Improving the Technology of Cadastral Appraisal of Agricultural Lands with the Account of Environmental Factors

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Abstract. The analysis of regulatory framework governing the appraisal activities in the Russian Federation suggests that at present all the conditions have been created for performing high-quality appraisal works. However, the authors believe that the system of cadastral appraisal of agricultural lands is not free of shortcomings, which lead to a conflict of interests between the taxpayer and the tax recipient. On the one hand, the profitability of agricultural land is determined by the purchase price for the products being produced, which in its turn depends on its content of various types of pollutants, including lead oxides. It is known that this type of pollutant enters the soil (and then the agricultural products produced on it) from the atmospheric air. In the course of research it was revealed that the main source of this kind of pollution is road transport. This problem is not fully solved by the so-called right-of-ways, forest belts and protective shields created in the process of designing roads. There is an obvious environmental damage that does not depend on the actions or inactions of both the owner of the land and the manufacturer of products. On the other hand, this factor is not by any means taken into account when determining the quality of land in the process of calculating the cadastral value of agricultural lands, particularly when determining the value of agricultural land and arable land in the first place. The authors propose a technology for adjusting the cadastral value of agricultural lands with the account of environmental factors. When calculating the cadastral value, this technology will allow taking into account not only the future revenues, but also the future potential costs that directly depend on the anthropogenic factor.

1. Introduction

The analysis of regulatory framework governing the appraisal activities in the Russian Federation [1-10, 13-17] suggests that at present all the conditions have been created for performing high-quality appraisal works. This conclusion applies to all types of appraisal works, including cadastral appraisal of agricultural lands. It is hard to overestimate the national importance of this type of appraisal, since it allows replenishing the budgets of all levels through the taxation system. Moreover, at the level of municipal entities the real estate tax is probably the main source of budget replenishment. However, we believe that the system of cadastral appraisal of agricultural lands is not free of shortcomings, which lead to a conflict of interests between the taxpayer and the tax recipient. On the one hand, the profitability of agricultural land is determined by the purchase price for the products being produced, which in its turn depends on its content of various types of pollutants, including lead oxides.
oxides. This type of pollutant enters the soil (and then the agricultural products produced on it) from the atmospheric air. This problem is not fully solved by the so-called right-of-ways, forest belts and protective shields created in the process of designing roads. There is an obvious environmental damage that does not depend on the actions or inactions of both the owner of the land and the manufacturer of products. On the other hand, this factor is not by any means taken into account when determining the quality of land in the process of calculating the cadastral value of agricultural lands, particularly when determining the value of agricultural land and arable land in the first place.

It is known that road transport is not the only source of environmental pollution. Environmental pollution is a process that occurs naturally or artificially. There are a lot of natural and anthropogenic factors of environmental pollution [11], and road transport is one of the most significant anthropogenic factors, since according to some data [11, 12] it accounts for up to 85% of total pollution of anthropogenic nature. Such high contribution of road transport to environmental pollution is due to the fact that firstly, the territories of all municipal entities (especially in the European part of Russia) are literally penetrated by roads of various levels; and secondly, in recent years the number of cars per capita has grown considerably and still continues to grow.

2. Results and discussion
We analyzed the current situation on the example of Semiluksky Municipal District of Voronezh Oblast of the Russian Federation. In 2010 there were 232 vehicles per 1,000 inhabitants in Semiluksky District, i.e. 6,032 vehicles in the area. In 2017 there were already 370 cars per 1,000 inhabitants, in actual the total number of cars amounted to 9,914 units. Over the analyzed period the number of privately-owned cars increased by 64%.

Most modern cars require high-octane gasoline. The main sources of pollution are internal combustion engines and fuel evaporation through the ventilation system. It is known that lead oxides are practically insoluble and are characterized by weak migration ability.

In Table 1 we present the average amount of harmful substances emitted conveniently by each type of vehicles.

| Type of vehicle      | Amount of lead emitted into the atmosphere by one vehicle per day (grams) |
|---------------------|-------------------------------------------------------------------------|
| Bus                 | 0.08                                                                    |
| Truck               | 0.2                                                                    |
| Light motor vehicle | 0.27                                                                   |

Using the data in Table 1 it is possible to calculate the average annual amount of lead oxide emissions from road transport in the Municipal District under consideration.

