Analysis of the water bodies zones influence on the cadastral value of garden and horticultural land plots

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Abstract. The paper proposes new methodological provisions for determining the cadastral value of garden and horticultural lands with water bodies zones. A method was developed for calculating the cadastral value differentiation coefficient, which takes into account the presence of a water protection zone on the land plot. A hypothesis was formulated about the influence of water bodies zones on the cadastral value of these lands and it was confirmed for the water protection zone. The analysis of statistical data was made, which was the basis for selecting analogous objects for calculations. Two stages of the cadastral value modeling were carried out, the results were compared to obtain the desired coefficient. The analysis of the obtained models quality confirmed the validity and adequacy of the cadastral value model.

1. Introduction and problem statement
Currently, the most acute problem in obtaining reliable data on the cadastral value of land plots is in incomplete consideration of all influencing price-forming factors. One of the topical issues of the cadastral valuation process is to determine the dependence of value on various kinds of constraints (encumbrances), significantly influencing the implementation of rational and full use of land in accordance with their intended purpose. In this paper, we consider water protection zone and a coastal protective strip of a water body. According to the Russian legislation they are refered to the zones with special conditions of use of the territories.

One of the segments of real estate, where there are significant restrictions on the implementation of economic activities in the areas of water bodies zones, is garden and horticultural plots. The assessment of such lands is carried out according to the approved in 2017 methodology, where a list of recommended influence factors is proposed. In the cadastral valuation of the lands of Saint-Petersburg in 2018, factors that did not correspond to the specified list were used for this segment, but, according to the experts, they were more important and fully justified for inclusion in the valuation model. The list of price-forming factors methodological guidelines for the cadastral assessment already contains the factor "The presence of encumbrances (restrictions) of the land plot", but there are no methodologies for that assessment in mass form. This once again confirms the relevance of the topic and the necessity to develop proposals for more accurate and fair cadastral valuation.

According to the last cadastral assessment of the land plots in Saint-Petersburg, which was conducted in 2018, factors for the presence of water bodies zones in garden and horticultural plots were not taken into account. Consequently, the land plots, partially or fully located in the specified zones and with restrictions on use, were assessed as free from these protection zones, which indicates incorrectness of the obtained results of the cadastral assessment, and, therefore, the unfairness of the the tax burden.
distribution between the subjects of this land market segment. In view of the foregoing, the purpose of the study was to improve the methodology for determining the cadastral value of garden and horticultural lands by calculating the coefficient of accounting for water bodies zones.

The practical significance lies in the possibility of using the results to modernize the existing methodology for determining the cadastral value of garden and horticultural lands located in settlements in order to ensure social justice in the implementation of tax policy.

2. Review of literature and the prerequisites for the modernization of the existing cadastral valuation methodology

The issues and ways of modernization as a methodology for cadastral valuation of horticultural lands and technical guidelines are described in the scientific works of many researchers. Separate developments that take into account the influence of zones with special conditions of use of the territories (ZWSCUT) were proposed by several Russian scientists. A.A. Varlamov gave the formula for calculating the value of land, taking into account the coefficient ZWSCUT, but the method of obtaining coefficients was not presented [1]. Kretinin K.V. and Kuznetsov N.A. proposed the formula for calculating the amount of damage caused by overhead transmission lines [2]. Sutyagin V.Yu. offered the calculation of the coefficient, which takes into account the degree of restriction of rights due to the establishment of a protected zone, by an expert method [3]. Kovyzin V.F. and Romanchikov A.Yu. presented a method for calculating the cadastral value of forest lands, which includes special forest factors [4]. The beginning of all these studies in the field of the influence of ZWSCUT on the value of land was laid in the USA by several researchers in 1979. Gustafson R.J., Grumstnup P.D., Herdrickson E.R. and Meyer M.P. They studied the negative impact of airborne power lines on economic activities in the agricultural lands. It was revealed that power lines affect the efficiency of air scattering of agrochemicals, machine tillage, and their electric field reduces crop yields [5].

One of the authors of this article Bykowa E.N. considered the cadastral valuation of horticultural and gardening lands associations in detail in one of her earlier work [6]. The work is based on the determination of the influence of ZWSCUT on the cadastral value of land by an expert, expert-analytical and statistical methods. These zones are considered as a price-forming factor in determining the cadastral value of land, and their accounting is associated with socially fair taxation.

Although the Federal Standard for Assessment No. 4 establishes the cadastral valuation taking into account the encumbrances (restrictions), but as a price-forming factor the availability of the ZWSCUT is not included. Justification of the influence of water bodies on the activities was carried out in weight terms by an expert method in the article [6]. According to the work in water protection zones activity limits are 14 and 16% for garden and horticultural plots and in coastal protective zones 18 and 20%. Spatial analysis of the territory showed that about 56% of garden and horticultural area associations of Saint-Petersburg are covered by ZWSCUT. By this fact the importance of the factor «presence of ZWSCUT on a land plot» in determining the market value of the consideration land is proven [6].

