

# Electronic field map is an informational basis for growing sustainable business in agriculture in the face of land quality differences

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**Abstract**— The paper presents the practical application of the author's methodology for determining the efficiency of grain crop production and build on this basis an electronic map. The offered technique is based on data of actual and planned use of arable land based on the assessment of agricultural land and data reports on the financial and economic status of agro-industrial complex commodity producers. The method allows to determine the estimated yield and value of production, cost of goods manufactured, the effect and efficiency of grain growing in the fields on the territory of agricultural producers. Digitalization of the territory using MapInfo Professional software product clearly demonstrates the levels of land use efficiency across fields in an agricultural organization and allows pointwise predict a lease plan of arable land based on a specific planning period. This equates to single out land classes of an inefficient and efficient production level, taking into account the scenarios for the development of the economy proposed in the study, which are associated with changes in the natural and economic conditions of land use.

**Keywords**— *land use efficiency, agricultural organizations, land quality, MapInfo Professional, electronic field map, development scenario.*

## I. INTRODUCTION

Land is the most important resource of production, but because of its origin and functioning, agroclimatic factors largely determine the land properties, significantly affect the efficiency of land use and determine the extent and results of agricultural production [1]. The land use efficiency is basic resource foundation for ensuring the efficiency and sustainability of agricultural production. Land resources management in the implementation of agricultural production, taking into account the diversity of land properties and natural and economic conditions, should be based on reliable, complete information about its quality, conditions for the realization of natural and industrial potential and be shown on the electronic field map. Application of the methodology for determining the efficiency of grain production (authors O.N. Dolmatova, Yu.M. Rogatnev) gives the possibility to visualize the cartographic basis of agricultural producers in municipal unit territory, to create an electronic map of the fields of a particular agricultural organization. This justifies the need, relevance and practical value of the development.

In a market economy, ensuring the efficiency of crop production is the key to the development of sustainable

business in agriculture. First of all, entrepreneurs using arable land of different natural properties, as well as municipalities and the state, replenishing the budget revenues through direct and indirect taxes on the land plots used should be interested in this.

Some aspects of research on the land use efficiency in agricultural enterprises can be found in the works by Yu.M. Rogatneva [2], V.G. Bryzhko [3], O. N Dolmatova [4], A.V. Kolmykova [5] and others.

The issues of territory sustainable development and land use are considered by scientists and specialists, such as: N.M. Edrenkina [6], V.V. Kuznetsov [7], N.G. Ovchinnikova [8], N.I. Proca [9], A.I. Sabirov [10] and others.

## II. RESEARCH METHODOLOGY

The scientific and methodological basis for the study was the theoretical and methodological development of Russian economists in the field of land economies on the mechanism for regulating the processes of land use and the territorial organization of agricultural production.

The purpose of the methodology is helping to agricultural organizations in ensuring the efficiency of crop production for the development of sustainable business in the face of significant land quality differences.

Tasks:

- increasing the crop production efficiency by rationalizing arable land use
- creation of an electronic map of fields for land use management in the implementation of crop production, taking into account the diversity of land properties, natural and economic conditions;
- determining the level of production effectiveness taking into account different planning periods.

In the practice of management, agricultural organizations are trying to take into account some indicators of land quality for planning crop production based on the use of soil maps and experience in using (field passports). However, the materials are quite outdated, and the certification of fields is carried out in a small number of farms. In addition, the lands

of the Omsk region vary considerably in fertility and cost, especially in the forest-steppe zone.

Taking into account the different quality of arable land will reduce the cost and improve the crop production efficiency, which is proposed in this method. Its implementation is based on information using on the quality of land for each field, information on crop production from annual reports on the financial and economic producers status in the agro-industrial complex, books on fields history, and the market state for agricultural products. The proposed method is implemented as a special calculation module in 2 stages:

The first stage is determined by the efficiency of crop production (grain crops) for a particular year:

- determination of the estimated yield and cost of products produced by the fields, depending on their fertility (quality score attributed to land);
- determination of cost of goods manufactured by fields, depending on their technological properties and distance;

- determination of the effect and efficiency of crops cultivation in the fields.

