Formation of information and cartographic material to ensure complex cadastral works using modern technologies

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Abstract. The effectiveness of land surveying, cadastral, as well as real estate management works directly depends on the quality of the initial data and the cartographic basis used. In the Russian Federation, cartographic data developed in the 80-90s of the 20th century are often used in practice. In connection with the transition to complex cadastral works, it becomes necessary to update the cartographic basis and its further application. The article presents material related to the development of proposals for the provision of integrated cadastral works with up-to-date information and cartographic documentation through the implementation of methods for collecting and processing initial information obtained from various official sources using the software "Statistica" v.10.0, JMP Statistic 15 and Minitab 19. The practical significance lies in the fact that the developed methodology can be useful when performing complex cadastral works and any cadastral works.

1. Introduction
At present, in the light of the latest trends in the development of the use of modern information and communication technologies, modern devices and equipment for carrying out survey and measuring operations at research objects, the widespread introduction of the use of remote sensing materials and GIS technologies, it becomes possible to plan and carry out complex works to obtain relevant information on the state and use of research objects in the complex [1]. This statement fully applies to the conduct of complex cadastral works, which will allow one in a shorter time to obtain reliable information for entering it into the Unified State Register of Real Estate (USRN).

One of the goals of this work is the development of proposals for improving the methodological provisions for carrying out complex cadastral works. The development of proposals was carried out on the basis of an analysis of the current regulatory and legal framework governing the conduct of complex cadastral works. The current legislation should ensure the filling of the taxable base, streamline the information base of the USRN. Earlier we have already addressed the issue of organizing complex cadastral works [2].

An analysis of the conduct of complex cadastral works showed that this is a complex and multifunctional form of state land use management. The production of these works covers several areas of activity in the field of land relations: from obtaining the coordinates of the boundaries of land plots and other real estate objects to entering them into the information of the state real estate cadastre, resolving land disputes and regulating the tax system. The study regions are the regions of the Far East; examples are considered on the materials of the Sakhalin region [3].
2. Materials and methods
When developing the proposals, an analysis of the general sequence of actions was carried out and the methodology for carrying out complex cadastral works is enshrined in article 42.6 of the federal law of 24.07.2007 No. 221-FL “On cadastral activities”, which are important tools for obtaining up-to-date information about the real estate object, the study area and comprehensively solving the problems of relevance of information in the USRN, which underlies the economic and social policy of the country [4]. For this purpose, materials obtained from publicly available sources (reports, statistical material) were used. As a result of the studies carried out on the application of complex cadastre works (CCW), the main problems of their application were identified and proposals were made to improve the methodological provisions for their implementation, as a result of their wider application.

3. Research to improve the methodology for performing complex cadastral works based on the formation of relevant information and cartographic material
The question of choosing information and cartographic documentation requires a very careful study. First of all, we will consider the main sources of obtaining cadastral information, which are presented in table 1.

| Table 1. Information systems containing information about land plots and real estate objects |
|---|
| **Source** | **Information** |
| Rosreestr Ministry of Natural Resources and Environment of the Russian Federation Federal Forestry Agency of the Russian Federation | Information about the boundaries and registered rights to real estate objects. Information on the state of the land fund. |
| Soil Atlas of the Russian Federation Federal Agency for Water Resources of the Russian Federation Ministry of Agriculture of the Russian Federation Executive authorities of the constituent entities of the Russian Federation and local self-government bodies | Information about forests and forest areas Information about the soil characteristics of the territory. Information about water bodies of the territory. Information about agricultural land. Information on the allocation of land plots, land use and development rules. Information about the rules of land use and development; borders of settlements and municipalities; on the presence and boundaries of zones with special conditions for the use of territories. Information from the unified state register of cultural heritage objects (historical and cultural monuments) of the peoples of the Russian Federation, as well as information on land plots within the boundaries of the territories of cultural heritage objects of federal significance and the protected zones of these objects. Information from the register of federal property on land plots. Earth remote sensing data. The state of the atmosphere and water resources. |
A number of normative acts have established a procedure in which the implementation of information support is impossible without carrying out cadastral work and the preparation of relevant documents, which significantly complicates the process of obtaining information, taking into account such factors that affect the receipt of cadastral information, such as:

1. The presence in the Unified State Register of Real Estate of information about the borders of the constituent entities of Russia, municipalities and settlements. Lack of borders leads to self-seizure of land plots and inefficient use of land. To achieve the necessary indicators, it is necessary to carry out comprehensive cadastral works in order to enter up-to-date information on the maximum possible number of land plots, perform land management work to describe the boundaries of land management objects in accordance with the requirements of the legislation of the Russian Federation.