3. Gathering and analysis of information

To calculate the cadastral value of garden and horticultural lands, the State Cadastral Valuation Method is used, approved by order of the Ministry of Economic Development of Russia on 12.05.2017 No. 226. According to it, the cadastral value of land plots of horticultural and gardening associations within the segment «Gardening and horticulture, low-rise residential buildings» is determined on the basis of a statistical analysis of market prices and other information about real estate, as well as other methods of mass real estate valuation.

The land plots of garden non-profit associations (GNA) «Slavyanochka-3» (217 land plots) and of GNA «Slavyanochka-2» (121 land plots) located in the borders of Saint-Petersburg were used to study the considered influence.

The cadastral value of land plots that are not in the areas of water bodies was calculated on the basis of price-forming factors used in the cadastral assessment of 2018. The list of such factors is formed by a specially created group of experts based on a typical list of factors of a particular segment.
Initially, based on the analysis of the market of the land plots in question, a list of all price-forming factors was formed that could influence their market value. Then, the type of factor was determined for each factor - qualitative or quantitative. For qualitative, a list of factor gradations (rank value), algorithms and description of these algorithms for calculating the values of factors were developed. Independent and importantly influencing factors were identified in the course of mathematical modeling of the significance price-forming factors of the cadastral assessment of 2018. These factors include: the area of the land plot; location (influence of highways and influence of local centers); engineering support (availability of electricity, water, heat, sewage and gas supply at the plot); air pollution level; «greening» of the plot; provision of the plot area location with social infrastructure objects; availability of access roads. Also two new factors were included: «availability of water protection zone on the plot» and «presence of the coastal protective strip on the plot». It will allow to estimate the difference in the cadastral value calculated in 2018 and the value determined with the inclusion of new factors. To obtain the values of price-forming factors and market data were used legitimate databases of state information resources «Regional geoinformation system of Saint-Petersburg» (RGIS), Public cadastral map and market data base of the City Department of Real Estate Inventory and Valuation (CDREIV).

After agreeing on the list of segment factors, there is a necessity in the transition to the definition of a reference land plot for each association. Therefore, a plot with an average GNA area and an incomplete set of utilities (power supply and water supply), which is typical of these GNAs, was selected. The use of a comparative approach in determining the value involves the search for reliable information about transactions or offers on the market of the segment to which the object of valuation belongs. Due to the CDREIV database, statistical information on objects-analogues was selected, which was necessary for calculating the value of the reference land plot. The required information includes individual characteristics of each analogue, its market value at the date of the offer in the market or purchase and sale transactions.

For the presentation of statistical market information, estimated objects and water bodies zones was used the geoinformation system (GIS) «MapInfo Professional 11.5». Figure 1 shows a part of the land plots partially or fully located within the boundaries of a water protection zone and a coastal protective zone and for which the cadastral value will be calculated.

![Figure 1. Objects of assessment of partially or fully located within the boundaries of water areas](image)

**4. Modeling the cadastral value of garden and horticultural lands**

To accomplish the research goal, the modeling was carried out under the conditions of the presence and absence of a water protection zone and a coastal protective strip on the land plots. The first step in building models was to make adjustments for the elements of comparison: terms of sale (discount for
the offer was taken into account according to CDREIV data) and market conditions (the dates of sale of objects were taken into account according to the method specified in [7]). Then, we made a qualitative analysis of the characteristics and prices of analogous objects, based on determining the rank values of the quality characteristics. The next step was calculated weighted quality indicators, but it was necessary to establish the weighting factor of each price factor for this [8]. In order to fully assess the situation on the market, weights of factors were calculated by a mathematical method for calculating weights using the feature «Search for Solution» of MS Excel [9, 10]. The results of calculating the weights for each of the models are presented in Table 1. The weighted relative quality indicators of the models are determined by multiplying the obtained weights by the values of the relative coefficients.

