



The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
<http://ageconsearch.umn.edu>
aesearch@umn.edu

Papers downloaded from AgEcon Search may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

**Tetiana Ostapchuk¹, Kateryna Orlova¹, Svitlana Biriuchenko¹,
Andrii Dankevych², Galyna Marchuk¹**

¹Zhytomyr Polytechnic State University

²National University of Food Technology
Ukraine

DEFUZZIFICATION IN THE PROCESS OF MANAGERIAL ESTIMATING THE VALUE OF AGRICULTURAL LANDS

Purpose. The main purpose of the research is to substantiate the methodological approach of defuzzification and to define its peculiarities in the process of estimating the value of agricultural lands.

Methodology / approach. The research purpose included the use of a set of appropriate methods. In particular, the fuzzy logic techniques formed the basis of the research. The system approach was used in order to determine the role of land resources in the enterprise potential and the corresponding spheres of their management. The analysis and synthesis methods were used in the process of definition of impact factors of land resources value. The cartographic method was used for the needs of graphical display of humus content in the land plots of the analyzed enterprise. The generalization method was used in the process of forming conclusions.

Results. The article defines the peculiarities of defuzzification in the process of estimating the value of agricultural lands. The results provided the methodological basis for considering the qualitative metrics in the process of estimation as well as for granting the numerical interpretation for linguistic variables. The corresponding methodology was overviewed at the example of land plot size. The quantitative reference limits for "small", "medium" and "large" land plots were defined. Research results made it possible to form the sequence of stages, which are to be undertaken, in order to provide numerical values for qualitative characteristics of agricultural lands. A decision tree was built for the needs of formation of management decisions. According to the data of researched enterprise, the dependence of the value of agricultural lands (for the needs of management accounting) on the size of the land plot and the humus content was determined.

Originality / scientific novelty. The article improves the methodological approach to determining the value of agricultural lands as of an element of enterprise potential based on the use of fuzzy logic techniques, which, in contrast to existing approaches, allows taking into account both quantitative and qualitative factors in the process of estimating the value of land resources for the needs of their management. Applying the respective approach increases the level of accuracy, relevance, and adequacy to market realities of the results of estimating the value of agricultural lands for the needs of their management.

Practical value / implications. The results of the research provided an opportunity to improve the quality and efficiency of the process of estimating the value of agricultural lands. The corresponding process is characterized by a high level of complexity and uncertainty due to the presence of a significant number of qualitative factors influencing the value of the land resources. The approach considered in the article makes it possible to take into account the influence of relevant qualitative factors by giving them numerical certainty through the use of fuzzy logic techniques. The proposed approach will provide an opportunity to increase the accuracy and relevance of estimating the value of land resources as of an element of enterprise potential for the making of corresponding managerial decisions. The proposed methodological approach was

implemented with the use of data of agricultural enterprise, which made it possible to take into account linguistic variables (land plot size and chemical properties of the soil) when forming the managerial decisions about land plots. The decision tree was also formed, which serves as a means of supporting management decisions in the process of forming the value of agricultural lands.

Key words: management of agricultural enterprises activity, agricultural lands, value of land resources, estimation, defuzzification, linguistic variables.

Introduction and review of literature. Enterprise potential reflects its possibilities to organize and conduct economic activity, to use its resources efficiently, and to produce and sale goods and services in order to satisfy the public and corporate needs. Thus, enterprise potential is a complex set of its resources and possibilities of their usage in the process of economic activity. As a complex set of resources, potential includes technical, material, labour, intangible resources, as well as land resources. Land resources are an essential part of the enterprise potential, as they not only provide the spatial and territorial basis for any type of economic activity, but also are used as production means in specific types of economic activity (e.g., agriculture, alternative energetics, etc.). Thus, effective management of land resources is important for providing the effective and efficient functioning of the enterprise as a whole.

Land resource management is a sophisticated process which includes appropriate stages and procedures, while one of them is estimation of land value. Estimation of land value is a crucial process due to its role in the land resource management which is defined by the following:

- proper estimating the value of land resources enables their accounting;
- estimating the value of land resources should be considered in the process of substantiation of managerial decisions about ways of use of land resources;
- as a part of enterprise potential, the value of land resources impacts the market value of the enterprise as a whole;
- as land resources can be an object to sale contracts appropriate value estimation provides the analytical basis for price establishment.

Thus, efficiency and effectiveness of the estimating the value of land resources is an important prerequisite for providing the efficient functioning of the enterprise.

Any estimation process provides for determination and assessment of the factors which influence the value of the estimated object. At the same time, land resources are characterized with a set of impact factors which do not have quantitative (numerical) measures. Essential part of impact factors, which influence the value of land resources, can be described as qualitative or linguistic variables. Meanwhile, taking such factors into account is crucial for the credible and reliable estimation. The fuzzy logic techniques namely the process of defuzzification provides numerical measures for linguistic variables. This emphasizes the necessity to understand the peculiarities of the defuzzification process and substantiates the relevance of the article.

As land resources management is an essential part of management system as a whole, and the role of land resources is defined by the fact that they provide spatial

basis for almost any type of economic activity, the relevant issues have been discussed actively by prominent scientists. In particular, the issues on land resource use are provided in research of O. Harazha (2016), V. Kurylo et al. (2017), R. Brukhanskyi et al. (2018), R. Kozhukhivska et al. (2018), A. Yerseitova et al. (2018), W. Fan et al. (2020), T. Adamopoulos and D. Restuccia (2020), O. Zaiets et al. (2021), Yu. Skliar et al. (2021). O. Harazha (2016) in the study identifies the features of the land economy as a means of land resources management. In particular, the research defines the concepts and spheres of application of land economy, its levels and levers. The research of V. Kurylo et al. (2017) deals with the problems of land fragmentation in the agriculture of Ukraine. The authors define that land fragmentation is one of the issues that influence the efficiency of land use, thus, necessitating the balanced politics in land management both at micro and macro levels. The peculiarities of accounting and analytical support of land management system are analyzed by R. Brukhanskyi et al. (2018), who state that the efficiency of managerial decisions in the respective sphere highly depends on the quality of support system. Land resource potential as an integral element of enterprise potential as a whole is considered by R. Kozhukhivska et al. (2018). The research provides comprehensive assessment of land resource potential of certain agricultural enterprises, as well as proposes the components of land management mechanism. A. Yerseitova et al. (2018) devoted the research to the estimation of efficiency of land use in the Republic of Kazakhstan. W. Fan et al. (2020) discuss the issues of land resource-asset-capitalization in the context of effective land policy. They believe that the relevant process is necessitated by the need to combine economic, social, and environmental contexts in the land resources management. Life cycle analysis method is used by the authors in order to quantify the process of land resource-asset-capitalization from the perspective of the environment and environment-economy. T. Adamopoulos and D. Restuccia (2020) provide a macroeconomic point of view on land utilization issues, as they analyze the peculiarities of land reform and its impact on farms size and productivity according to the data of Philippines. O. Zaiets et al. (2021) consider the peculiarities of land resources use from the legal perspective. They analyze ecological and economic aspects of land reform, taking into account foreign experience in the relevant sphere. The comprehensive approach to the assessment of land resources and management is provided by Yu. Skliar et al. (2021). The integrated land valuation method, comprehensive assessment of land resources management approach, and the system of criteria of land management efficiency is provided in the research. The authors also propose land use optimization algorithm, which depends on the purpose of land use, as well as on the decisions in the respective sphere.

