

The Intelligent Managerial Decision Support System for Agricultural Land Evaluation

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Abstract. The article presents the structure of the intelligent managerial decision support system for agricultural land evaluation. The assessment problem has been a technique of defining performance indicators of productive agricultural land with account for geographical and regional features of its configuration and infestation that should be considered in making decisions during field operations. The indicator evaluation scheme is given. The specific example of evaluation is stated. Land cultivating deficiency depending on its overgrowing by trees and shrubs is shown. The results obtained are proved to be used in managing an agricultural sector of the region.

1. Introduction

Analyzing land as a component of the country's national wealth is a comparable quantitative and economic evaluation of its usability and the ecological and economic effects of using land plots as an object of evaluation for different purposes.

An objective basis for solving evaluation problems is knowledge about the object of evaluation as a spatially localized part of the earth's surface, characterized by a set of measurable factors. On the one hand, land, as a natural resource, is characterized by location in space, relief, soils, plant and animal life. It is evaluated as its possibility of performing multi-purpose functions [1-4]. On the other hand, land, as an object of economic relations, is evaluated in terms of its utility and profitability from using a particular plot [3]. Besides, agricultural land evaluation is influenced by economic, physical and social factors, location aspects (distance to communities, water bodies, etc.), transport network development, etc. Under the influence of these factors, the demand for land plots increases or decreases and their market prices are adjusted.

This way, agricultural land, as an object of economic relations, has use and market value, which is defined by its agricultural land evaluation, as well as the land occupied by buildings, structures used for the production, storage and primary processing of agricultural products [4].

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The system considered in this paper allows us to formulate assessments of the state of agricultural land, as well as carry out information support for decision-making in managing land resources.

2. The functional structure of the intelligent managerial decision support system

The intelligent managerial decision support system is composed of the following subsystems:

- 1) Agricultural land evaluation has a complex, multifactor analysis. In general, it is necessary to take into account the influence of climatic factors, characteristics of soil and vegetation cover, infrastructure features, geospatial characteristics of the estimated areas of the Earth's surface, etc. *The knowledge base* is the key block of the system.
- 2) *The knowledge base editor* allows the expert responsible for the ontology content to perform interactive operations on creating a new ontology (ontology version) and editing it.
- 3) *The problem solution generator* allows the expert responsible for the problem to create and maintain a problem description model within a certain version of the ontology, and also perform operations to migrate the problem description into updated versions of the ontology.
- 4) When creating and modifying an ontology, there is a procedure describing computational relationships for evaluation metrics. This procedure is based on using *the formula editor* that is a component of the knowledge base editor and the problem solution generator. The formula editor contains basic math operations and is able to build table functions.
- 5) *The geospatial data editor* serves to prepare and operate a geospatial description of the instance of the problem being solved.
- 6) While creating an empty instance of the problem being solved, *the upload module of the problem solution generator* generates a vector layer template with a predefined set of attributes, specified in the problem solution scheme. The template is placed in the geospatial database.
- 7) *The geospatial database* is a set of layers filled with data on the spatial coordinates of evaluation objects.
- 8) Attribute data contains the values of the actual parameters of evaluation objects. *The data import-export module* is responsible for data transfer. This module interacts with an agricultural monitoring automation system [6] and other external systems, which allows receiving data based on the processing and analysis of satellite imagery, ground measurements, weather station data and other sources.
- 9) *The evaluation module* does interim and final evaluation.
- 10) Evaluation visualization is carried out through *the calculator interface*.

3. Approbation

The system has been tested in solving performance evaluation problems of using agricultural land with analyzing the degree of overgrowing by trees and shrubs.

It is quite natural that to improve the agroeconomic performance of agro-industrial enterprises it will be expedient to increase the agricultural land area by carrying out a complex of reclamation work on overgrown cropland [3].

At the first stage of the methodology, the problem of evaluating the technological efficiency coefficient of the agricultural contour (TECAC).