Table 1. The weighting factors of price-forming factors for 1 and 2 models

| Model / Factor | Plot area | Location | Engineering support | Level of air pollution | Greening area of the plot | Provision of the plot location district to social infrastructure | Presence of access roads | Share of water protection zone on the land | Share of coastal protective strip on the land | Sum |
|----------------|-----------|----------|---------------------|------------------------|--------------------------|-----------------------------------------------------------------|------------------------|--------------------------------------------|---------------------------------------------|-----|
| Weight for 1 model, % | 7.8       | 21.3     | 25.9                | 17.9                   | 6.3                      | 10.2                                                             | 10.6                   | 5.0                                        | 18.6                                        | 2.2 | 100 |
| Weight for 2 model, % | 1.4       | 11.7     | 28.6                | 14.0                   | 12.2                     | 12.2                                                             | 5.0                    | 18.6                                      | 2.2                                         | 100 |

At the next stage, the coefficients of factors were calculated, the value of which determined the feasibility of introducing them into the value model (the factor was excluded with a coefficient of significance less than 0.3 according to the Cheddock scale). The test for multicollinearity revealed the interdependence between the factors «the share of the water protection zone on the land plot» and «the share of the coastal strip on the land plot» (coefficient of inter-factor correlation is more than 0.75). As a result, the second of the indicated factors was excluded from the calculations, since its coefficient of partial correlation is lower, and therefore weights and weighted quality indicators are recalculated.

Figure 2. Dependence of the price on integral quality indicator: linear model (taking into account the water protection zone)

The construction of the regression equations was made on the basis of the calculated integral quality factor (IQF) and the price of land. 4 types of the equations were built for each of the 2 models (linear, exponential, logarithmic and power) to determine which of them best describes the statistical information. According to the results of the analysis, the most reliable was a linear model (Figure 2) for
both models without taking into account the water protection zone. Coefficients of determination are 0.64 and 0.77, which indicates that the model is above average.

Determination of the cadastral value of the land burdened with ZWSCUT is proposed to be calculated using the formula presented in the monograph [5]. It contains the ZWSCUT accounting coefficient for the \(i\)th burdened part of the land plot. This coefficient can be determined by different methods depending on the development of the land market, but in this study it is calculated for the water protection zone based on the obtained cadastral value models. It includes the ratio of the received specific cadastral value (SCV) without considering ZWSCUT \(Y_{\text{without ZWSCUT}}\) and SCV taking into account ZWSCUT \(Y_{\text{with ZWSCUT}}\) according to the formula:

\[
C_i = \frac{Y_{\text{without ZWSCUT}}}{Y_{\text{with ZWSCUT}}} = \frac{y = 4049.1x - 27.959}{y = 4252.4x - 339.9} = 0.92
\]

The calculation of the water protection zone coefficient is presented in Table 2.

**Table 2.** Calculation of the water protection zone coefficient for cadastral valuation of garden and horticultural lands

|                     | Model 1 (without water protection zone) | Model 2 (with water protection zone) |
|---------------------|----------------------------------------|---------------------------------------|
| \(R^2\)             | 0.64                                   | 0.77                                  |
| \(F_{\text{calc}}\) | 45.19                                  | 83.45                                 |
| Level of significance \(F\) | 4.80E-07                              | 1.92E-09                             |
| \(F_{\text{crit}}\) | 4.24                                   | 4.24                                  |
| Value, rub/sq.m     | 1346.59                                | 1233.07                               |
| Area, sq.m          | 1034.8                                 | 1034.8                                |
| Value, rub          | 1393454.73                             | 1275977.09                           |
| Water protection zone coefficient \(C_{WPZ}\) | 0.92                                 |                                       |

5. Analysis of the results

The results obtained in the research process allow us to draw a number of conclusions concerning both the improvement of the methodology for determining the cadastral value of land in general and the results of calculating the coefficient of water protection zone accounting directly. In general, the proposed changes in the methodology for cadastral valuation of land burdened by ZWSCUT allow for ensuring socially fair land taxation.

Modification of the method in terms of accounting for the factor «availability of ZWSCUT» allows one to use as its parameters the share of the area occupied by ZWSCUT, as well as the rules for using the territory within its limits. Using these options will help to calculate the coefficient of accounting for a specific type of ZWSCUT. In this case, the method of calculating these coefficients depends on the development of the land market and the availability of information to the population about the presence of restrictions on the use of the territory.

In general, it can be said that there is a market reaction to the presence of a water protection zone, which is confirmed by the significance of this factor in modeling. The influence of the water protection zone is logical (a «-» sign with regression equation coefficients) and corresponds to the hypothesis of a decrease due to its presence in the price of land.
6. Conclusion
Thus, it should be noted that the use of the calculated coefficient of accounting the water protection zone in determining the cadastral value of land plots of garden and horticultural associations by the example of Saint-Petersburg showed the following.

Firstly, when covering a part of land plots of equal size with a water protection zone, the cadastral value on average decreases by 65 000 rubles (5% of the value), which, respectively, reduces the land tax for right holders by 195 rubles.

Secondly, the greatest change in the cadastral value concerned the land plots completely located within the boundaries of the water protected zone, the value of which on average decreased by 120 000 rubles (9% of the value; land tax decreased by 360 rubles).

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