Digital land management and land resource data generation

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Abstract. The article deals with issues related to the creation of digital land management, the information basis of which is data obtained by replacing traditional methods of obtaining information with new technologies, including: unmanned aerial vehicles, laser scanning, high-resolution satellite images. New technologies should create a higher level of information support for land management, due to a significant increase in information content and, in accordance with this, taking into account more factors that affect land management decisions. In this regard, the state data Fund formed on the basis of land management documentation should be improved and such modernization should be carried out simultaneously with the technological re-equipment of land management, based on network cloud storage of information, big data and blockchain, using modern computer tools.

1. Introduction

The Federal Service of State Registration, Registry and Cartography (Rosreester) on the basis of State’s Registration, Registry and Cartography Service, approved by the Russian government’s decree of 01.06.2009 No.457 (p. 5.1.11) conducts in accordance with the legislation of the Russian Federation the order of the state fund of data obtained as a result of the land development. [1-3, 6, 8]

In view of objective reasons information is formed in the course of the activities of the cadastral service, Rosreester, and other public and private organizations in the field of land management.

However, in our view, traditional approaches in the collection, storage and processing of land and resource information do not meet modern requirements and do not cope with the multiplier volumes of information due to the increased ability to collect data, greater accounting of quantitative and qualitative indicators, and the design of their use. [1-5, 7]

In addition, the digitalization of the economy, and as a consequence that of all its industries, including agriculture and land management, also increases the amount of processed and stored information many times.

Therefore, as an example, let us look at these issues from the point of view of the need to create a digital land management and land-building design, which becomes in these conditions a highly sought-after product because of the land and resource information that will be generated by these innovations. Modern requirements for the quality and speed of design in any industry, including in land management, imply the use of high-performance technologies at all stages of the creation of the design documentation. The need for a quick, detailed design, as well as economic, social, environmental and other assessments,
a comprehensive rationale for design proposals and solutions; By organizing the permanent collection of the necessary information and the formation of databases at all stages of design with multiplied amounts of data due to the significant development of their monitoring, storage and processing tools. These requirements are achieved through digital

These requirements are achieved through digital modelling in both graphic and engineering processing systems and automated earth design systems (SAEDS).

Over the past decades, the approach to the basic results of engineering research and design has fundamentally changed. This is reflected in the transition from a "paper" result (drawings, tablets) to a model, i.e. to creation of a digital model of the terrain (DMT) as the main result of engineering and geodesic exploration; creation of a three-dimensional model of the terrain; creation and evaluation of the digital model of the project (DMP) as a result of the design. Ensuring that the digital model of the area (DMA) of its topographical reality corresponds to

- spatial representation in the model of underground and above-ground communications;
- multistraturning the relief model and the situation with a given, appropriate designer, distribution of data by hierarchically organized layers;
- information saturation of model objects with the information needed to make design decisions and approvals.

The development of computer technologies of SAEDS and GIS is now reaching a new qualitative level. Namely, there is a transition from the stage of mastering the capabilities of software and hardware with the creation of simple digital maps and related databases, to the implementation of specialized SAEDS and GIS. It is focused not only on production applications, but also for a wide range of consumers, on creating electronic atlases and 3-D models with elements of artificial intelligence and virtual reality.

At the same time, one of the most important tasks, in our opinion, is to build special purpose maps based on the information already available and re-received. The initial information may be based on previously compiled thematic maps, aerial photographs, ground survey results, statistics, etc., supplemented by new technical tools, due to the emergence of new technologies (laser scanning, unmanned aerial vehicles (UAVs), high-resolution surveys of the Earth by spacecraft, etc.). As noted earlier, the most satisfying goal of creating graphic computer design tools in land management is satisfied with the concept of GIS - layered (distributed) data organization.

SAEDS and GIS technologies allow to interpret space-coordinated information related to a particular territory for land design purposes. In our opinion, it is in the field of creating thematic mapping software (creating electronic atlas passports for each site) that the idea of digital (smart) land management can be successfully promoted.

