

# Creation and use of the module "Sustainable agrolandscape" in the framework of the digital transformation of agriculture

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**Abstract**—The digital transformation of agriculture in the Russian Federation is designed to optimize the use of agricultural land, which should contribute to an increase in labor productivity in agricultural enterprises and a reduction in the cost of agricultural products. To come to this result is impossible without the formation of sustainable agricultural landscapes. Authors of the article propose to introduce the "Sustainable agrolandscape" module in the structure of the state program "Digital Agriculture". The key element of the module is the ecological and economic zoning scheme of the municipal districts territories formed on the data basis from an agricultural landscapes map. The main purpose of the agricultural landscape maps is the study of the morphological structure of agricultural landscapes. Information on the suitability of land will make it possible to carry out ecological and economic zoning, taking into account the types of agricultural landscapes that are similar in ecological status. The use of is the scheme of ecological-economic zoning will allow not only to assess the state and use of land, but also to determine the direction of their use for the future. The scheme of ecological and economic zoning of agrolandscapes is the basis for the formation of schemes and projects of land management of the territory, as well as for the development of farming systems on a landscape basis. The article presents the results of a pilot project, which substantiated the effectiveness of the use of the module "Sustainable agrolandscape".

**Keywords**—*sustainable agrolandscape, scheme of ecological and economic zoning, agricultural landscapes map of types, digital terrain model, digitalization of agriculture, landscape-forming components, sustainable agrolandscape, digital transformation, ecological and economic zoning, Omsk region, state of land use, land typing.*

## I. INTRODUCTION

Digital farming is one of the most important fields of digitalization. The proof is the experience of a number of developing countries that have implemented digital technologies in agriculture [1]. Digital agriculture is managed using computer systems that are represented by technologies such as automation, informatization, digitization, etc. [2]. The use of GIS technology is inevitable with the digital transformation of agriculture.

At the moment, the agro-industrial complex of the Russian Federation is ready to introduce various kinds of innovations. The integration of modern digital technologies in agriculture is designed to ensure its intensification as well as optimization of agricultural land use [3]. It should be

facilitated by the draft concept "Digital agriculture", developed on the instructions of the Russian Federation Government, whose main goal is to increase labor productivity in agricultural enterprises. The concept identifies priority projects for the scientific and technological development of digital products and technologies for agriculture - these are "Digital technologies in the management of the agro-industrial complex" and "Digital land use and land management".

## II. PRACTICAL SIGNIFICANCE

The goal of the project "Digital land use and land management" is the creation of an intelligent multi-level system of planning and sustainable agricultural landscapes formation. The introduction of such a system is designed to increase the productivity of agricultural producers and reduce the cost of agricultural products as a result of the land resources effective use.

The module "Sustainable agrolandscape" in the structure of the project "Digital Land Use and Land Management" is recommended for integration in the state program "Digital Agriculture" to reduce the time and cost of restoring the fertility of the country agricultural landscapes.

The purpose of the module is to provide public authorities and local governments, legal entities and individuals with information on the ecological status of agricultural landscapes and their suitability for use. The key element of the module is the scheme of ecological-economic zoning (SEEZ) of the territories of municipal districts formed on the basis of the data from the type map of agricultural landscapes (AgrTM).

This module is designed to provide visualized access to public authorities, local governments, businesses and individuals to graphic and attribute data AgrTM and SEEZ in order to create highly productive and environmentally sustainable agricultural landscapes and improve farming systems on a landscape basis.

The interface structure of the "Sustainable agrolandscape" module is presented in Fig. 1.