The AC ontology is given by a quadruple:

$$O = \langle K, T, E, M \rangle \tag{1}$$

where K is the taxonomy of the evaluation criteria, T is the set of solved problems, E is the set of metrics for characteristics evaluation, M is the set of primary metrics that allow evaluating the numerical value of the characteristic in physical term.

The heart of the ontological model under consideration is the K taxonomy of the TECAC:

$$K = \langle N, R \rangle \tag{2}$$

where $N = \{ni\}$ is the set of taxonomy classes – attributes of the evaluation object, $R \subset N \times N$ is N order relation.

At the second stage of the methodology, the formula module forms the computational procedure for the TECAC.

The TECAC basic procedure consists in calculating the ratio of the current technological efficiency of the AC to the maximum possible.

$$K_{TECAC} = TECAC_c / TECAC_T \tag{3}$$

where K_{TECAC} is the technological efficiency coefficient of grain production for the AC; $TECAC_T$ is the total technological efficiency of the AC, evaluated without trees and shrubs;

$TECAC_c$ is the current technological efficiency of the AC, evaluated with trees and shrubs as pegs.

In general, the TECAC is evaluated by the following ratio:

$$TECAC = PI - PC \tag{4}$$

where PI is the projected income and PC is the projected cost of grain production, which includes the cost of fertilization, seeds, fuel and lubricants, salaries and wages, annual depreciation and service of grain harvesting machines, etc.

When going around a plot of trees and shrubs, the path length is calculated as the arc length of the cut-off sector s . For each subsequent roundabout, the height of the cut-off sector h increases, thereby increasing the length of the arc s .

Table 1. Cost indicator values in grain production

Index	Estimated value
Fuel consumption per hour	$C_{hour} = C_{sp} * P_{en} = 162 * 235 = 38.07 \text{ kg / h}$ C_{sp} – specific fuel consumption, gr / (horsepower-hour) P_{en} – engine horsepower
Fuel consumption per 1 ton of threshed grain	$C_c = C_h / HC_h = 38.07 / 14 = 2.72 \text{ kg / t}$ HC_h – harvester capacity per hour, t / h
Consumption of fuel and lubricants per 1 ha, at a given yield	$C_{ha} = C_f * GY_{ha} = 2.72 * 2.3 = 6.26 \text{ kg / ha}$ C_f – fuel consumption per ton, kg / t GY_{ha} – grain yield per hectare, t / ha For the region considered, the mean value is 23 dt / ha.
Expenses for fuel and lubricants in value terms	$C_T = C_f * C_{df} = 2.72 * 35 = 95.2 \text{ RUB / t}$ C_f – fuel consumption per ton, kg / t C_{df} – cost of diesel fuel, rubles / kg Calculated as the producer price of 1t of diesel fuel, which was 35.000 rubles per ton in 2015. $C_{ha} = C_{ha} * C_{df} = 6.26 * 35 = 219.1 \text{ RUB/ha}$ C_{ha} – fuel consumption per 1 ha, kg / ha C_{df} – cost of diesel fuel, rubles / kg

At the third stage of the methodology, the cost indicator values in grain production (Subproblem 1) are evaluated (see Fig. 1).

At the fourth stage of the methodology, the evaluation module calculates the total and current technological efficiency of the AC with the use of cost indicators from Table 1:

$$\text{TECAC}_t = \text{PI} - \text{PC} = 23000000 - 219100 - 667000 - 332810 - 3408000 = 18373090 \text{ RUB}$$

$$\text{TECAC}_c = \text{PI} - \text{PC} = 20700000 - 197190 - 8389.5 - 600300 - 299529 - 3062700 = 165131891.5 \text{ RUB}$$

The TECAC coefficient is equal to:

$$K_{\text{TECAC}} = \text{TECAC}_c / \text{TECAC}_t = 0.89 * 100\% = 89.95\%$$

This means that the AC (Subproblem 1) uses 89.95% of its agro-economic capability.

At the fifth stage of the methodology, the evaluation module calculates the TECAC coefficient for different degrees of overgrowing by trees and shrubs in Table 2.