In this case, the calculations are based on the actual average yield in the organization, the average cost and the average cost of goods manufactured per 1 hectare of arable land, the average sales price for the previous period.

The second stage 2: levels of efficiency are determined taking into account different planning periods.

At the first stage when forming the system of necessary measures in organizations, it is necessary to assess the actual scale and intensification level of land use. For these purposes, it is necessary to rely on the calculation of the arable land use efficiency based on average annual grain production indicators proposed in the study. Therefore, an analysis of the economic efficiency of the existing use of arable land is made on the example of "Alekseevskoye" LLC of the Gorky district of the Omsk region (table 1).

TABLE I. ANALYSIS OF THE ECONOMIC EFFICIENCY OF THE EXISTING USE OF ARABLE LAND FOR 2015 (BY GRAIN CROPS)

Field number	Quality score attributed to land	Estimated yield, centners per hectare	Cost of production, rub./hectar	Technological properties index	Production costs, rub./hectar	Conditional net income, rub./hectar	Production profitability (R), %
<i>Medium level of production efficiency</i>							
1–10	88	23,8	11900	1,15–1,24	6998–7546	4354–4902	58–70
12–17	88	23,8	11900	1,19–1,25	7242–7607	4293–4658	56–64
<i>Low production efficiency</i>							
11	88	23,8	11900	1,31	7972	3928	49
31–36	72	19,4	9700	1,06	6450	3250	50
38–42	72	19,4	9700	1,23	7485	2215	30
<i>Insufficient (unstable) level of production efficiency</i>							
18–21	69	18,6	9300	1,21–1,31	7363–7972	1328–1937	17–26
48–51	69	18,6	9300	1,2–1,27	7302–7728	1572–1998	20–27
<i>Persistently inefficient level of production</i>							
22–30	48	13,0	6500	1,31	7972	-1472	-
37	48	13,0	6500	1,31	7972	-1472	-
43–46	45–52	12,2–13,0	6100–6500	1,2–1,23	7302–7485	-802 –(-1202)	-

Foreign scientists [14, 15] are also engaged in the development, use of point maps, the creation and implementation of a single (electronic) agricultural data processing system. Based on GIS software product MapInfo Professional (US developer) the scheme of the existing use of arable land, presented in Figure 1. In LLC "Alekseevskoe" defined levels of production efficiency on arable land. On the diagram you can see that about 30% of arable land is not effective, while the loss per hectare in several fields reaches 1.5 thousand rubles. More than 30% are effective, the rest are unstable and low-efficient lands.

Since all these plots are rented, these calculations allow us to give an objective picture of the effectiveness of arable land use across the fields and to clarify the plan for their lease. The price of land lease is currently set for the whole agricultural organization as a whole, without taking into account the quality of land of individual leased plots, and in cash equivalent amounts to 985 rubles / ha. This is an additional financial burden on production, which makes land use on 15 fields inefficient; which leads to an additional 8.7 million rubles. inefficient investment. Therefore, we can recommend LLC "Alekseevskoye" not to lease these lands (the leased areas will be reduced by 1–2 thousand hectares).

In case of a high demand for these areas, it is necessary to carry out highly effective ameliorative measures, allowing to significantly increase their productivity.

