad Xc < Xn < Xpc$$

– *crisis status*

$$X_1 < Xc \quad and \quad X_{2\ldots N} = \text{does not matter}$$
$$or \quad \ldots or = \text{does not matter} \quad and \quad Xn < Xc,$$

where N is the number of parameters.

Logical operations AND and OR (intersection and combination of fuzzy subsets) are defined as follows:

$$\mu(x) = \min\{\nu(x), \lambda(x)\}, \tag{1}$$

$$\mu(x) = \max\{\nu(x), \lambda(x)\}. \tag{2}$$

Formula (1) describes the logical operation "AND", and formula (2) – "OR". During decision-making it is necessary to take into account the value of the situation membership grade in all classes, using the concepts of clear membership, membership to some extent and the ε-level membership. Based on the example of the triple class knowledge base, with situation membership grades by the classes $\lambda_1 = 1$, $\lambda_2 = \beta$, $\lambda_3 = \varepsilon_3$, the following expressions can be formulated: the situation clearly

belongs to class 1, but to some extent $(\varepsilon_2 < \beta < 1)$ it belongs to class 2, the situation does not belong to class 3.

The results of using the method. The output parameters' database for the calculation (given in Table 2) is formed according to the data [15, 16]; and includes 16 ECS indicators combined in 7 blocks (spheres of life).

Table 2. **The list and the range of threshold values of indicators for Ukrainian ECS blocks** (erected in according to the data [15, 16])

Indication	Marker	Range		Treshold values	
		min	max	PC	C
Macroeconomic security					
Gross fixed capital formation,% of GDP	X_1	15	50	30	25
Change in stocks of tangible current assets,% of GDP	X_2	-2	2	-0,5	-1,5
Scientific and technological security					
The share of government expenditure on science in GDP, %	X_3	0,5	6	2	1
The number of specialists who carry out scientific and technological works, % of total employment in the state's economy (for 1000 persons)	X_4	1	15	6	5
The share of firms that implement innovations, in the total number of industrial enterprises, %	X_5	30	100	70	50
Demografic security					
Life expectancy at birth, years	X_6	65	85	75	70
Natural increase rate (per 1 thousand), persons	X_7	-7	7	5	2,8
The total population's birth rate (average number of children born by a woman during all her life), persons	X_8	0,5	5	2,2	1,5
Social security					
Availability of housing in average per capita, м^2	X_9	6	50	25	13
Expenditures of consolidated budget on health,% of GDP	X_{10}	1	6	3	2
Expenditures of consolidated budget on education,% of GDP	X_{11}	3	10	7	4
Food security					
Milk and dairy priducts (consumption per capita per year, kg)	X_{12}	121	423	363	353
Potato (consumption per capita per year, kg)	X_{13}	73	164	90	81
Fruits, berries and grape (consumption per capita per year, kg)	X_{14}	61	154	90	62
Energy security					
Amount of coal production, million tons	X_{15}	40	120	70	50
Ecologic security					
Emissions of pollutants and greenhouse gases into the atmosphere per 1 км^2	X_{16}	0	15	5	9

Dynamic of the ECS indicators' values is presented in Table 3.

Table 3. **Dynamics of the ECS indicators' values**
(erected in according to the data of the official website of the State Statistics Committee Ukraine http://www.ukrstat.gov.ua)

Marker	Year					
	2002	2004	2006	2008	2010	2012
X_1	19,17	20,6	22,55	21,97	24,6	32,38
X_2	0,98	1,18	-1,41	0,62	0,12	-0,48
X_3	0,33	0,4	0,42	0,39	0,43	0,49
X_4	4,83	4,73	4,8	4,74	4,5	4,21
X_5	14,6	11,5	10	8,2	10	11,5
X_6	68,3	68,2	68,2	68	68,1	68,3
X_7	-7,6	-7,5	-7,05	-7,6	-6,4	-6,1
X_8	1,1	1,2	1,2	1,2	1,3	1,3
X_9	21,3	21,6	21,8	22	22,2	22,7
X_{10}	3,34	3,63	3,52	3,51	3,63	3,79
X_{11}	5,43	5,6	5,31	6,07	6,21	6,22
X_{12}	225	226	226	226	235	220
X_{13}	133	138	141	136	134	130
X_{14}	29	33	34	37	35	44
X_{15}	59,6	59,8	59,4	60,4	61,7	56,7
X_{16}	10,11	10,26	10,48	10,96	11,65	12,27

As shown in Table 4 analysis of the calculation results shows that Ukraine's economy in many areas is in crisis because the majority of the indicators are of the crisis status class, particularly: the environmental areas indicators, the food indicators, the demographic area indicators, the scientific and technological area indicators.