Table 2. The TECAC coefficient for AC with trees and shrubs

Index	Estimated value for AC with trees and shrubs,%					
	0	10	20	40	60	80
The cultivated area of AC, ha	1000	900	800	600	400	200
Projected income from grain marketing, million rubles	23	20.7	18.4	13.8	9.2	4.6
Costs for fuel for harvesting (without idling while driving around the pegs), rubles	219100	197190	175280	131460	87640	43820
Costs for fuel at idling while driving around the pegs, rubles	0	8389.5	16779	33558	50337	67116
Depreciation and service, thousand rubles	667	600.3	533.6	400.2	266.8	133.4
Salaries and wages, rubles	332810	299529	266248	199686	133124	66562
Other costs, thousand rubles	3408	3062.7	2726.4	2044.8	1363.2	681.6
Losses, million rubles	-	1.85	3.69	7.38	11.08	14.77
K_{TECAC} , %	-	89.95	79.91	59.81	39.72	19.6

The data, calculated by the TECAC, show the volume of financial losses for different degrees of the AC overgrowth by trees and shrubs.

The scale of acceptable and unacceptable losses is determined by the expert in Table 3, based on the agro-economic expediency of the decisions made.

Table 3. The scale of loss acceptability of the AC overgrowth by trees and shrubs

Index	Acceptable losses	Unacceptable losses
Losses, million rubles.	≤ 3.69	> 3.69
K_{TECAC} , %	≥ 79.91	< 79.91

At the sixth to ninth stages, the results obtained are compared to make the necessary managerial decisions. The calculator interface provides the decision maker with the results.

Conclusion

The paper considers the intelligent decision support system that allows solving the problems of ranking agricultural land based on their characteristics and agronomical GIS data. The technique of determining technical and economic indicators for cultivating agricultural fields in the system for managing the efficiency of the agro-industrial complex of the region is formulated. As a basis for determining technical and economic indicators, an example of calculating the technological efficiency coefficient of an agricultural contour using an intelligent system for agricultural land evaluation is given [4]. The technological efficiency coefficient calculates the impact of negative processes, expressed in the AC overgrowth by trees and shrubs, on the AC capacity.

At present, the methodology is being tested in solving the problem of complex agro economic land evaluation by the example of the Sukhobuzimsky district of the Krasnoyarsk Territory. The technological efficiency coefficient of the AC is one of the factors of the AC evaluation [4].

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References

1. K.V. Shatrova, Y.A. Maglinets. The decision support system for agricultural land evaluation // The current issues of Earth remote sensing from space: collection of abstracts of the 12th Open Russian Conference (Moscow, November 10-14, 2014). M.: Space Research Institute, 2014. P. 394.
2. K.V. Shatrova, Y.A. Maglinets, G.M. Tsibulsky. The view model for agricultural land state and dynamics data // Journal of Siberian Federal University. Series: Engineering and Technology. 2014. V. 7. No. 8. P. 984–989.
3. I.V. Zenkov, E.V. Loginova. Managing the innovative development of the land sector of the agro-industrial complex in the Krasnoyarsk Territory: monograph. Krasnoyarsk: SibFU, 2013. 236 p.
4. K.V. Raevich, I.V. Zenkov, Y.A. Maglinets. Managing the productive agricultural land of the Krasnoyarsk Territory agro-industrial complex using the agro economic potential factors // Bulletin of Irkutsk State Technical University. 2016. No. 3. P. 57–66.
5. The functional subsystem “The electronic atlas of agricultural land”. EPassport FS-7713 No 0296 from 07.02.2013. URL: <http://atlas.mcx.ru> (29.03.2016).
6. K.V. Shatrova. Spatial data representation for the best route search area organization / K.V. Shatrova, Y.A. Maglinets // International Scientific Conference “The regional issues of Earth remote sensing” / science editor E.A. Vaganov; publications assistant. A.V. Mashukova – Krasnoyarsk : SibFU, 2014. – 366 p. P. 345 – 348.