2. Materials and methods

Let us consider the above issues of digitization of the land-building industry through the example of individual tasks of domestic land management. Traditional approaches to the organization of the territory of crop rotations and their design require special agronomic knowledge from the land builder, taking into account a large number of factors and regional features. With mass maintenance of design work on a regular basis, this becomes a time consuming task difficult to complete at a proper level. Therefore, its solution should be included in the common complex of the SAEDS being developed. In accordance with the proposed methodology, the rational structure of planting areas for the entire administrative area is calculated on the basis of analysis of economic, natural and environmental factors (for example, when the structure of planting areas, climatic anomalies, etc. is changed in the economy). After that, the crops can be distributed between farms and further between departments, brigades, production sites, fields and work areas. With this sequence of works within each crop-rotation array creates a differentiated alternation of crops across fields and work areas, that is, there is an effective tool for managing crop rotations. Our methodology in many areas of the country can be used in the introduction or development of crop rotations, and the increase in the gross harvest of all crops is guaranteed, as the rational use of arable land is ensured by the selection of cultivated sites for specific
crops suitable for cultivation in accordance with their soil and microclimatic conditions. The use of this technique to improve the territorial organization of crop rotations allows:
- to optimize the structure of the acreage in terms of the most efficient use of soil fertility;
- to ensure the maximum output of gross crop production;
- by adjusting the types, quantity and size of crop rotations, to create the most favorable organizational and territorial prerequisites for agricultural production.

In our opinion, the work on the placement of crops in crop rotations should be carried out in stages, in accordance with Figure 1.

3. Results and Discussion
The method is also appropriate with the unchanged structure of the acreage, as it allows more rationally with less losses of gross harvests of crops to distribute their crops between farms up to a separately cultivated site. If there is no need to adjust the structure of the acreage in the area (let us say that it is appropriate), it remains to determine the best placement of crops on working areas within each farm, which also provides the highest possible gross harvest of crops with the existing agricultural equipment. Thus, in the course of preparatory work to draw up a project of intra-economic land management, it is

![Figure 1. Infological model of differentiated crop placement in crop rotation [5]](image-url)
necessary to apply GIS technologies, on the basis of soil contours to distinguish the types of land and to make a map of agro-ecological types and groups of land. Then, taking into account geomorphology, maps of erosion hazard, reclamation, geo-botanical surveys in SAEDS, the allocated taxonomic groups of land (by overlay and comparison) are adjusted.

On the basis of this map, the boundaries of homogeneous plots and possible land grouping in the land development project into complexes, types and groups are established in the field conditions. This takes into account the resource capabilities of the producer to overcome the factors limiting cultivation of crops, with the help of agronomic and reclamation techniques and means. The dedicated agro-ecologically homogeneous sites (species, types and groups of land) correspond to certain forms of organization of the territory (from work sites and fields of crop rotations to types of crop rotations and farming systems). When developing crop rotations, it is necessary to calculate the most likely gross yield of products annually in the proposed placement of crops on work sites and fields. This work, in our opinion, should be carried out during the author’s supervision by land engineers (based on the land management project) to clarify the placement of crops for the next year. Such management of crop rotations is the responsibility of the chief agronomist of the farm together with the land developer. All the factors of the crop rotation are to be considered, such as a giant volume of different information, and need real decisions in the system of digital land management.

First, it is necessary to analyze crop-rotation arrays on the materials of soil survey and cadastral assessment of land, to characterize the state of each work site and field, to determine the degree of their suitability for crop cultivation. After establishing the structure of the acreage in the farm, it is necessary to optimize the placement of the main groups of crops on soils with different fertility on the basis of a qualitative assessment of arable land.

However, such placement of crops is possible if they are grown in one place, which definitely leads to a decrease in yields. For the cumulative consideration of all conditions and visibility in the placement of crops and the design of crop rotations, it is recommended to zone the area on the basis of the results of a qualitative assessment of arable land. At the same time, each crop is evaluated according to its predecessors, and zones of suitability of each culture are established with the compilation of digital zoning maps on the suitability of cultivation. Thus, on the basis of this zoning, the locations of each crop, especially the most desirable places of leading crops, are established. Then the types of crop rotations are designed and put into practice.

Work sites are designed agro-technically homogeneous, so the cadastral assessment of their suitability for the cultivation of certain crops has a high degree of confidence. The assessment of land for the cultivation of different crops is determined, first of all, by the degree of their cultivation, mechanical composition, erosion, water regime, etc., that is, properties to which crops react differently. Therefore, it is necessary to differentiate the cultivation of crops by fields as much as possible. The alternation of crops should not hinder, but, on the contrary, contribute to the possible fuller use of microclimatic and soil features of individual plots and land massifs.