The issues of evaluation, value and price estimation of land resources were discussed in research of G. D. Rossiter (1995), W. H. Verheye (2000), D. de la Rosa and C. A. van Diepen (2002), Y. Yang et al. (2015), O. Dengiz and M. Usul (2018), M. A. Berawi et al. (2018), M. A. Berawi et al. (2019), O. Kovalova et al. (2020), A. C. Sant'Anna and A. L. Katchova (2020), F. Tu et al. (2021). The main stages of

land evaluation process are defined in the research of G. D. Rossiter (1995), as well as evaluation units, measures of economic suitability, and the influence factors. A comprehensive consideration of land evaluation methods is provided by W. H. Verheyen (2000). Peculiarities of GIS-based web system application in the process of land evaluation from the standpoint of information support are considered by Y. Yang et al. (2015). The architecture of such system, its users and user requirements, and the system functions are also provided in the research. Evaluation from the suitability point of view is provided by D. de la Rosa and C. A. van Diepen (2002) and O. Dengiz and M. Usul (2018). D. de la Rosa and C. A. van Diepen (2002) considered the evaluation methods, including fuzzy-set methodologies, from the standpoint of land suitability evaluation. Application of econometric methods in the process of land suitability assessment is provided by O. Dengiz and M. Usul (2018). M. A. Berawi et al. (2018) propose the use of land value capture technique and multiple regression model for forecasting the land price. The further implications of the model and its expanding is highlighted by M. A. Berawi et al. (2019). O. Kovalova et al. (2020) consider the ways of improvement of the normative monetary evaluation of agricultural lands. The research also determines the land resources peculiarities, which should be considered in the evaluation process and are based on the specifics of land resources as of a production means. The determinants of land value volatility are a subject of research of A. C. Sant'Anna and A. L. Katchova (2020). The scientists define responses of land value volatility to the positive and negative changes in land value determinants. F. Tu et al. (2021) define the peculiarities of land price formation in terms of industrial lands. The authors use the regression model in order to determine the most important factors of influence on industrial land prices.

Fuzzy logic techniques have been considered by scientists in different spheres. The research of V. Badenko, D. Kurtener (2006), P. Burrough (2006), J. Novaline, R. Krishnan (2008), O. Sharapov, D. Kaidanovich (2012), V. Novak, I. Perfilieva, I. Mochkorzh (2006), V. Borisov, A. Fedulov, M. Zernov (2014), et al. should be mentioned.

Meanwhile, the use of fuzzy logic techniques and defuzzification particularly in the process of estimating the value of agricultural lands remains insufficiently studied, that forms the expedience of the presented article.

The purpose of the article. The main purpose of the research is to substantiate the methodological approach of defuzzification and to define its peculiarities in the process of estimating the value of agricultural lands.

Results and discussion. Under conditions of increasing competition, uncertainty, and exaggeration of crisis factors both at national and worldwide level the special emphasis in the management process is put on the issues of effective and efficient resources formation and utilizing. The main tool for such task is the rational management of the enterprise potential as a complex and integrated system that connects the different types of resources of the enterprise and peculiarities of their use in the process of achieving strategic and tactical development goals. The structure

of the enterprise potential is quite complex, given the complexity and scale of the resources involved in economic activity. This complexity has led to the lack of a unified approach to structuring the enterprise potential in the scientific literature. Based on the research of I. Azhaman and O. Zhydkov (2018), we formed a conceptual model of the structure of the enterprise potential, and also determined the place of land resources in the corresponding model (Fig. 1).

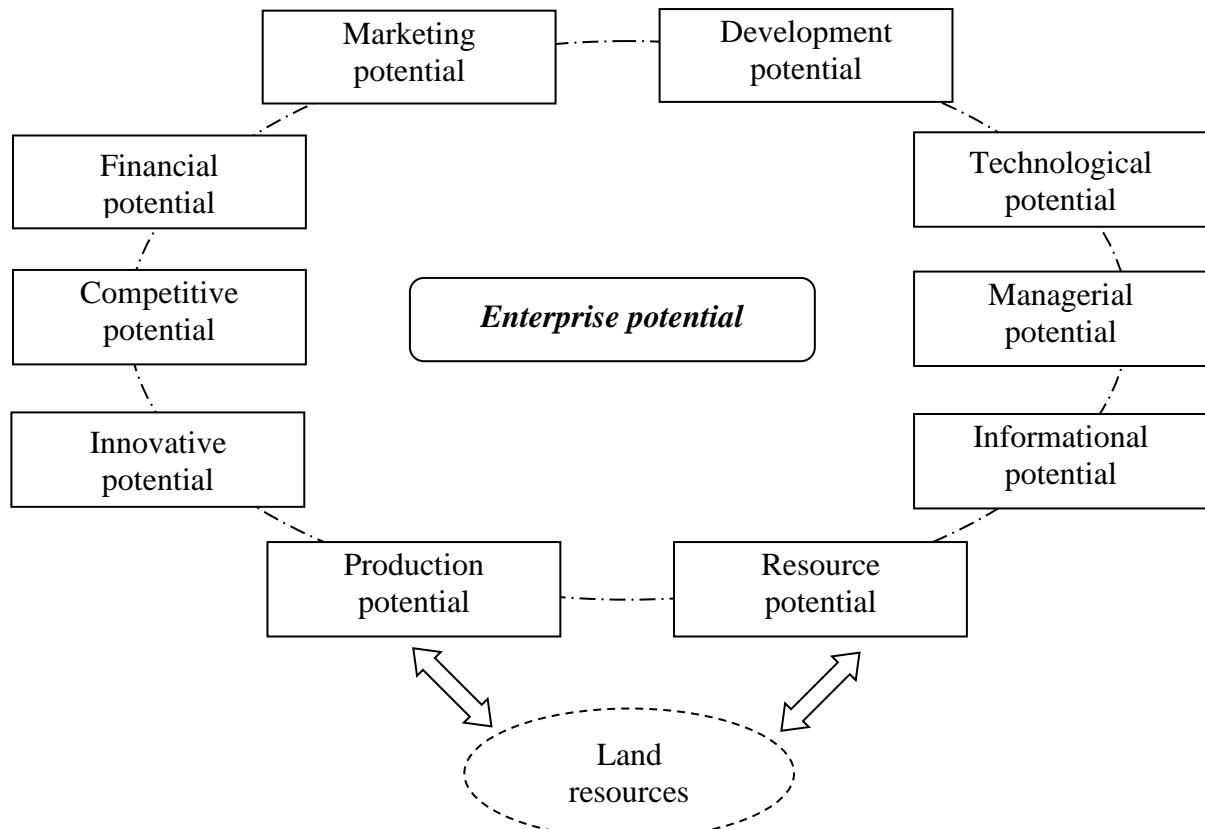


Fig. 1. The structure model of enterprise potential

Source: formed by the authors on the basis of Azhaman and Zhydkov (2018).