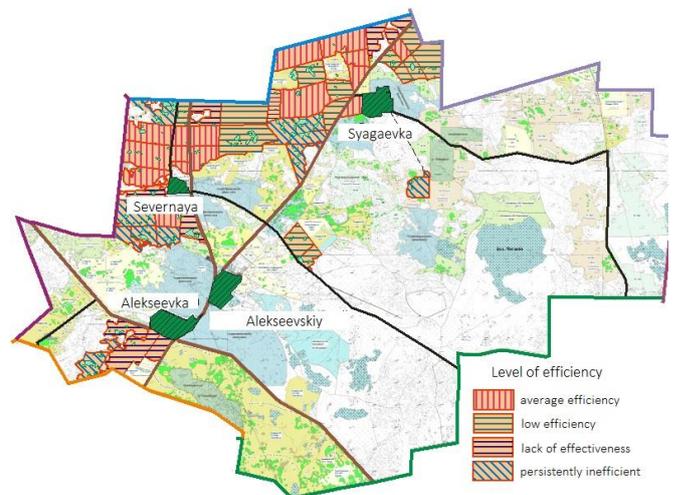


Fig. 1. Electronic map of fields by the efficiency levels of arable land existing use

The calculations for the proposed module and the electronic map construction should precede the beginning of the agricultural year and serve as the basis for making decisions of crop production organization by the agricultural business for the current year. This should be one of the main consulting services for agricultural producers.

The opening or development of agricultural business requires decision-making for the future, in terms of a probable change in the conditions of its operation. Such conditions include: changes in natural conditions, agricultural commodities market (and therefore prices), market for components of crop production (prices for fuel, spare parts, fertilizers, ameliorants, seeds). These factors have different degrees of probability of occurrence, but when forecasting agricultural business this is an important determining condition and therefore is included in the calculation module of crop production efficiency, taking into account the planning horizon. Therefore, at the second stage of the proposed methodology, it is necessary to make a forecast of changes in natural factors and changing conditions, and also to perform calculations on the levels of production efficiency in the fields, depending on the economic development scenario (Table 2).

TABLE II. THE DISTRIBUTION OF FIELDS AT THE LEVELS OF PRODUCTION EFFICIENCY IN ACCORDANCE WITH THE POSSIBLE ECONOMIC DEVELOPMENT SCENARIOS IN LLC "ALEKSEEVSKOE"

Economic development scenario	Production efficiency			
	Inefficient		Efficient	
	field number	area, ha	field number	area, ha
Yield increase in the most favorable years by 20%	22 – 30, 37, 47	894,1	1 – 21, 31 – 36, 38 – 46, 48 – 51	3605,9
Yield decrease in dry years by 20%	19 – 30, 37, 43 – 47, 50 – 51	1464,0	1 – 18, 31 – 36, 38 – 42, 48 – 49	3036,0

The growth of market prices for products by 20% at constant costs	22 – 30, 37	879,2	1 – 21, 31 – 36, 38 – 51	3620,8
The increase in costs (cost of fuel, fertilizer, seeds, rent, etc.) by 10%	22 – 30, 37, 43 – 47	1101,9	1 – 21, 31 – 36, 38 – 42, 48 – 51	3398,1

Depending on the proposed scenarios, the fields are divided into two groups: an inefficient and efficient production level. After that, the fields in the whole household are distinguished by correlating the fields into a separate group for all the options:

- permanently inefficient land (under any conditions);
- permanently effective lands in case of any changes in natural and economic conditions
- a group of unsustainably efficient lands, in accordance with the presence or absence of certain conditions, arable lands can provide both efficient and inefficient production.

The economic consequences of production in the conditions of the selected scenarios are given in table 3.

TABLE III. THE GROUPING OF FIELDS ON THE EFFICIENCY LEVELS OF ARABLE LAND IN THE CONDITIONS OF THE SELECTED SCENARIOS IN LLC "ALEKSEEVSKOE"

Indicator	Production efficiency		
	persistently inefficient	sustainable effective	unstable effective
Field number	22 – 30, 37.	1 – 18, 31 – 36, 38 – 42, 48 – 49.	20 – 21, 43 – 47, 50 – 51.
area, ha	879,2	3136,0	484,8

On the basis of the calculations, the farm independently makes a decision on the use or non-use of individual fields.