2. The quality of cadastral works by cadastral engineers. The information contained in the USRN is entered, including on the basis of documents prepared by cadastral engineers, the quality of which depends on the level of their professional knowledge and skills.

3. Availability of information at the disposal of public authorities and local self-government bodies of the constituent entities of the Russian Federation.

4. The quality of the preparation of land use and development rules (LDR). For cadastral registration, it is important not only the formal availability of LDR, but also their unambiguous compliance with the requirements of the legislation. In particular, the law determines the need to include the boundaries of territorial zones in the USRN.

It should be noted that in crisis transition periods, innovative technologies acquire special significance when production technologies are almost completely changed and there is an urgent need to modernize cadastral and other production and management of all spheres of public life, in their transformation into a new state that is adequate to the national idea (transition to innovative, digital economy). Different types of cadastral works have specific output documents. For example, cadastral work with land plots can be divided into two large groups: work on education and work on making changes to the existing characteristics of a land plot, which, depending on the method and features of the process of cadastral work, are divided into specific types [5].

Thus, modern conditions set the task of forming up-to-date information and cartographic documentation for the purpose of performing complex cadastral works, and for the solution of which the following algorithm can be proposed, which makes it possible to select, justify and carry out complex cadastral works with the greatest efficiency (Fig. 1).

For careful planning of the implementation of complex cadastral works, it is necessary for each territory subject to cadastral survey to obtain a unique set of indicators that will reflect its specific features, distinguishing it from other territories and allowing to complete with a high degree of reliability with initial data defining the methods of carrying out complex cadastral works.

The Sakhalin region, as the object of research in the presented work, is of great economic importance for the Far Eastern economic region, the main branches of the region's specialization are oil and gas, fishing, forestry, mining and metalworking. The creation of a reliable information base of the FSIS USRN of the Sakhalin Region will allow one to streamline the use, spatial development of the territory and update the tax base [6].

The following industries are undergoing great development: fishing and fish-processing complexes; oil and gas complex; coal mining complex; transport infrastructure; creation of industrial and logistics marine complexes; tourist complex, etc. [7].
For the successful solution of the tasks set, first of all, it is necessary to have relevant and reliable information on the development territory, the receipt of which is advisable to carry out in a complex on the basis of carrying out complex cadastral works.

To carry out CCW information is collected and analyzed (Table 2).

Thus, it follows from the table that in the complex of cadastral works it is possible to single out the main proposals for their successful implementation [8]:

- collection and analysis of existing information and cartographic documentation obtained from various official sources;
- processing the information received to determine the most representative update indicators using "Statistica" v.10.0, JMP Statistic 15 and Minitab 19;
- development of a project for carrying out complex cadastral works (CCW) using modern technologies, instruments and equipment;
- recommendation of the preliminary development of documentation for the planning of the territory for the most complete provision of the USRN with information about real estate objects when carrying out complex cadastral works [9];
- coordination of decisions made in relation to CCW objects at the stage of forming a map (plan).
Table 2. Classification of real estate objects

| By legal status          | By the relevance and reliability of information                                                                 |
|-------------------------|---------------------------------------------------------------------------------------------------------------|
| Land plots              |                                                                                                               |
| Recorded (registered)   | Clarified (delimited without cadastral errors)                                                                |
|                         | Declared (not delimited)                                                                                      |
|                         | Erroneous (delimited with the presence of a cadastral error)                                                  |
| Unrecorded (actually    | Fields geodetic work is required to determine the location of the boundaries.                                  |
| existing)               |                                                                                                               |
| Capital construction    |                                                                                                               |
| objects                 | Location information entered into USRN without errors                                                         |
| Recorded (registered)   | The information entered in the USRN requires clarification (corrections)                                      |
|                         | The USRN does not contain information about the location                                                       |
| Unrecorded (actually    | The location of the contour can be determined cartometrically                                                 |
| existing)               | Field geodetic work is required to determine the location of the boundaries.                                  |

Compliance with the methodology presented in the section will allow you to perform complex cadastral work, avoiding the loss of time for field surveys, approvals, as well as to perform the work better and more efficiently [10].