According to Fig. 1 we should note that land resources are an important component of production potential and resource potential, depending on the characteristics of their use in economic activities. The role of land resources is difficult to overestimate, due to their specificity:

- land resources are an integral component of the potential of almost any enterprise, as they form the spatial basis for economic activity;
- land resources are not subject to depreciation in the case of their rational use, which increases their value to the enterprise in terms of ensuring long-term balanced functioning;
- in some economic activities land resources can act as fixed assets (means of production);
- land improvements not only increase the productivity and efficiency of land use, but also increase its economic value.

Land can serve both as an investment and as a production tool (Sant'Anna and Katchova, 2020). Thus, land resources are resources of a great significance both for

agricultural and industrial enterprises, as well as for a country as a whole.

Another reason that determines the importance of scientific and applied research in the field of efficient use of land resources is that Ukraine has a significant land fund, at the same time, there is a reduction in agricultural lands, which indicates the presence of negative trends in this sphere (Table 1).

Table 1
The dynamics of land fund of Ukraine, thsd. ha

Land types	Years						Deviation 2019 to 2012	
	2012	2013	2014	2015	2017	2019		
Agricultural lands	42756.0	42744.5	42731.5	42726.4	41489.3	41310.9	-1445.1	-3.4
Forests and other wooded areas	10621.4	10624.4	10630.3	10633.1	10674.9	10686.8	65.4	0.6
Built-up lands	2535.2	2542.6	2550.4	2552.9	3597.8	3767.5	1232.3	48.6
Underwater lands	2423.0	2422.9	2426.4	2426.4	2425.0	2415.4	-7.6	-0.3
Open wetlands	980.1	981.6	982.6	982.3	1089.4	973.8	-6.3	-0.6
Other lands	1039.2	1038.9	1033.7	1033.8	1078.5	1200.5	161.3	15.5
Total lands	60354.9	60354.9	60354.9	60354.9	60354.9	60354.9	0.0	0.0

Note. The data is shown as of January 1 of the year following the reporting year.

Source: generalized by the authors according to the data of State Statistical Service of Ukraine.

According to the Table 1 it should be noted that at invariance of the general size of the land fund of Ukraine, reduction of agricultural lands and growth of the area of the built-up lands are observed. This indicates a tendency of urbanization of Ukrainian territory and, at the same time, reduction of the efficiency of land use as an element of the agricultural enterprise potential. Therefore, this trend highlights issues related to the effective management of land resources of enterprises, which, in turn, places special emphasis on the land value estimation issues.

Land resources are not only an important component of the enterprise potential, but also form a crucial element of the Ukrainian resources. O. Zaiets et al. (2021) mention that access to land resources defines the perspectives of famine and other food disasters, which stresses the necessity of effective management of land resources.

Land resource management is a purposeful process that involves the formation of targeted impact on land resources in order to ensure their efficient use and increase the value of the enterprise potential.

Land management methodology is considered as the research of management methods in the sphere of studying land resources, organizing activities on them, and their evaluation. The methodology includes methods of analyzing of land resources, their practical use, and evaluation (Harazha, 2016).

Ineffective management of land resources leads to soil degradation, which results in further decrease of land resource productivity (Yerseitova et al., 2018). This fact also emphasizes the necessity of efficient management of land resources.

The main tasks of system of land resource management should be (Kozhukhivska et al., 2018):

- providing the rational use of land resources;
- ensuring the resource saving approaches in processes of land resource use;
- implementing the advanced innovative technologies and technics;
- following the legislative regulations of the relations in the respective sphere.

We believe that the process of land resource management should be considered in the context of general management functions, namely:

- analysis of the availability, state, and features of land resource use in previous periods (including estimating the value of land resources);
- planning peculiarities of land resource use for the purpose of achievement of the enterprise development goals (including planning of improvements of the land plots);
- organization of efficient use of land resources, which provides for the formation of tools and mechanisms for land resource use, and determination of responsible persons and implementers of land use activities;
- development of a motivation system for employees involved in relevant activities;
- control over the implementation of the developed measures and implementation of corrective actions if necessary.

One of the key stages of management and the one that forms the information and analytical basis for the development and substantiation of further managerial decisions is the estimation of land resource value.

Value estimation is an important element of the overall system of land resources management because it forms the information support of managerial decisions, allows accounting of land resources, and is a component of value estimation of the enterprise potential as a whole, etc. Estimation of land value forms an important part of analytical and accounting support of land management system (Brukhanskyi et al., 2018), therefore, the rational organization of the process of the estimating the value of land resources is an important managerial and analytical task.

Another issue which puts a special emphasis on necessity of value estimation is the land fragmentation, that can be observed in agriculture of Ukraine. According to V. Kurylo et al. (2017) land fragmentation phenomenon is typical for Ukraine as well as it impacts the land use peculiarities in agriculture. Land fragmentation is considered as a situation when an individual agricultural enterprise may own several land plots, which are spatially separated from each other (Kurylo et al., 2017). Thus, each of these separated land plots may and will vary in its characteristics, which in their turn will form an impact on the specific land plot value. So, a comprehensive approach to estimating the value of land plots is an objective necessity for efficient and effective land management.

Land evaluation is concerned with the assessment of land performance when used for specified purposes (Dengiz and Usul, 2018). In turn, the estimation of the value of land resources involves the formation of monetary definition of the value (price) of a particular land plot as an element of the enterprise potential as a whole.

According to G. D. Rossiter (1995), the following evaluation stages should be

performed in the relevant process:

- definition of the land units which are to be analyzed;
- identification of economic measures to be used in the evaluation process;
- definition of the key impact factors;
- specifying the way the physical land characteristics influence its economic value;
- assessment of the economic land suitability;
- performing a sensitivity analysis to reveal the effect of errors in physical factors and model assumptions.

Identification of key factors influencing the value of land resources is an important step in the process of estimation. Taking into account all, or at least as many as possible, the most influential factors increases the reliability of the assessment, its compliance with market conditions.

Land resources value is influenced by a number of factors. In particular, scientists define such factors as: value-added premium, such as any improvement made for more beneficial use of land plot, and integration to the development programmes, land allocation, zoning, environmental regulations, infrastructure development (Verheye, 2000), land productivity, physical and chemical properties of various soils (Dengiz and Usul, 2018), geographic characteristics, land use planning, benchmark land price (Yang et al., 2015), relationship between demand and supply in the land market, land's location, physical structure, surrounding area (Berawi et al., 2018), inflation, cash rent, population growth (Sant'Anna and Katchova, 2020), land use regulation, location attributes, firm attributes (Tu et al., 2021), etc.

According to O. Kovalova et al. (2020) the following land resources characteristics should be taken into account in the process of value estimation:

- characteristics of land resources as of a means of labour: the natural qualities of soil, e.g., productivity, ecological condition, etc.;
- characteristics of land resources as of a subject of labour, e.g., size of land plot, landscape, improvement, etc.;
- characteristics of land resources as a spatial basis, e.g., the distance to product sales places, infrastructure, transport system, etc.