TABLE IV. THE ECONOMIC CONSEQUENCES OF POSSIBLE SCENARIOS FOR THE DEVELOPMENT OF LLC "ALEKSEEVSKOE" ECONOMY

Economic development scenarios	The area of arable land, taking into account the production level efficiency of grain crops, ha			The overall effect of the production of grain crops, thousand rubles.	B T. Ч.		Production cost, thousand rubles	including		The size of inefficient investments (production costs, including rent), thousand rubles.
	ineffective $R < 0$	unstable effective $0 < R < 50$	sustainably effective $50 < R < 100$		income	losses		effective	unprofitable	
Yield decrease in dry years by 20%	1464	3036	0	1328	4308	2979	34493	26008	8485	11464
Yield increase in the most favorable years by 20%	894	570	3036	18669	18820	151	47488	40521	6967	7118
The growth of market prices for products by 20% at constant costs	879	585	3036	18658	18810	151	51823	44966	6857	7008
The increase in costs (cost of fuel, fertilizer, seeds, rent, etc.) by 10%	1101	2903	4950	6601	8979	2378	41226	34069	7156	9534

According to Table 4, it can be seen that the use of inefficient arable plots brings a rather significant loss in the

whole economy, hidden by the general positive effect of grain production on the remaining arable plots. The proposed

calculations should precede the development of most management decisions in the field of crop production.

A significant help in the use of the proposed calculation module is the use of GIS technology to digitize the territory. This clearly demonstrates the levels of land use efficiency across fields in an agricultural organization. The electronic map of the fields becomes the main source of information about the properties and parameters of the land in the context of individual fields and working areas. This electronic document reflects the positioning of the following elements - the boundaries of the site, the bonitet score and the technological costs index for each part of the field, location of production centers, places of sale of products, routes of movement of agricultural machinery within the field and along the roads to the production center. The electronic map has an information transfer interface (automatic or on request) to the calculation module by the proposed method. Therefore, all changes related to the location of the arable land and the properties of the land within its limits promptly allow you to specify the effectiveness of crop production. The calculation module also takes into account the changes taking place in a particular agricultural organization - actual or planned yields, production costs, the predicted or actual selling price. The results of the calculations are returned to the electronic map, where the level of production efficiency of a particular culture is indicated by coloring or shading.

Provisions relevant to the issues under the approach have existed before, but the proposed methodology using GIS technology has a sufficiently flexible structure and is applicable for solving large number of economic and crop production problems. It enables to assess the productive capacity of the crop industry, to form the most efficient land use for a certain amount of agricultural production in specific environmental conditions and depending on agricultural production market state, provides current and operational management of crop production business. The use of this method increases the efficiency of traditional crop management methods. It should be an obligatory part of any business plan of an agricultural enterprise. The study results may be used by legislative and executive authorities for the formation of long-term programs and plans in order to develop agricultural production [16]. It also can be used by goods producers for the development of current plans and projects for arable land use.

### III. CONCLUSION

The proposed method allows to provide impact analyses (yield, cost of production), cost of goods manufactured and production efficiency for individual arable areas. This provides information for deciding on the sowing plan and the arable land use. The use of separate stages of calculation provides a measure:

- the arable land area and its placement, ensuring the receipt of the required number of products, the number of products of a given level of efficiency;
- the arable land area and its placement, at given cost projections or certain efficiency cost.

The calculations use for the proposed scenarios or scenarios selected by the farm allows, taking into account the

planning horizon and forecast of production conditions (natural conditions, price for the market and the price of necessary materials for production) to establish areas with a stable level of production efficiency, as well as risk zones in the production.

Digitizing of the territory provides an opportunity to demonstrate the levels of land use efficiency across the fields and is the basis for making decisions on the further use of unsustainable arable land. The agricultural organization makes these decisions based on risk analysis and additional measures to stabilize land use conditions: sowing certain varieties of grain and other crops, conducting various kinds of improvements and measures to change the arable land lease plan.

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