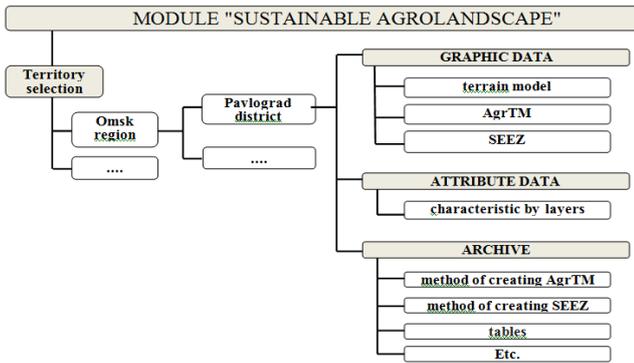


Fig. 1. Structure of the interface module "Sustainable agrolandscape"

The software of the module is GIS MapInfo Professional 12.0.2. In this program, AgrTM and SEEZ are formed, which graphic and attribute data have been loaded into the module "Sustainable agrolandscape".

GIS MapInfo Professional was chosen due to the presence of a direct connection between the map display and the database, which contains the necessary information on all the objects shown on the map. Another advantage of this program is the ability to perform spatial analysis of graphical objects and their attribute data. The ability to manipulate data not only facilitated the work, but also reduced the time spent on it due to creating AgrTM and SEEZ.

The creation of AgrTM and SEEZ begins with the formation of a geo-information basis for the territories of municipal districts. In this case, a geo-information base is understood as a digital terrain model (DTM) [4, 5] of municipal districts with a set of necessary indicators for carrying out ecological and economic zoning of agrolandscapes contained in the database. Indicators are represented by two groups: graphic data and attribute (semantic) data.

The DTM structure of the municipal district is presented in Fig. 2.

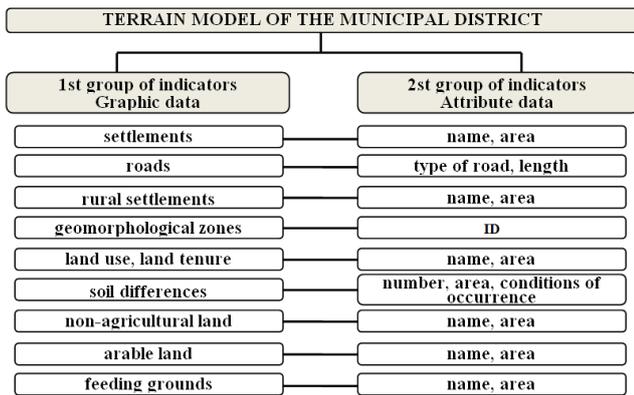


Fig. 2. The structure of the digital municipal district terrain model

To form the DTM of the municipal area, to carry out ecological and economic zoning of lands in an agrolandscape, we need such materials as materials of soil surveys (soil maps, soil essays, cartograms of eroded lands), cartographic basis of the area.

The availability of already formed DTM municipal districts in a unified database will simplify work and save time. In addition, you can create DTM in semi-automatic mode, according to the results of geodetic and aerial photography work [6].

DTM is the basis for creating two digital maps: the scheme of ecological and economic zoning (SEEZ) of the municipal districts territories formed on the basis of agricultural maps database (DB) landscapes (AgrTM). The map structure is shown in Fig. 3.

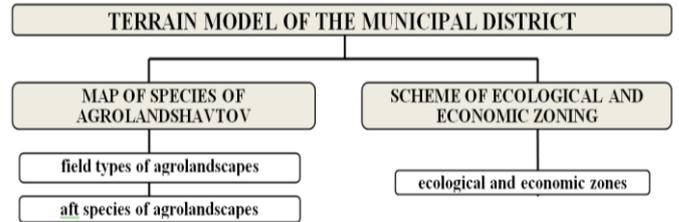


Fig. 3. Structure of AgrTM and SEEZ

AgrTM is a visual reproduction form of the anthropogenic territorial complexes structure, reflects the morphological structure of agricultural landscapes and can be used as a basis for carrying out various types of land typing and zoning [7]. The task of AgrTM is to study the properties of agricultural landscapes [8]. Therefore, the use of such maps is necessary for conducting work on the assessment of agricultural lands [9, 7].

AgrTM is a map where the types of agrolandscapes are shown by different colors. Fig. 4 presents an example of AgrTM.