Table 4. **Results of Ukraine's ECS calculation for the period of 2002-2012**
(developed by authors)

Situation	The normal status membership	The pre-crisis status membership	The crisis status membership
2002	0,2101745830 X_1, X_{10}, X_{13}	0,2472723394 X_9, X_{11}, X_{16}	1 X_1, X_3, X_4, X_5, X_6, X_7, X_8, X_{12}, X_{14}, X_{15}
2004	0,1967535052 X_2, X_{10}, X_{13}	0,2658401234 X_9, X_{11}, X_{16}	1 X_1, X_3, X_4, X_5, X_6, X_7, X_8, X_{12}, X_{14}, X_{15}
2006	0,2060844463 X_{10}, X_{13}	0,2938147673 X_2, X_9, X_{11}, X_{16}	1 X_1, X_3, X_4, X_5, X_6, X_7, X_8, X_{12}, X_{14}, X_{15}
2008	0,1980682960 X_2, X_{10}, X_{13}	0,2472723394 X_9, X_{11}, X_{16}	1 X_1, X_3, X_4, X_5, X_6, X_7, X_8, X_{12}, X_{14}, X_{15}
2010	0,1051271487 X_2, X_{10}, X_{13}	0,3268756784 X_9, X_{11}, X_{16}	1 X_1, X_3, X_4, X_5, X_6, X_7, X_8, X_{12}, X_{14}, X_{15}
2012	0,1051271487 X_2, X_{10}, X_{13}	0,3368361702 X_1, X_9, X_{11}, X_{16}	1 X_3, X_4, X_5, X_6, X_7, X_8, X_{12}, X_{14}, X_{15}

Conclusions and further researches directions. Current paper represents the main ideas for applying of methodology of analysis sustainable development of Ukraine by using the theory fuzzy logical. The proposed mathematical description corresponds to the information nature and reflects its fuzziness. On the basis of experts' or expert groups' statements a database, that describes the situation classes, is formed for all ECS indicators. In addition to, any current or predicted situation can be assigned to a particular class by comparing it with already known data, which was entered into the database. In general fuzzy set characteristic is the membership function (MF). In addition, using the ranking of indicators the priority directions of emerging the economy from the crisis can be determined. Thus, the created system accurately and properly formalized knowledge about the object of research, which, in turn, facilitates communication with experts; provides an opportunity with a minimum scope of knowledge to solve problems on the analyzed object properties. The further development of this approach could create a methodological framework for sustainable development oriented for social, economic and environmental support of decision– making processes.

References

1. Zadeh, L.A. (1965). *Fuzzy Sets.* Information and Control, Vol. 8(3), pp. 338-353.

2. Bellman, R.E., Zadeh, L.A. (1965). *Decision-Making in Fuzzy Environment.*Management Science, Vol. 17 (4), pp. 141-160.

3. Bellman, R.E., Zadeh, L.A. (1976). *Prinyatie reshenij v rasplyvchatyh usloviyah [Decision making under uncertainty*]. V kn.: Voprosy analiza i procedury prinyatiya reshenij. M: Mir [in Russian].

4. Phillis, Y.A., Andriantiatsaholiniaina, L.A. (2001). *Sustainability: an ill-defined concept*

and its assessment using fuzzy logic. Ecological Economics, Volume 37, Issue 3, pp. 435-456.

5. Andriantiatsaholiniaina, L.A., Kouikoglou, V.S., Phillis, Y.A. (2004). *Evaluating strategies for sustainable development: fuzzy logic reasoning and sensitivity analysis* / Ecological Economics, 2004, Volume 48, pp. 149-172.

6. Gagliardi, F., Roscia, M., Lazaroiu, G. Gheorghe. (2007). *Evaluation of sustainability of a city through fuzzy logic*. Energy, Volume 32, Issue 5, pp. 795-802.

7. Hîncu, D. (2011). *Modelling the urban sustainable development by using Fuzzy sets*. Theoretical and Empirical Researches in Urban Management, May 2011, Volume 6, Issue 2.

8. Lazim, A., Nurhanadia, W. (2010). *A fuzzy decision making approach in evaluating ferry service quality*. Management Research and Practice, Vol. 2, Issue 1, pp. 94-107.