Yu. Skliar et al. (2021) propose a comprehensive approach to the land resources assessment, which results in improving monetary valuation of land. The key assessment criteria in the respective approach are the following: revenue, productivity of agricultural land; number of working places and wage system; social development of the territory; soil properties and features. The use of the appropriate tools and methods results in improving the monetary valuation of land and preparation of ecological passport of land, which, in their turn, provide for efficient land resources management.

Therefore, we note that the value of land resources is formed under the influence of a significant number of factors which can be both macroeconomic and microeconomic in nature, determined by specific characteristics of the land or by socio-economic conditions that define the peculiarities of its use. It should also be

mentioned that some influence factors have the quantitative nature, while others are of qualitative character. Taking into account both qualitative and quantitative factors is important from the standpoint of ensuring the accuracy, relevance, and reliability of estimation results.

A great number of methods and techniques of estimating the value of land resources can be applied, according to the type of land, its use peculiarities, the type of land market etc. In particular, the assessment methods can be based on few simple parameters or provide for the use of more detailed information, different mathematical procedures can be applied, the methods can be universal or specified (Verheye, 2000). The traditional management tools, such as life cycle analysis and life cycle cost assessment (Fan et al., 2020) can also be used in the process of land resources value estimation.

As the factors of impact on the value of land resources are quite diversified, and a number of them have the qualitative nature, this complicates the task of estimating the value of land resources greatly. That fact defines the scientific interest in issues of use of fuzzy-set methodology in the relevant process (de la Rosa and van Diepen, 2002).

Using the definition of the founder of the fuzzy set theory Lotfi Askar Zadeh, the linguistic variable is a variable whose meanings are words or sentences of the natural language, i.e., qualitative terms. Thus, by means of fuzzy sets you can create a formalized model, taking into account both quantitative and qualitative indicators. Such a model is created on the basis of fuzzy logic (Novak et al., 2006; Borisov et al., 2014).

The basic principles of linguistic modeling are (Novak et al., 2006; Borisov et al., 2014):

1) the principle of linguistics of input and output variables;

2) the principle of formation of the structure of the “input-output” dependence on the basis of a fuzzy knowledge base.

The structure of the linguistic variable is described by the tuple $\langle x, T, U, G, M \rangle$, where x is the name of the linguistic variable (e.g., ownership, properties, and time); T – term-set x (which is the content of a linguistic variable, for example, small, medium and large land); U (universe) – universal set of base variable u (for example, the size of the land plot in ares (1 are is equal to 100 square meters); G is a syntactic procedure that describes the process of formation of new meaningful values of the linguistic variable from the elements of the set T (for greater detail); M is a semantic procedure that allows each new value of a linguistic variable to be transformed into a fuzzy variable.

According to the purpose, the land of Ukraine is divided into nine categories:

- agricultural land;
- land of settlements (urban, rural);
- lands of nature reserves and other nature protection purposes;
- recreation land;
- land of historical and cultural value;
- land of forest fund;

- land of water fund;
- land for industrial, transport, communication, and defense purposes;
- land for other purposes (Land Code of Ukraine).

Land in each category has certain physical properties. Physical properties include factors such as climate, land size, relief, geology, chemical properties of the soil, and other parameters, as well as location indicators that describe the plot in terms of location in accordance with the business center, motorway, urban infrastructure objects etc.

We believe it is expedient to consider the proposed method of defuzzification at the example of agricultural land, as ensuring the effective functioning of agricultural enterprises forms the basis of food security of the country and is an important component of the national economy. At the same time, issues related to the assessment of the value of agricultural lands become especially relevant in the context of land reform, which was initiated by the Law of Ukraine “On Amendments to Certain Legislative Acts of Ukraine on the Conditions of Circulation of Agricultural Land”, adopted on 31.03.2020 (entered into force on 01.07.2021).

According to the Land Code of Ukraine, agricultural land is the land provided for the production of agricultural products, agricultural research and training activities, the location of relevant production infrastructure, including the infrastructure of wholesale markets for agricultural products, or intended for these purposes.

Agricultural lands include:

- a) agricultural lands (arable land, perennial plantations, hayfields, pastures, and fallow lands);
- b) non-agricultural lands (economic paths and roads, field protective forest strips and other protective plantings, except for those classified as lands of other categories, lands under farm buildings and yards, lands under infrastructure of wholesale markets of agricultural products, lands of temporary conservation, etc.) (Land Code of Ukraine).

Thus, the proposed methodology will be used for the lands defined as actually agricultural.

We define a set of linguistic variables:

$$Z = \{x_1, x_2, \dots, x_7\}, \quad (1)$$

where x_1 – climate; x_2 – size of the land plot; x_3 – relief; x_4 – chemical properties of the soil; x_5 – location according to the business center; x_6 – location according to the motorway; x_7 – location according to the city infrastructure objects.

The variability of the definition of the set of linguistic variables by categories of land can be determined by the grouped properties (x_1, x_2, \dots, x_7). Since x_2 is the “size of the land” property that is relevant for each category of land, so let us consider it in more detail. We will define that the distribution of the set of linguistic variables will be formed in such a range: a plot of land from 1 to 10 ares is small (i.e., from 1 are, the linguistic variable will take a value that can be defined as “very, very small”, in the range of 4 to 6 ares is “very small” and, accordingly, 10 ares will be determined by a linguistic variable “small”). From 10 ares to 50 ares, land plot may be “very

medium”, “medium” and “not very medium”. For more than 50 ares, the distribution of linguistic variables is as follows: “large”, “very large” and “very, very large”. Then the base term set of the linguistic variable will be the set $T = \{\text{small, medium, and large}\}$. Each formulated term will match its range of values.

Having defined the terms of a linguistic variable, we turn to the construction of membership functions. The membership function $\mu_A(u)$ is an intuitive relation between the base and fuzzy value of an object variable, which is expressed quantitatively, can take values from 0 to 1 and indicate membership of the corresponding term (in our case, the size of the land plot). This will allow us to calculate the necessary indicators that will be used as a basis for the numerical measurement of the land plot. To construct the membership function, it is sound to use the following functions: triangular, Z-function, S-function (Kofman, 1982; Leonenkov, 2003) involved in the detailed disclosure of a definite Term-set.

In the analytical form, the triangular-shaped membership function of the fuzzy term-set (which graphically reflects a definite affinity, see Fig. 2) can be shown as follows:

$$f(x, a, b, c) = \begin{cases} 0, & x < a, \\ \frac{x-a}{b-a}, & a \leq x \leq b, \\ \frac{c-x}{c-b}, & b \leq x \leq c, \\ 0, & x > c, \end{cases} \quad (2)$$

where a and c – the membership function parameters that define the basis of the triangle; b – the membership function parameter that corresponds to the coordinate of the maximum of the function and the vertex of the triangle.

