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Original research paper

Modeling the Processes of Land Resources Administration

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Abstract: In this publication, the strategy of land resources administration is presented on the basis of consideration of proposed result factors. The research methodology is based on the use of the PESTLE analytical model in conjunction with economic-mathematical modeling. The scientific novelty of the publication is developing the technology of administration of land resources on the basis of cadastral and other statistical information, which allows obtaining scientifically grounded solutions on the use of land resources. Considering the process of Land Resources Administration as a procedure based on making certain decisions when creating a management system which takes into account the internal and external relationships in this system, the postulate is about determining the degree of trust in this system, establishing economic, environmental and social risks when using it. To a certain extent, the process of Land Resources Administration is a prediction of the effective use of this natural potential in the future. It should be noted that the reliability of the forecast decision depends on the nature and parameters of uncertainties and the duration of their validity. Consequently, while making operational decisions on land resources for a short perspective, the forecasting is more reliable than for a long one. It becomes an effective mechanism of objective evaluation of the state of land resources and the prospects for their use. In this publication the main influencing decision making factors and the technological scheme of the solution of the problem are given.

Keywords: land resources, administration, model, risk

1. Introduction

The system of modeling the Land Resources Administration (LRA), which connects the aspects of natural resource potential of the earth with external natural phenomena and factors, as well as with a set of other factors, in particular demographic, social, legal, economic is extremely complicated (Cronan et al., 2010). In this aspect, the selection of

a model for reflecting the real state of the object of research, through analytical thinking, and then mathematical modeling, is extremely difficult. The system of Land Resources Administration will be understood as a complex probable dynamic system that is covering the structure of land resources by category of lands, their intended use, soil cover, zones of restrictions and encumbrances, forms of ownership, estimated value in combination with the influence of natural phenomena and processes, as well as social and demographic status of territories (Andras, 2011). Thus, this system is a complex of interconnected elements between its individual objects.

The purpose of this study is to develop a Land Resources Administration strategy based on comparing the results of analytical and economic-mathematical modeling taking into account the proposed classification of influential factors. In the application of factors, it is important to reach the consensus on the goals of territorial communities with the objectives of regional and state interests regarding the use of land on this territory. Development programs for individual administrative units should be closely linked to regional and state target programs (Enemark et al., 2005). Considering the process of Land Resources Administration as a procedure based on making certain decisions when creating a managed management system (Williamson et al., 2010), which takes into account the internal and external relationships in this system, the postulate is about determining the degree of trust in this system, establishing economic, environmental and social risks when using it. To a certain extent, the process of Land Resources Administration is a prediction of the effective use of this natural potential in the future. It should be noted that the reliability of the forecast decision depends on the nature and parameters of uncertainties and the duration of their validity. Consequently, while making operational decisions on land resources for a short perspective, the forecasting is more reliable than for a long one.

All this requires the application of economic and mathematical methods and approaches for analyzing and assessing the impact of various factors on decision-making in Land Resources Administration, using for that GIS technologies.

2. Data used and methods applied

In order to develop a theoretical and analytical model of land resources administration at any level of state and local government, it is necessary to identify groups of factors and their factors that have the greatest influence on the development of the strategy of LRA.

A number of models are used in the development of management strategies, some of which are models based on the use of SWOT, PEST and PESTLE analysis (SWOT, PESTLE and other models for strategic analysis by Invest Northern Ireland service). Models based on SWOT-analysis take into account strong (S) and weak (W) factors of influence on the final result, potential opportunities (O) and threat (T) factors. Models based on PEST analysis take into account political (P), economic (E), socio-cultural (S) and technological (T) factors, but they do not take into account a range of legal (L) and environmental (E) factors that are significant in LRA.

From the analysis of existing analytical models, the most complete one, which will most contribute to the development of an adequate model of LRA is the PESTLE model. Such a model takes into account political, economic, socio-cultural, technological, legal and environmental factors. Models developed on this basis of analytical analysis take into account the influence of all factors that influence the adoption of final decisions considering the specifics of efficient and rational use of land resources, their conservation and protection, which in turn requires the establishment of weighty indicators in each group. For this model, the main impact factors on decision-making in the LRA system (see Table 1) are formed. At any level of land resources administration, the model should include the factors that have the greatest impact on the development of LRA strategy, including cadastral data (Wallace, 2018).