9. Shengquan, Ma., Jing, F., Huhua, C. *Fuzzy model of regional economic competitiveness in GIS spatial analysis: Case study of Gansu, Western China*. Fuzzy Optim Decis Making, № 5, pp. 99-111.

10. Suxorukov, A.I. Eds.). (2009). *Systema ekonomichnoyi bezpeky` derzhavy`[The system of economic security]*. Nacionalnyj instytut problem mizhnarodnoyi bezpeky pry RNBO Ukrayiny. – K. : VD «Stylos» [in Ukranian].

11. Zgurovskyj, M. Z. (Eds.). (2010). *Analiz stalogo rozvytku – globalnyj i regionalnyj konteksty: U 2 ch. [Analysis of sustainable development – global and regional contexts: in 2 hours*]. K. : NTUU «KPI» [in Ukranian].

12. Bogatyrev, L.L. (1995). *Reshenie ehnergeticheskih zadach v usloviyah neopredelennosti [The solution of energy problems under uncertainty]*. E*katerinburg: UGTU-UPI* [in Russian].

13. Albrekht E.H., Bogatyrev L.L., Bochegov A.V. (2004). *Modelirovanie sostoyaniya I prognozirovanie razvitiya regionalnyh ehkonomicheskih I ehnergeticheskih sistem [Simulation and forecasting the state of development of regional economic and energy systems]*. RAN YrO, Int-t ehkonomiki, In-t teplofiziki, In-t ehnergeticheskih issledovanij. M.: ZAO «Izdatelstvo Ehkonomika» [in Russian].

14. Malyshev, N. G., Bershtejn, L. S., Bozhenyuk, A.V. (1991). *Nechetkie modeli dlya ehkspertnyh system v SAPR [Fuzzy models for expert systems in CAD]*. M.: Ehnergoatomizdat [in Russian].

15. *Metodychni rekomendaciyi shhodo rozraxunku rivnya ekonomichnoyi bezpeky Ukrayiny* (2013). *[Guidelines for calculating the level of economic security Ukraine]*. (n.d.). *cct.com.ua*. Retrieved from http://cct.com.ua/2013/29.10.2013_1277.htm. [in Ukranian].

16. *Indykatory ta porogovi znachennya dlya normalizaciyi pokaznykiv za pershym metodom normuvannya* (2013). [*Indicators and thresholds for the normalization of the first valuation method*]. (n.d.). *asyan.org.* Retrieved from http://asyan.org/potra/Індикатори+та+порогові+значення+індикаторів+для+нормалізації+показників+за+першим+методом+нормуванняа/main.html [in Ukranian].

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МЕТОДОЛОГІЯ АНАЛІЗУ СТАЛОГО РОЗВИТКУ УКРАЇНИ НА ОСНОВІ ТЕОРІЇ НЕЧІТКОЇ ЛОГІКИ

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Стаття присвячена аналізу теоретико-методичних аспектів визначення рівня сталого розвитку в умовах кризи. Запропоновано методичний підхід до аналізу сталого розвитку України на основі оцінки рівня економічної безпеки. Доведено необхідність, в умовах системної кризи розвитку економіки України, розробки комплексного методичного підходу до обліку властивостей невизначеності й багатокритеріальності в задачах забезпечення економічної безпеки на основі використання теорії нечіткої логіки (або теорії нечітких множин). Представлені результати використання методів теорії нечіткої логіки для аналізу динаміки сталого розвитку України за 2002-2012 рр.

Ключові слова: *сталий розвиток, економічна безпека, індикатор, теорія нечіткої логіка і нечітких множин, функція приналежності.*

МЕТОДОЛОГИЯ АНАЛИЗА УСТОЙЧИВОГО РАЗВИТИЯ УКРАИНЫ НА ОСНОВЕ ТЕОРИИ НЕЧЕТКОЙ ЛОГИКИ

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Статья посвящена анализу теоретико-методических аспектов определения уровня устойчивого развития в условиях кризиса. Предложен методический подход к анализу устойчивого развития Украины на основе оценки уровня экономической безопасности. Доказана необходимость, в условиях системного кризиса развития экономики Украины, разработки комплексного методического подхода к учету свойств неопределенности и многокритериальности в задачах обеспечения экономической безопасности на основе использования теории нечеткой логики (или теории нечетких множеств). Представлены результаты использования методов теории нечеткой логики для анализа динамики устойчивого развития Украины за 2002-2012 гг.

Ключевые слова: *устойчивое развитие, экономическая безопасность, индикатор, теория нечеткой логика и нечетких множеств, функция принадлежности.*