The suitability of soils for growing different crops is determined by the culture and mechanical composition, erosion, water regime and acidity of the soil within three gradations: the best – with good conditions for the placement of culture; suitable, meaning that the placement of crops on this work site is permissible, but it is difficult to obtain a high yield; unsuitable – the placement of culture on this site this year is unacceptable. Taking into account the solution of the problem and fulfilling all the requirements for the placement of crop rotations, a project of intra-economic land management in SAPR is being drawn up.

In order to intensify agriculture, it is very important not only to investigate the mechanism of influence of various factors on crop yields, but also to be able to quickly influence these factors. At the same time, it is necessary to strive to equalize the fertility of all fields by introducing organic and mineral fertilizers, sour, soils, in order to further eliminate agro-technical heterogeneity and be able to enlarge crop rotation fields if necessary. In order to calculate the probabilistic trend of yield and intra-economic cadastral score of each crop and for each working area and on a computer, it is necessary to prepare the following information: a list of crops for which the area and numbers of fields and work sites will be
assessed, the soil code of each site, the area of fields and sites on which the researched culture was located in the previous three years, and the gross harvest received from these sites. The result of the program is the calculation of the cost-effectiveness of crop rotations over time.

The proposed approach to the organization and management of crop rotations allows annually to determine the appropriate option of placing crops in the farm. Thus, crop rotation, first of all, should be considered not as a frozen scheme of alternating crops by year and field, but as a dynamic system, i.e. requiring constant management, annual choice of the optimal option for the placement of crops on crop rotation fields, taking into account the prevailing conditions for the given year (precursors, quality and condition of each field of crop rotation, order for the production of agricultural products, the timing of the development of land, the implementation of the land.

Secondly, the design of crop rotation should be considered not as a one-time act of project development and the production of necessary documentation, but as a whole set of activities, including, in addition, annual operational management of crop rotations in the farm, constant monitoring of the use of each field, site, their condition. In this case, a completely different approach to the organization of the system of crop rotations, the composition and content of the original information, the order of documentation for each crop rotation using new technologies is required. Using this data and computers, we believe that we can obtain an objective tool to manage not only crop rotations, but also other elements of the farming system.

4. Conclusion

Analysis of the cost-effectiveness calculations of our methodology and software has allowed us to determine the averages of the main indicators of economic efficiency. With differentiated placement of crops, the yield of winter grains increases by 2-4 per cents per hectare, potatoes by 30-40 per cents per hectare, corn by 6-8 per cents per hectare, if the differences in fertility are about 10-15 points. The proposed techniques and software in the form of SAEDS will accelerate the development and development of rational technologies in the production that prevent the loss of humus, preserve the quality of the land and provide a greater economic impact.

In order to further intensify agricultural production, based on a differentiated scientifically sound approach to maximizing the potential of each land, based on the application of digital technologies that provide a sustained high level of crop yield (in accordance with the potential of the variety), the preservation and improvement of soil fertility should be used electronic technological and economic passport of the design facility, which should be developed at the preparatory stage taking into account the specifics of the zone, its climatic and economic conditions. In the established practice of crop rotation in the region's farms, one of the defining tasks was to ensure the high-performance use of agricultural machinery. To do this, large fields and basically the correct configuration were designed. In the conditions of complex terrain or wet soil cover, creating large fields that are homogeneous in economic terms is almost impossible. Heterogeneity of conditions even within the same field leads to significant crop losses due to the inability to grow, develop, mature, etc.

Experience shows that the difference in yield in different parts of the field located on the slope does not allow making an accurate adjustment of a combine harvester and, as a result, increases the losses during cleaning. All these losses, caused by environmental heterogeneity, exceed the efficiency of the application of technology at high technological characteristics. Based on the foregoing, the main purpose of the passporting (i.e. registration certificating) of each field is to create a data bank for SAEDS in the system of digital land management, allowing to use on this basis systems of precision farming. To do this, large fields and basically the correct configuration were designed. In the conditions of complex terrain or wet soil cover, creating large fields that are homogeneous in economic terms is almost impossible. Heterogeneity of conditions even within the same field leads to significant crop losses due to the inability to grow, develop, mature, etc.

The results of the research should ensure the creation of a methodological basis of the database for the automation of graphic design, the development of complex land development projects, the analysis
of the possible consequences of decisions in accordance with the concept of the state in the development of land relations and land management, as well as a multiple increase in the volume of land and resource information. [3, 5, 7, 9]

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