The proposed model of land resources administration (Figure 1) involves four main stages: the first – collection of information necessary for effective decision-making; the second – establishment of groups of key dominant factors and identification of priority factors in each group, their quantitative and qualitative characteristics; the third – economic and mathematical processing of information, establishment of effective administrative decisions on the use of land resources; the fourth – future risks and chances, assessment of proposed solutions, recommendations, etc.

Determination of priority factors should take place using one or several mathematical methods: expert evaluations, correlation-regression analysis, center of gravity or potential, main components, hierarchies and taxonomic index. The selection of a method of determining the priority factors depends on the degree of confidence in the information database, skills of practical possession of a certain mathematical apparatus, professional preparation in the domain of the formation of LRA system. On the basis of the appropriate analytical and economic-mathematical processing of systematized priority factors, it becomes possible to form a program for LRA. The most suitable solution for this part of the task is simulation and scenario modeling, as well as mathematical forecasting. From the point of view of mathematical severity of solution of this problem, the method of mathematical forecasting (Ludchak, 2010) may be the most acceptable one.

The application of the proposed methodology will determine the priorities in the development of land resources and formulate the strategies for development of individual territorial communities and regions. It should be noted that the overwhelming majority of the methods of priority (most important) factors are determined by expert evaluation (stage II), which is based on the conclusions and judgments of experts in this field of knowledge or production that allows taking into account hidden links between certain groups of factors or factors themselves, which does not allow them to be identified by traditional economic and/or mathematical methods. In this case, the identification of priority factors is established on a point scale based on criteria agreed by experts. In most cases, the ten point scale is chosen, where the indicators of influence are determined in three groups: low, medium, high.

An important final step is to evaluate the design of LRA versions. To do this, such criteria systems as Wald's maximin, Routh–Hurwitz stability, Regret, Pessimism and others should be used. In the period of creation of a socially oriented economy, the

Table 1. Factors for forming a model based on PESTLE analysis

Factors					
Political (P)	Economic (E)	Social & Cultural (S)	Technological (T)	Legal (L)	Ecological (E)
Targeted programs of regional and local development of land reform Administrative-management system of coordination and control of use, preservation, reproduction and protection of soils Coordination of interests of local communities with the interests of region, the state	Economic efficiency of land use Normative and expert monetary price of land of different categories The estimated value of the rights of land rent for different functional use	Demographic situation Unemployment The level of social and material provision of population Intensity of migration Educational level	Development of the latest technologies in the use and protection of land Possibilities of development of information technologies Investments in land resources Newest technologies for mapping of lands according to their categories, use, forms of ownership, agricultural production groups	Laws and regulations on land relations Sectoral norms and standards for land use Masterplans of the settlements Materials of cadastral zoning of territories	Nature protection zones Sanitary and hygienic zones Water-protective zones Contaminated lands Affected lands Lands of excessive moisture Especially valuable lands Karst territories Erosive areas Flood lands