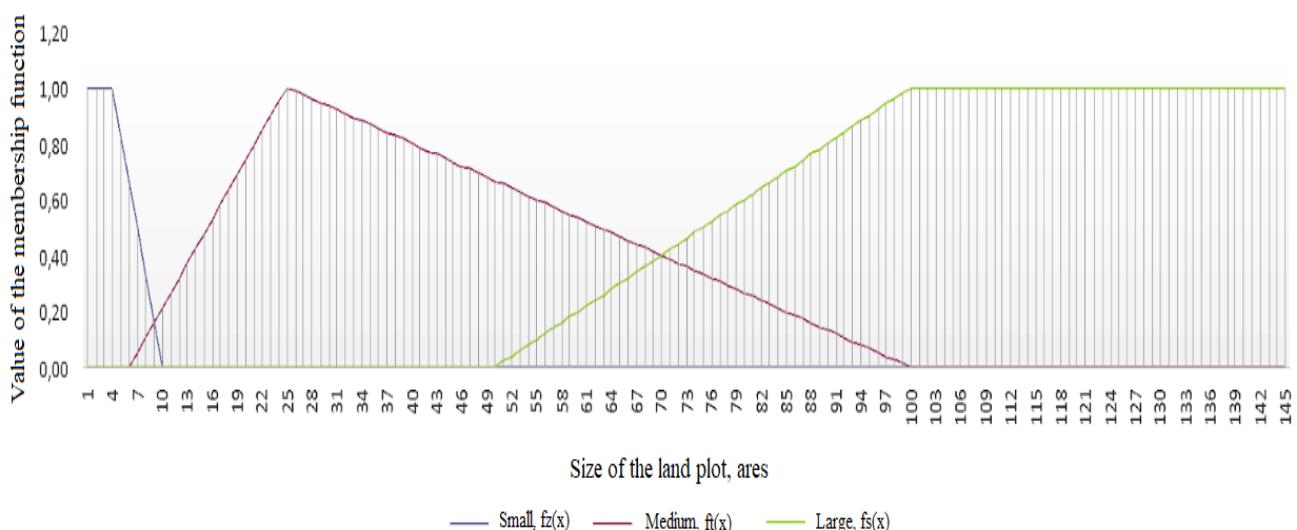


Fig. 2. The relationship between the base and fuzzy values of the object linguistic variable “land size”

Source: formed by T. Ostapchuk.

In an analytic form, the Z-shaped membership function of a fuzzy term-set can be written as follows:

$$f(x, a, b) = \begin{cases} 1, & x \leq a, \\ \frac{b-x}{b-a}, & a \leq x \leq b, \\ 0, & x \geq b, \end{cases} \quad (3)$$

where a and b – membership function parameters that specify the range of variable change.

In the analytic form, the S-shaped membership function of the fuzzy term-set can be written as follows:

$$f(x, a, b) = \begin{cases} 1, & x \leq a, \\ \frac{x-a}{b-a}, & a \leq x \leq b, \\ 0, & x \geq b, \end{cases} \quad (4)$$

where a and b – membership function parameters that specify the range of variable change.

We will present terms in the form of a fuzzy set. In order to use the Z-function for the definition of the term “small land”, a triangular function will be used to define the term “medium land”, the S-function will be used to define the term “large land”. This corresponds to the physical content of these plots.

Moreover \tilde{A} is the fuzzy set for the corresponding term (small, medium, large) defined in a certain range (for example, for a “small plot of land” from 1 to 10 ares, in which the numerator has the value of the membership function, and in the denominator is the size of the land plot in ares):

$$- \text{“small”} \quad \tilde{A}_s = \frac{1}{1} + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \frac{0.83}{5} + \frac{0.67}{6} + \frac{0.5}{7} + \frac{0.33}{8} + \frac{0.17}{9} + \frac{0}{10}, \quad (5)$$

$$- \text{“medium”} \quad \tilde{A}_m = \frac{0}{6} + \frac{0.21}{10} + \frac{0.47}{15} + \frac{0.74}{20} + \frac{1}{25} + \frac{0.93}{30} + \frac{0.67}{50} + \frac{0.4}{70} + \frac{0.13}{90} + \frac{0}{100}, \quad (6)$$

$$- \text{“large”} \quad \tilde{A}_l = \frac{0}{50} + \frac{0.2}{60} + \frac{0.4}{70} + \frac{0.6}{80} + \frac{0.8}{90} + \frac{0.9}{100} + \frac{1}{110} + \frac{1}{120} \quad (7)$$

In Fig. 2 the range of fuzzy sets for land plots grouped by size is graphically presented (small is from 1 to 10 ares, the medium is from 6 to 100 ares, the large is from 50 ares and more), which is the basis for further calculations to determine the value component of the object. In this case, in Fig. 2 in the numerical range with respect to the size of the “large”, “medium” and “small” sections in the corresponding relationship, the following functions were used as described above: for the “small” – Z-function, for the “medium” – the triangular function, for “large” – S-function.

In addition, the syntactic procedure (G) can form new terms using the “and”,

“or” linkers and modifiers (linguistic uncertainties) of the type “very”, “not”, “more or less”, and others. For example, “a very small plot of land” or “not a large plot of land”, or “not very large plot of land”, etc. For the modifier “very”, the membership function takes value $(\mu_t(u))^2$, and for “not” $1 - \mu_t(u)$. The use of the syntactic procedure (G) is necessary when the user of the land plot will need more detailed information about its size within the linguistic variable.

After carrying out the corresponding calculations and defining their basis, it is necessary to carry out the process of transformation of the linguistic variable into a quantitative indicator, i.e., to conduct a defuzzification procedure (the process of converting a fuzzy set into a distinct number). There are many methods of defuzzification: COG (Center of Gravity); Bisector – Median; LOM (Largest of Maximums); SOM (Smallest of Maximums); MOM (Mean of Maximums) (Shtovba, 2007). The most effective of these techniques is the COG (Center of Gravity), which is calculated using the following formula:

$$a = \frac{\sum_{i=1}^k u_i \cdot \mu_A(u_i)}{\sum_{i=1}^k \mu_A(u_i)} \quad (8)$$

We will conduct defuzzification for the term “not very large land” on the basis of the next fuzzy set:

$$\tilde{A}_s = \frac{1}{50} + \frac{0.96}{60} + \frac{0.84}{70} + \frac{0.64}{80} + \frac{0.36}{90} + \frac{0}{100} + \frac{0}{110} + \frac{0}{120} \quad (9)$$

Result of defuzzification (a):

$$a = \frac{1 \cdot 50 + 0.96 \cdot 60 + 0.84 \cdot 70 + 0.64 \cdot 80 + 0.36 \cdot 90}{1 + 0.96 + 0.84 + 0.64 + 0.36 + 0} = 65.79 \quad (10)$$

After defuzzification, we conclude that the expression “not very large land” by transformation into a numerical dimension is equal to 65.79 ares, with the basis for calculations of “large land”.

Thus, on the example of the term of the linguistic variable “not very large plot of land”, we have proved that there is a real possibility of transferring qualitative indicators of a certain economic object into a numerical measure.

The proposed methodology can also be applied for interpretation of other linguistic variables in order to implement a comprehensive approach to the land value estimation process. We believe that considering both quantitative and qualitative land characteristics will contribute to the comprehensive approach to the land value estimation as well as to the land management efficiency as a whole.