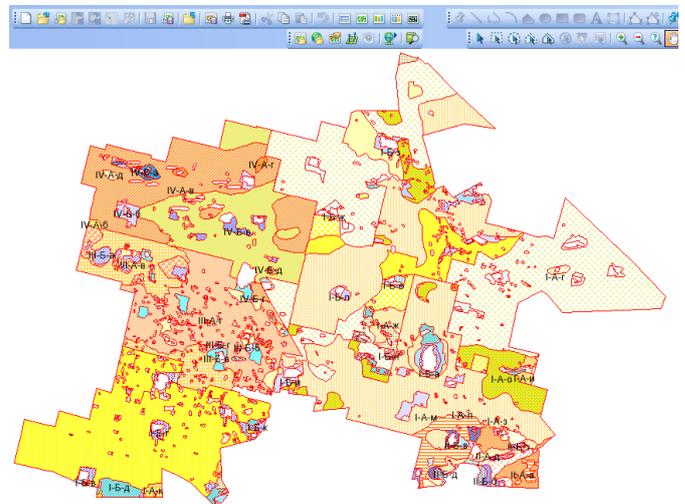


Fig. 4. Type map of agricultural landscapes

Species are isolated from the field and meadow-pasture subclasses of the agrolandscape. When differentiating the structure of the agrolandscape into subclasses, the method of identifying significant landscape-forming components was used, taking into account the relief mesospheres (geomorphological areas). The criteria for identifying the types of agrolandscape is the uniformity of the relief and the soil.

It is convenient to conduct a subsequent study of the territory with AgrTM in digital form by superimposing information layers on a unified cartographic basis using

modern computer products. In our case, AgrTM serves as the basis for the development of the SEEZ, in fact, the process of its creation is the next step of the territorial DB formation.

SEEZ of agrolandscapes is the basis for the schemes and projects of territory land management formation. Also, the accumulated in the course of the work DB will serve as a good basis for creating various necessary cartographic materials for developing farming systems on a landscape basis.

On the SEEZ, a certain hatching shows the location of the zones identified as a result of ecological and economic zoning. Ecological and economic zones are allocated according to the results of the typification carried out. The purpose of land typing in agricultural landscapes is a more detailed account of the natural features of agricultural landscapes. For typing, the types of agricultural landscapes were assessed by environmental (type and degree of negative processes) and economic (score of bonitet and land productivity) indices. Further, the types of agricultural landscape with the same manifestation of negative processes, a close score of bonitet and, accordingly, close yields were combined into one fitness group for use as arable land or forage lands included. For each group, there are methods for regulating their properties, which consist in carrying out certain measures. On the basis of taking into account the suitability of land in agrolandscape for arable land or forage lands, taking into account the need for special organizational, economic, agrotechnical, land reclamation measures from groups of agrolandscapes, seven types of land are formed, presented in Table 1 [10].

TABLE I. TYPES OF LAND IN AGROLANDSCAPE

Land type number	Land Type Name
I	Land suitable for arable land
II	Land suitable for arable land, requiring special agricultural technology
III	Lands suitable for arable land after improvement
IV	Earth suitable for forage lands
V	Land suitable for feeding grounds after improvement
VI	Land suitable for forage lands after amelioration
VII	Lands unsuitable for agricultural land

The selected land types are confined to certain categories of relief, and are characterized by close productive capacity and ecological state. On the basis of land typing, ecological-economic zoning is carried out. It is proposed to apply land zoning in agrolandscapes based on the merger of two subspecies of functional zoning: agrolandscape and ecological-economic. The essence of the presented zoning is the organization of agricultural environmental management at different levels of landscape differentiation of the

territory, taking into account the natural-ecological and socio-economic factors of agricultural environmental management. This approach is based on the allocation of areas homogeneous in landscape-ecological state, functions performed and production capacity.

Selected areas include types of agrolandscape close to the ecological state. For the zones developed land use modes are presented in Table 2.