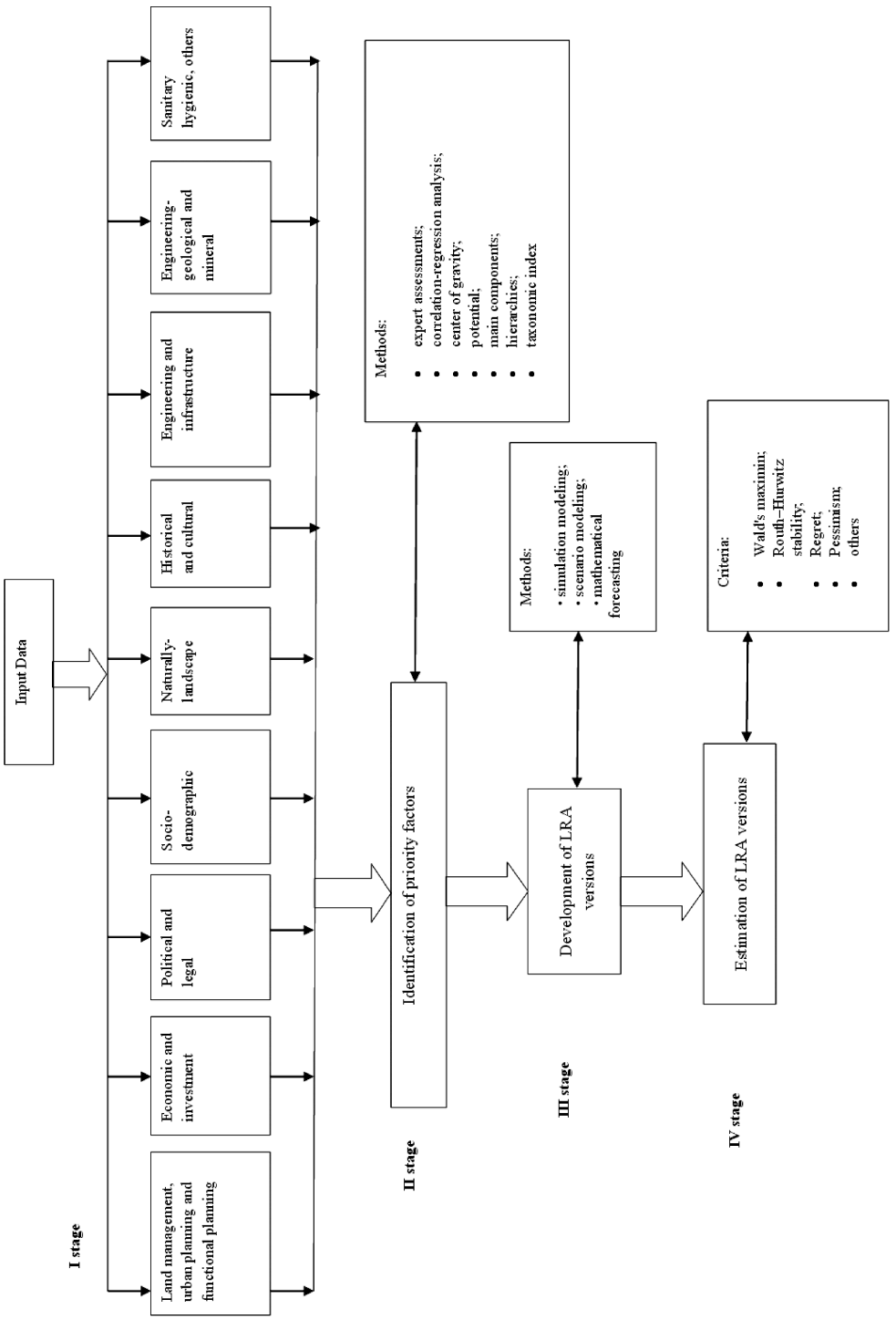

Fig. 1. PESTLE technological model

active introduction of market mechanisms into the economy increases the value of the importance of "risk" category. As a rule, "risk" is objectively present in all spheres of our lives. And in this aspect, when making decisions in the process of administration of land resources, it is important not only to assess correctly the degree of risk in specific circumstances and terms, but also to be able to manage it, thus reducing its negative impact.

The basis for making balanced solutions in terms of efficient use of land resources is the environmental and socio-economic research of all factors that can have a significant impact on the sustainable development of the territory. In this case, there is a problem of decision-making under conditions of uncertainty, that is, when decision-making on the actions of the subject is difficult due to the causal factors caused by natural phenomena and processes that are difficult to foresee.

Decision-making in these conditions includes analyzing the economic situation, evaluation of the effectiveness of decisions, selection of the most optimal alternatives that most contribute to solving the tasks. The selection of alternative for making strategic decisions is based on statistical data that reassign the influence of factors. Solving the problems of the theory of making strategic decisions is necessary when choosing investment projects that take into account the problems of land resources protection and increase of social and material well-being of population living on these territories. In this case, it is expedient to use the evaluation matrix. The "nature" acts unconsciously, and is one of the fundamental bases of influence on the adoption of appropriate decisions. If it is possible to estimate the influence of "nature" at its certain state on a decision and to obtain its value, it becomes possible to create a matrix of evaluation

$$F = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{bmatrix}, \tag{1}$$

a_{ij} – numerical result for each combination.

The numerical values of the matrix elements are obtained as the weighted mean of the influence of each individual indicator on the resulting value, determined on the basis of expert assessment. The evaluation matrix allows to choose a solution in the LRA system, which is most advantageous in terms of the existing information database. In the case of a negative F-value, the decisions aimed at reducing losses and risks should be corrected. The positive value of the evaluation matrix is used to optimize the effectiveness of achieving the goals. Sometimes in LRA system the task of developing a model that would maximize the gross income from the production appears. In this case, it is reasonable to create an economic-mathematical model. Such a model, for example, for agricultural production in expanded form will be as following:

To find out:

$$F_{\max} = c_1X_1 + c_2X_2 + c_3X_3 + c_4X_4\,, \tag{2}$$

with restrictive conditions:

$$\left.\begin{aligned} &a_{11}X_1 + a_{12}X_2 \le B_1 \\ &a_{23}X_3 + a_{24}X_4 \le B_2 \\ &a_{31}X_1 \le B_3 \\ &a_{43}X_3 \le B_4 \\ &a_{51}X_1 + a_{52}X_2 + a_{54}X_4 \le B_5 \\ &a_{61}X_1 + a_{62}X_2 + a_{64}X_4 \le B_6 \end{aligned}\right\}, \tag{3}$$

$$X_1 \ge 0; \quad X_2 \ge 0; \quad X_3 = 0; \quad X_4 \ge 0, \tag{4}$$

where:

$F_{\max}$ – linear objective function;
X_1 – area of cultivated pastures (ha);
X_2 – area of arable lands (ha);
X_3 – area of perennial plantings (ha);
X_4 – area of grasslands (ha);
B_1, B_2, B_3, B_4 – the maximum allowable areal sizes of transformation of each type of agricultural lands;
B_5, B_6 – monetary and human resources allocated for the purposes of transformation;
a_{ij} – expenditures for the purposes of transformation of i-type of land;
a_1, a_2, a_3, a_4 – gross income per unit area of transformed agricultural lands respectively.

3. Results

Approbation of theoretical studies on the modeling of the effective use of lands is carried out on the territory of 89 hectares. The practical realization of the above-mentioned research was aimed at revealing in the given territory, on the one hand, unproductive and degraded lands, and on the other – abandoned valuable lands that can be used in agricultural production and on this basis to form proposals and recommendations for improving the efficiency of land use. A special commission was set up to develop administrative decisions on efficient and rational use of lands: a representative of the local self-government body; specialists of land resources and a representative of the project organization.

Based on the analysis of materials collected during the preparatory works on the actual use of land according to their intended usage, their legal regime and the compliance of the areas of land plots with the data in land cadastral documentation based on the model PESTLE, it was recommended:

– for cultivated pasture (lands with unfavorable geographical conditions, namely, waterlogging, high groundwater, high herbaceous vegetation, etc.) to allocate a land plot of 17 hectares;

– land plots with a total area of 15 hectares is expedient to use under the arable lands, as they are located near the boundaries of the settlement and have correct geometric shape;
– for grasslands to allocate unproductive and degraded lands, which now are arable lands with a total area of 41 hectares;
– land plots with a total area of 15.64 hectares are proposed to be allocated for perennial plantings.

In accordance with theoretical developments for this territory, an economic and mathematical model was created, the purpose of which was to obtain the maximum income from the agricultural production within LRA according to the developed model.

The solution of economic-mathematical models of this type is carried out in most cases by methods of linear programming. One of the most common methods for solving a given problem is the simplex method for which the corresponding software product has been developed. Actually, in this case the solution of the problem is carried out by a simple method using MATLAB environment. Here is a comparative description of the use of land of this territory by the economic-mathematical model and model PESTLE (Table 2).

Table 2. Comparison of the resulting modeling values, ha

Type of land	PESTLE Model	Economic-mathematical Model
cultivated pastures	17	17
arable lands	15	53
grasslands	41	9
perennial plantings	16	10
Total	89	89

4. Discussion

The analysis of the results shows that the greatest economic efficiency (total gross income) can be obtained if 53 hectares are allocated for arable lands and 10 hectares – for perennial plantings.

The comparison of the results of the modeling of areas of land plots by the PESTLE method and economic and mathematical method indicates significant differences. Thus, for example, according to the economic-mathematical model, reduction of hayfields by 32 hectares and increasing of arable lands by 38 hectares is foreseen in comparison with the data of the PESTLE-analysis model.

Therefore, in Land Resources Administration, it is necessary to use both methods in a comprehensive manner, and in the final decision-making, the benefits should be given to the results which most fully satisfy the interests of the community.

5. Conclusions

The modeling of land administration processes is proposed to be performed on the basis of theoretical and analytical model PESTLE and economic and mathematical methods of processing a wide range of physical, economic, natural, social, engineering, legal, functional planning, environmental and other factors. It becomes an effective mechanism of objective evaluation of the state of land resources and the prospects for their use.

In order to create an effective model for LRA, a specific classifier of key factors (indicators) has been developed that influence the adoption of relevant decisions. In this publication a technological scheme for the solution of the problem is proposed.

Experimental studies in the implementation of the proposed models showed ambiguity of the final results, regarding which a decision should be made, which leads to the conclusion of the need for decision-making guided by the interests of territorial communities.

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