In order to implement the results of the research, we will apply the methodological approach that we proposed above, to the economic activity of the agricultural enterprise, which is located in Chernihiv region (the company name is not specified in accordance with data protection under the privacy policy).

The analyzed agricultural enterprise provides economic activity in the following

spheres: growing of cereals (except rice), leguminous crops and oil seeds; growing of vegetables and melons, roots and tubers; growing of other non-perennial crops; raising of dairy cattle; raising of swine/pigs; support activities for crop production. The enterprise has respective land resources, which are used in production.

From the set of linguistic variables $Z = \{x_1, x_2, \dots, x_7\}$, where x_1 is climate; x_2 – size of the land plot; x_3 – relief; x_4 – chemical properties of the soil; x_5 – location according to the business center; x_6 – location according to the motorway; x_7 – location according to the city infrastructure objects, in addition to the size of the land plot (x_2) we will also use the chemical properties of the soil (by the humus percentage) (x_4).

Humus percentage is one of the most important soil characteristics, which defines the productivity of land resources, thus, the value of particular land plots. Land productivity is an especially important factor of influence on land value for agricultural lands, as in this case we are considering land resources as a means of production. This fact has influenced the choice of the linguistic variables, which will be considered in the method. Focusing on only two variables of the seven considered in the model significantly simplifies the computational component of the practical application of the model. It is clear that the exclusion of other factors from consideration reduces the accuracy of the model, but increases its practical value in terms of use by specialists of agricultural enterprises. The data on the 23 land plots of the agricultural enterprise is provided in Table 2.

Table 2
Generalization of the linguistic variables and land value grouped according to the data of the enterprise

N	Size of the land plot, hectares	x_2	Humus, %	x_4	Z, thsd. UAH	N	Size of the land plot, hectares	x_2	Humus, %	x_4	Z, thsd. UAH
1	3.6	1	2.7	m	89.0	13	93.0	vl	2.6	m	2296.2
2	21.7	vl	4.3	h	544.7	14	49.0	vl	2.8	m	1212.2
3	31.3	vl	1.9	low	767.5	15	155.0	vvl	1.8	low	3797.2
4	42.0	vl	2.6	m	1037.0	16	106.9	vvl	2.3	m	2631.7
5	29.5	vl	1.5	low	720.6	17	186.7	vvl	1.6	low	4564.8
6	17.7	vl	5.3	vh	448.5	18	185.2	vvl	2.2	m	4554.9
7	7.4	1	9.4	vh	194.8	19	187.3	vvl	2.1	m	4602.0
8	217.4	vvl	3.8	i	5430.5	20	15.6	vl	1.9	low	382.5
9	105.0	vvl	2.3	m	2584.9	21	17.3	vl	2.7	m	427.6
10	102.0	vvl	2.9	m	2525.8	22	95.9	vl	2.2	m	2358.6
11	123.0	vvl	4.0	h	3078.4	23	169.3	vvl	2.5	m	4176.1
12	43.0	vl	1.9	low	1054.5						

Note. N is the number of the enterprise land plot; x_2 – size of the land plot (1.0–10.0 – large (l); 10.1–100.0 – very large (vl); >100.0 – very very large (vvl)); x_4 – chemical properties of soil (humus content (<1.1 – very low (vlow); 1.1–2.0 – low (low); 2.1–3.0 – medium (m); 3.1–4.0 – increased (i); 4.1–5 – high (h); >5.0 – very high (vh)).

Source: formed by the authors according to the data of the enterprise.

According to the data of Table 2 we can note, that 2 out of 23 land plots of the enterprise can be described as “large”, 11 out of 23 land plots are described as “very large” and 10 plots out of 23 land plots are referred to as “very very large”. As for the humus percentage, 6 land plots have low content of humus, 12 land plots are described as such with medium humus content, 1 land plot has increased humus content, 2 land plots have high and 2 land plots have very high content of humus.

For greater visualization of the humus percentage in the relevant agricultural lands, we provide the zones of grouping by the content of organic matter (humus) in Fig. 3. The visualization is formed on the basis of the enterprise data. The respective analysis of soil samples was conducted in 2019 and provided for the analysis of enterprise land plots. The visualization provides for the better understanding of the specifics of zoning land plots of the enterprise.

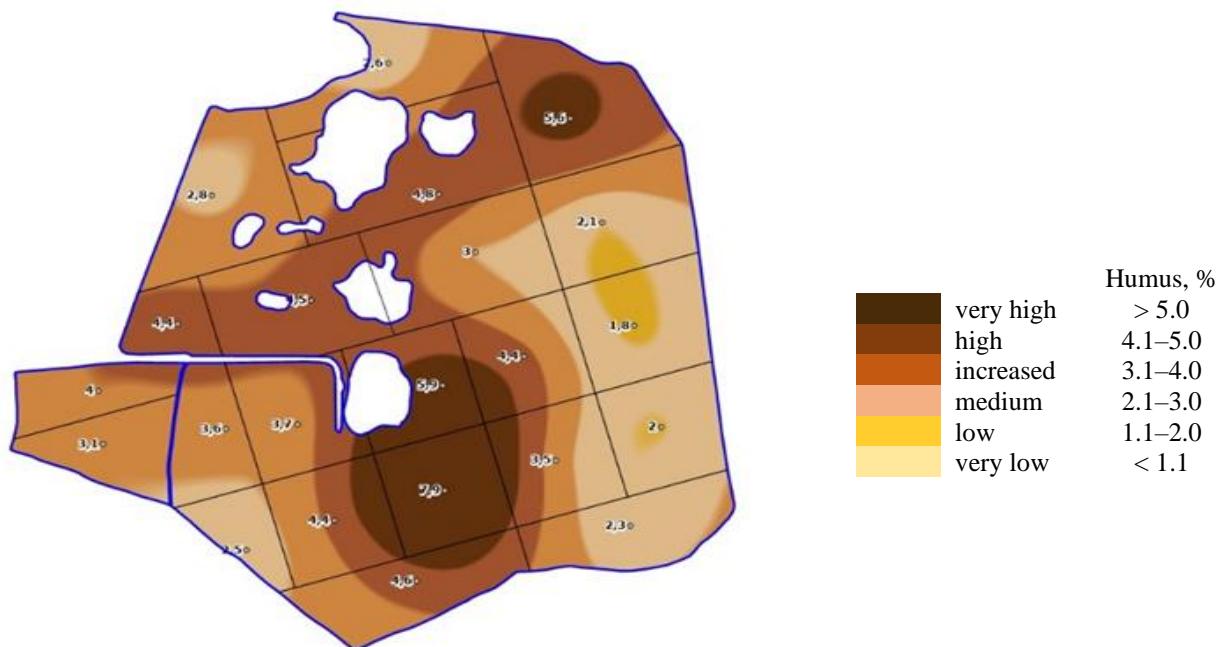


Fig. 3. Visualization of humus percentage in the respective agricultural lands of the enterprise

Source: the enterprise data.

On the base of the Table 2 and Fig. 3 indicators we will build a decision tree to assess and analyze the impact of two linguistic variables on the future value of agricultural lands of the enterprise.