Work using the proposed methodology was carried out on the territory of the cadastral quarter 65: 05: 000029 (Fig. 2), located in the village of Novotroitskoye, Anivsky district, Sakhalin region.

![Figure 2. Fragments of the public cadastral map - the territory of the cadastral quarter, 65: 05: 000029: a) northern part, b) southern part](image)

At the first stage, the collection and analysis of information and cartographic data were carried out on the basis of determining the influence of cadastral indicators and indicators of the area of territories of districts on the effective indicator. When selecting analytical indicators, a working hypothesis was chosen to assume that the most complete state of cadastral data in the USRN is characterized by information about real estate objects at the moment, information about registered and previously...
recorded real estate objects in the study area [10]. When entering the values of each indicator within the framework of municipalities, an analysis of the subordination of data to the law of normal distribution was carried out and a factor analysis was carried out in the software "Statistica" v.10.

Factor analysis made it possible to calculate factor loadings for each variable, i.e. determine the correlations between factors and corresponding indicators, determine the most representative indicators in a given set of variables.

In this regard, for further analysis, nonparametric methods of analysis were used: correlation analysis based on the Spearman coefficient, the method of factor analysis [11]. The number of factors was determined on the basis of a matrix of eigenvalues with a percentage of total variance exceeding 10%. Highlighted 4 factors affect the variables in the database.

Despite the fact that the study adopted a three-component model of an integrated cadastre (land area, number of accounted land plots, population), the maximum possible number of factors was used to select representative indicators by the method of factor analysis.

Further, in order to determine the number of factors, a matrix of eigenvalues was constructed with the percentage of total variance, accumulated eigenvalues and accumulated percentages. Interpretation of factor loadings showed that factor 1 refers to the group of indicators of land area (stock, agricultural land, forest land, water resources, municipal district), and factor 2 is an indicator of population, to which, among other things, indicators of recorded land sites and capital construction projects.

Processing of the data obtained made it possible to obtain the following results (Table 3).

**Table 3.** The effectiveness of complex cadastral works on the territory of the cadastral quarter

| Indicators                  | Before the CCW | When carrying out CCW with an approved draft map of cadastral works | Percent | When carrying out CCW without an approved draft map of cadastral works | Percent |
|-----------------------------|----------------|--------------------------------------------------------------------|--------|---------------------------------------------------------------------|--------|
| Land plots                  | 120            | 148                                                                | 123,3  | 123                                                                 | 102,5  |
| - created                   | 15             |                                                                    |        |                                                                     |        |
| - specified                 | 3              |                                                                    |        |                                                                     |        |
| - fixed                     | 1              |                                                                    |        |                                                                     |        |
| Total area of land plots    | 37,3           | 42,6                                                               | 114,2  | 36,8                                                                | 101,3  |
| accounted for in accordance with the legislation, ha | | | | | |
| Capital construction objects| 60             | 93                                                                | 155    | 93                                                                  | 155    |
| - specified                 | 33             |                                                                    |        |                                                                     |        |

It follows from the table that when carrying out complex cadastral works on the territory of the quarter under study, subject to the availability of an approved draft map of cadastral works (PCC), developed on the basis of a preliminary analysis of the collected data and processing it using the software "Statistica" v.10.0, JMP Statistic 15 and Minitab 19 will make it possible to achieve an increase in the USRN data on land plots and other real estate objects by more than 20% in comparison with carrying out work without choosing those indicators that must first of all be updated and presented in the form of digital and cartographic information.

The analysis showed that the system of indicators of the complex real estate cadastre fully fits into the model determined by three factors: total area, population, cadastral data. Also, reliable reflection
has such data as: land plots with refined boundaries 2 - 6 times less than their total number; capital construction objects (CCO) - 6-10 times and more.

4. Conclusion
Analysis of the results of the collected information and cartographic materials for the object of study, using space information and stock cartographic materials and other data, showed that the processing of these data according to the proposed method of obtaining representative indicators and using them for the subsequent development of the Project of complex cadastral works, which will subsequently be performed with the use of modern technologies, devices and equipment and in the sequence and timing planned in terms of complex cadastral works, allows one to reduce the time for the production of cadastral works and conduct registration and registration actions, to increase the information content and reliability of information on objects of territorial research by an average of 5-6 times.

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