TABLE II. CHARACTERISTICS OF ECOLOGICAL-ECONOMIC ZONES [10]

Room of the zone	Name of the zone	Zone Usage Modes
I	Favorable for arable land and the cultivation of all groups of agricultural crops	It is allowed to use for the cultivation of all groups of agricultural crops in the system of crop rotation with the obligatory carrying out of organizational, economic and land management activities. The use of intensive technologies, chemical fertilizers is limited.
II	Favorable for arable land and the cultivation of all groups of crops, but requiring special agricultural technology	It is allowed to use for the cultivation of all groups of agricultural crops in the crop rotation system with the obligatory use of special agricultural technology and carrying out organizational, economic and land management activities. The use of intensive technologies, chemical fertilizers is limited.
III	Relatively favorable for arable land and the cultivation of major groups of agricultural crops	It is allowed to use for the cultivation of major groups of agricultural crops (barley, oats, rye, sunflower, hedgehog, peas, grains, wheatgrass, etc.) in the crop rotation system with mandatory organizational economic and land management activities. Limited in the cultivation of groups of crops.
IV	Favorable for mowing and grazing	It is allowed to use for grazing cattle and mowing in the system of hay cultivation and pasture rotation, with the obligatory carrying out of organizational, economic and land management activities. The use of intensive technologies, chemical fertilizers, plowing is limited.
V	Improvements of forage lands	It is allowed to use only for regulated cattle grazing and mowing in strictly fixed terms. The placement of garden plots, the use of chemical plant protection products is prohibited. Haying, grazing, plowing, and the use of organic fertilizers are limited.
VI	Preservation	Preservation

An example of the SEEZ of the municipal district territory is presented in Fig. 5.