We'll detail the relevant information according to the classification groups of agricultural lands, such as arable lands (1), hayfields (2), and pastures (3) (Fig. 4).

The proposed method can be used for the estimating value of agricultural lands with the purpose of their management. According to the Table 2 data, the authors have built a model of the dependence of the land plot value (for the needs of managerial accounting) on the size of the land plot and on the humus percentage. The model took the form:

$$Z = -21.29 + 24.71x_2 + 6.4x_4, \quad (11)$$

where x_2 – size of the land plot; x_4 – humus percentage.

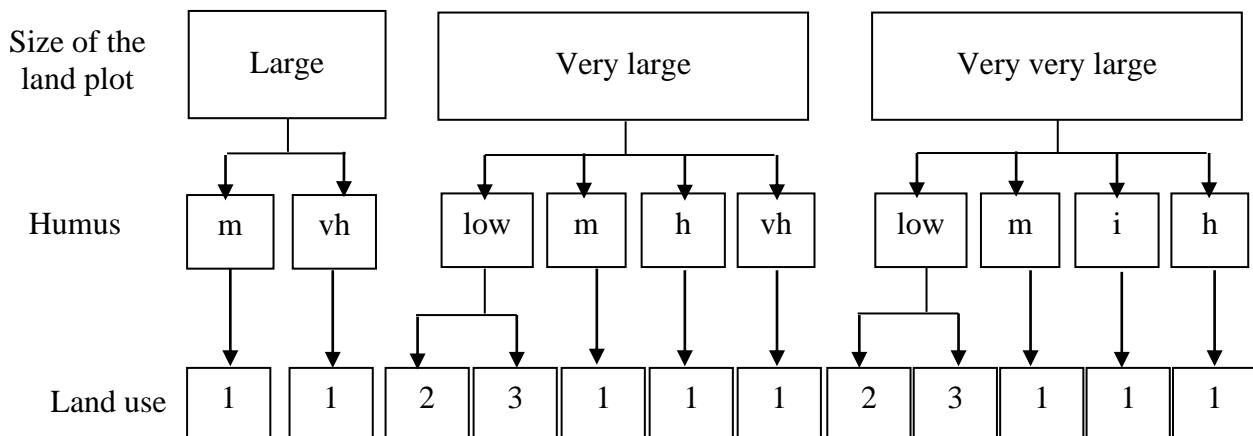


Fig. 4. Decision tree according to the classification groups of agricultural lands of the enterprise

Source: formed by the authors.

It should be noted that the developed model is built for the agricultural enterprise of Chernihiv region and determines the value of land plots for the needs of their management. At the same time, the use of the proposed model by enterprises of other regions of Ukraine needs its adaptation.

We use the developed model to substantiate the value of land plots determined with the help of linguistic variables. In particular, we determine the value of a not very large land plot (according to the calculations of defuzzification, the size of such a plot is 65.79 ares) with high humus content. Regarding the interpretation of the values of humus content, the following intervals are proposed: high humus content – 4.1–5 %. For the purposes of calculation, we will use the middle of the interval – 4.55 %.

In this case, the value of agricultural land for the needs of managerial accounting will be as follows:

$$Z = -21.29 + 24.71 \cdot 0.6579 + 6.4 \cdot 4.55 = 24.09 \text{ thsd. UAH}$$

So, we should mention that the humus percentage has a great influence on the value of land plots of the enterprise for the need of their management.

On the basis of the conducted research, it is possible to draw the following conclusion. The methodological tools proposed in this article provide a real opportunity for agricultural sector entities to take into account linguistic variables as qualitative characteristics of land plots in the formation of their value.

Conclusions. The process of land resources value estimation is an important stage of land resources management. While assessing the land resources value, it is crucial to understand the factors of influence, which determine the final estimation. Due to the peculiarities of land resources, such factors of influence include qualitative and quantitative metrics. Both are important to be considered in the process of value estimation. The tool to make such consideration possible is the fuzzy logic technique. In order to interpret qualitative characteristics into numerical metrics the defuzzification process is used. Such process enables to provide a comprehensive approach to the estimation process as well as to consider both qualitative and

quantitative impact factors.

The use of the proposed method of considering linguistic variables in the activity of the enterprise provided a real opportunity to take into account in the process of formation of the value of twenty-three agricultural land plots of the enterprise two linguistic variables (land plot size, chemical properties of the soil). The respective process of value formation was provided according to the three classification groups: arable land (1), hayfields (2), and pastures (3). The decision tree (Fig. 4) acted as a means of supporting of managerial decisions in the formation of the agricultural land plots value and provided an opportunity to create the model that forecasts the value of the target variable (land value) on the base of two linguistic variables used in the research. As a result of these studies, it was found that not always a large area of land means that it will have a high value. Therefore, for the considered enterprise the variability of the value formation of the agricultural land plots through the systematization of qualitative indicators of land plots and their belonging to certain classification groups of agricultural lands was proposed. According to the data provided by the analyzed enterprise, the model of dependence between the value of land plot and its size and humus content was formed. The proposed model provides the opportunity to define value of land plots with the purpose of substantiation of managerial decisions.

Prospects for further research are in the development of methodological approaches to the formation of a model for determining the value of land with the selection of the most influential factors for different groups of land and the application of a comprehensive approach to this process.

References

1. Harazha, O. P. (2016), Land economics in land management of Ukraine. *Global and National Problems of Economics*, vol. 11, pp. 108–112.
2. Kurylo, V., Pantaliienko, P., Bogdanets, V. and Ovcharuk, S. (2017), Land fragmentation in Ukraine: agricultural land-use management and jurisprudence issues. *Problems and Perspectives in Management*, vol. 15, is. 2, pp. 102–109. [https://doi.org/10.21511/ppm.15\(2\).2017.10](https://doi.org/10.21511/ppm.15(2).2017.10).
3. Brukhanskyi, R. F., Yazlyuk, B. and Bincharovska, T. A. (2018), Effective land management in Ukraine using accounting and analytical support. *Problems and Perspectives in Management*, vol. 16, is. 2, pp. 241–251. [https://doi.org/10.21511/ppm.16\(2\).2018.22](https://doi.org/10.21511/ppm.16(2).2018.22).
4. Kozhukhivska, R., Kulbitsky, V., Kyryliuk, I., Maliuga, L. and Podzigun, S. (2018), Managing the efficiency of enterprises based on assessment of the land resource potential. *Problems and Perspectives in Management*, vol. 16, is. 2, pp. 164–178. [https://doi.org/10.21511/ppm.16\(2\).2018.15](https://doi.org/10.21511/ppm.16(2).2018.15).
5. Yerseitova, A., Issakova, S., Jakisheva, L., Nauryzbekova, A. and Moldasheva, A. (2018), Efficiency of using agricultural land in Kazakhstan. *Entrepreneurship and Sustainability Issues*, vol. 6, no. 2, pp. 558–576. [https://doi.org/10.9770/jesi.2018.6.2\(7\)](https://doi.org/10.9770/jesi.2018.6.2(7)).
6. Fan, W., Chen, N., Li, X., Wei, H. and Wang, X. (2020), Empirical research on

the process of land resource-asset-capitalization – a case study of Yanba, Jiangjin district, Chongqing. *Sustainability*, vol. 12(3), 1236. <https://doi.org/10.3390/su12031236>.

7. Adamopoulos, T. and Restuccia, D. (2020), Land reform and productivity: a quantitative analysis with micro data. *American Economic Journal: Macroeconomics*, vol. 12, no. 3, pp. 1–39. <https://doi.org/10.1257/mac.20150222>.

8. Zaiets, O., Vlasenko, Yu., Busuyok, D. and Pozniak, E. (2021), Ecological aspect of legal provision of modern land reform as a factor of sustainable development. *European Journal of Sustainable Development*, vol. 10, no. 1, pp. 168–184. <https://doi.org/10.14207/ejsd.2021.v10n1p168>.

9. Skliar, Yu., Bohinska, L., Kapinos, N. and Prokopenko, N. (2021), Improvement of land management in Ukraine. *Journal of Optimization in Industrial Engineering*, spec. is., pp. 175–183. <https://doi.org/10.22094/JOIE.2020.677866>.

10. Rossiter, G. D. (1995), Economic land evaluation: why and how. *Soil Use & Management*, vol. 11, is. 3, pp. 132–140. <https://doi.org/10.1111/j.1475-2743.1995.tb00511.x>.

11. Verheyen, W. H. (2000), Use of land evaluation techniques to assess the market value of agricultural land. *Agropedology*, vol. 10, pp. 88–100.

12. De la Rosa, D., Van Diepen, C. (2002), Qualitative and quantitative land evaluation. *Land Use and Land Cover and Soil Sciences*, vol. II, available at: <https://www.eolss.net/Sample-Chapters/C12/E1-05-02-02.pdf>.

13. Yang, Y., Sun, Y., Li, S., Zhang, S., Wang, K., Hou, H. and Xu, S. (2015), A GIS-based web approach for serving land price information. *ISPRS International Journal of Geo-Information*, vol. 4 (4), pp. 2078–2093. <https://doi.org/10.3390/ijgi4042078>.

14. Dengiz, O. and Usul, M. (2018), Multi-criteria approach with linear combination technique and analytical hierarchy process in land evaluation studies. *Eurasian Journal of Soil Science*, vol. 7, is. 1, pp. 20–29. <https://doi.org/10.18393/ejss.328531>.

15. Berawi, M. A., Suwartha, N., Kurnia, K., Gunawan, Miraj, P. and Berawi, A. R. B., (2018), Forecasting the land value around commuter rail stations using hedonic price modeling. *International Journal of Technology*, vol. 9, no. 7, pp. 1329–1337. <https://doi.org/10.14716/ijtech.v9i7.2589>.

16. Berawi, M. A., Suwartha, N., Salsabila, F., Gunawan, Miraj, P. and Woodhead, R. (2019), Land value capture modeling in commercial and office areas using a big data approach. *International Journal of Technology*, vol. 10, no. 6, pp. 1150–1156. <https://doi.org/10.14716/ijtech.v10i6.3640>.

17. Kovalova, O., Yarova, I., Mishenina, H., Pizniak, T. and Dutchenko, O. (2021), Evolution of improving the normative monetary evaluation of agricultural lands. *Agricultural and Resource Economics*, vol. 7, no. 1, pp. 137–163. <https://doi.org/10.51599/are.2021.07.01.08>.

18. Sant'Anna, A. C. and Katchova, A. L. (2020), Determinants of land value volatility in the U.S. Corn Belt. *Applied Economics*, vol. 52, is. 37, pp. 4058–4072.

<https://doi.org/10.1080/00036846.2020.1730760>.

19. Tu, F., Zou, S. and Ding, R. (2021), How do land use regulations influence industrial land prices? Evidence from China. *International Journal of Strategic Property Management*, vol. 25, no. 1, pp. 76–89.
<https://doi.org/10.3846/ijspm.2020.14051>.

20. Badenko, V. and Kurtener, D. (2004), Fuzzy modelling in GIS environment to support sustainable land use planning. *7th AGILE Conference on Geographic Information Science*, 29 April–1 May 2004, Heraklion, Greece, pp. 333–342.

21. Burrough, P. A. (2006), Fuzzy mathematical methods for soil survey and land evaluation. *European Journal of Soil Science*, vol. 40, is. 3, pp. 477–492.
<https://doi.org/10.1111/j.1365-2389.1989.tb01290.x>.

22. Novaline, J. and Krishnan, R. (2008), Fuzzy logic approach for sustainable land use planning. *COORDINATES*, available at: <https://mycoordinates.org/fuzzy-logic-approach-for-sustainable-land-use-planning/all/1>.

23. Sharapov, O. D. and Kaidanovych, D. B. (2012), Estimation of probable bankruptcy on the basis of company's financial state indicators with the use of counter-propagation neural networks. *Neirono-nechetki tekhnolohii modeliuvannia v ekonomitsi*, vol. 1, pp. 207–227.

24. Novak, V., Perfilieva, I. and Mochkorzh, I. (2006), *Matematicheskie pryntsypy nechetkoi lohiki* [Mathematical principles of fuzzy logic], Fizmatlyt, Moscow, Russian Federation.

25. Borisov, V. V., Fedulov, A. S. and Zernov, M. M. (2014), *Osnovy teorii nechetkikh mnozhestv* [Fundamentals of fuzzy set theory], Horyachaia liniia-Telekom, Moscow, Russian Federation.

26. Azhaman, I. A. and Zhydkov, O. I. (2018), The nature and structure of the economic potential of the enterprise. *Ekonomika ta derzhava*, vol. 4, pp. 22–25.

27. The Verhovna Rada of Ukraine (2001), Land Code of Ukraine, available at: <http://zakon3.rada.gov.ua/laws/show/2768-14>.

28. Kofman, A. (1982), *Vvedenye v teoriyu nechetkykh mnozhestv* [Introduction to the fuzzy set theory], Radyo i sviaz, Moscow.

29. Leonenkov, A. V. (2003), *Nechetkoe modelirovaniye v srede MATLAB i fuzzyTECH* [Fuzzy modelling in MATLAB and fuzzyTECH environment], BKhV-Peterburh, Saint-Petersburg, Russian Federation.

30. Shtovba, S. D. (2007), *Proektirovaniye nechetkikh system sredstvami MATLAB* [Designing Fuzzy Systems Using MATLAB], Horyachaia liniia-Telekom, Moscow, Russian Federation.

Citation:

Стиль – ДСТУ:

Ostapchuk T., Orlova K., Biriuchenko S., Dankevych A., Marchuk G. Defuzzification in the process of managerial estimating the value of agricultural lands. *Agricultural and Resource Economics*. 2021. Vol. 7. No. 4. Pp. 62–81. <https://doi.org/10.51599/are.2021.07.04.04>.

Style – APA:

Ostapchuk, T., Orlova, K., Biriuchenko, S., Dankevych, A. and Marchuk, G. (2021), Defuzzification in the process of managerial estimating the value of agricultural lands. *Agricultural and Resource Economics*, vol. 7, no. 4, pp. 62–81. <https://doi.org/10.51599/are.2021.07.04.04>.