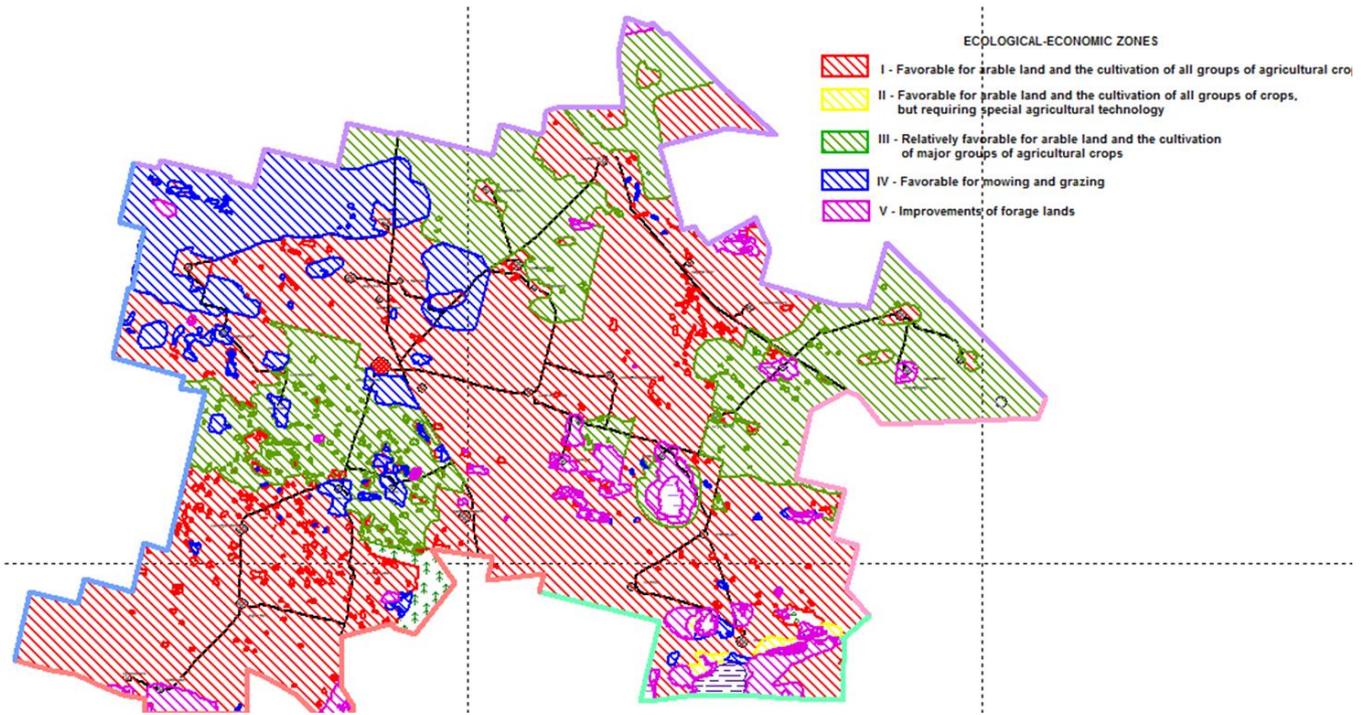


Fig. 5. Scheme of ecological-economic zoning

III. RESEARCH RESULTS

It will not be difficult for any interested person to assess the existing conditions of land use, draw conclusions and determine their further economic use, having free access to the SEEZ and a location map of the fields.

Fig. 6 shows the window with the “Ecological-economic zones” loaded to the layer with the grid of fields.

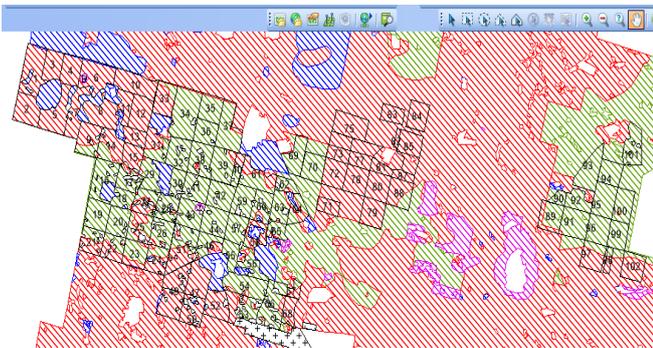


Fig. 6. Ecological and economic zoning of the economy

Table III shows the results of the visual analysis of the fields.

TABLE III. ECOLOGICAL AND ECONOMIC ZONING OF FARM FIELDS

Field number	Ecological economic zone
1-5,7,8,10-13,15,47-50,52,71-87	I Favorable for arable land and the cultivation of all groups of crops
16-20,26,28-30,32,34-38,41,42,44-46, 54-57,59, 62,63, 65,66,69,70,90-96,99-101	III Relatively favorable for arable land and the cultivation of major groups of crops
6,9,14, 21-25, 27,31,33, 39,40,43, 51,53,58,60,61, 64,67,68,88,89, 97, 98,102	Mixed zones

Based on the land use modes which were developed for each ecological and economic zone, it is recommended for fields in the I zone: regulated mode of use; the cultivation of all groups of crops in the system of crop rotation with the obligatory carrying out of organizational, economic and land management activities; limited use of intensive technologies, chemical fertilizers [10].

For fields covered by zone III, it is recommended: regulated use; the cultivation of the main groups of crops (barley, oats, rye, sunflower, hedgehog team, peas, wheatgrass, wheatgrass, etc.) in the crop rotation system with mandatory organizational, economic and land management activities; limited cultivation of crop groups [10].

For fields that fall into several zones, it is recommended: to transform part 6 and 43 of the fields that fell into the V zone into forage lands, since agrolandscapes located in this zone can only be used for regulated cattle grazing and mowing in strictly fixed terms [10]; re-design the rest of the fields taking into account the boundaries of the ecological-economic zones.

The process of drawing up recommendations on the effective use of 102 fields of the studied economy did not take much time and consisted in loading the layer with fields to the SEEZ and visual analysis.

IV. FINDINGS

Thus, we can conclude that the proposed module "Sustainable agrolandscape" can be recommended for inclusion in the structure of the project "Digital Land Use and Land Management", as it carries the necessary information for the formation of sustainable agrolandscapes, which is one of the main goals of this project. At the same time it is easy to use and it is available for all categories of users. Creation of maps is almost completely automated; a

step-by-step method for creating them in the GIS MapInfo Professional has been developed. GIS MapInfo Professional can be replaced with Russian analog programs if it is necessary.

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