Light motor vehicles annually emit: Pb = 0.27 × 365 × 9,914 = 0.977 tons.

Semiluksky District is crossed by many bus routes. Their average traffic interval is 10-20 minutes. Every day there are about 350 trips (full circle). The amount of substances emitted per year can be calculated as follows: Pb = 0.08 × 365 × 36 = 0.001 tons.

It should be noted that trucks are necessary for servicing the industrial and commercial enterprises. The average number of passing trucks is about 2,835 per day. The amount of substances emitted per year can be calculated as follows: Pb = 0.2 × 365 × 2,835 = 0.207 tons.

In addition, the Kursk-Voronezh-Borisoglebsk highway passes through the district. On average 21,547 trucks, 26,735 cars, and 312 intercity buses pass through this segment of the road per day. In view of the above, a very impressive picture of possible land contamination is taking shape.

At the same time, the main wealth of Semiluksky District is fertile soils represented by typical, podzolized, and weakly alkaline chernozems. In the land structure of the district the agricultural lands account for more than 80%, of which 81% is arable land. Hence, the main specialization of the district is the production of agricultural products.
Since the soil has the property of accumulating pollutants, this aspect cannot be ignored in land appraisal. In other words, it is necessary to complement the cadastral value calculation algorithm with an environmental indicator that will reflect the ecological condition of land plots.

In the course of research the authors have identified a number of reasons that impede the development and use of such indicator. These reasons include the following.

1. Ignoring the environmental problem when calculating the production losses.
2. Difficulties in collecting the data on the composition of pollution sources.
3. Difficulties in obtaining reliable information on land profitability.
4. The absence of data on the qualitative and environmental condition of lands in the cadastral documentation.
5. A significant increase in the cost of appraisal works that allow taking into account the ecological state of the assessed objects due to the need to conduct an annual monitoring of the state of soils and pollution sources.
6. The absence of legal and regulatory framework, which allows for prompt control of enterprises that are the sources of pollution.

Notwithstanding the above, the authors believe that it is possible to solve this problem by amending the existing algorithm for determining the cadastral value, taking into account the environmental losses caused by each type of pollution. In general, the formula for calculating the cadastral value of agricultural lands with the account of environmental damage \( C_{val} \) may be as follows.

\[
C_{val} = S \times SICV - E_{nd} \tag{1}
\]

where \( S \) and \( SICV \) are the area of the appraised contour of a particular type of agricultural land (calculated in \( \text{sq. m} \)) and the specific indicator of cadastral value adopted for the appraised territory (calculated in \( \text{rubles} \times \text{sq. m}^{-1} \)), respectively, and \( E_{nd} \) is the value of environmental damage (losses) in monetary terms (calculated in rubles).

The concept of damage itself represents the actual or potential losses that result from negative changes or changes caused by anthropogenic impact. The economic damage is considered as an estimated monetary value, which is based on actual or potential losses.

As mentioned above, the most dangerous and easily identifiable source of pollution is motor transport. It is well known that the busiest roads are Federal highways, which are located far from the settlements, but always pass through agricultural lands. Based on this the authors suggest introducing the zoning of territories within each cadastral quarter with the reflection of losses in case of crossing the plots with harmful objects.

The model of an approximate forecast of pollution from emissions of lead oxides by vehicles will be based on the length of the transport section crossing the agricultural land and average emissions from each traffic participant.

Due to the fact that this issue is understudied the authors are aware of the magnitude of error of the calculations being made. However, the objective of development work is to draw attention to the existing problem and propose a possible direction for its solution.

In view of the above, the total amount of emissions from motor transport in tons \( (\Sigma E) \) can be determined as follows:

\[
\Sigma E = Ne \times n \times L \tag{2}
\]

where \( Ne \), \( n \) and \( L \) are the average amount of emissions from one vehicle (calculated in tons), the number of vehicles, and the length of the road segment under study (calculated in km).

It should be noted that the only barrier between the polluting elements and the lands is the forest belt that limits the right-of-way. It is proved that it reduces the amount of contaminating elements by two times. Then the formula (1) will be as follows:

\[
\Sigma E = (Ne \times n \times L) : 2 \tag{3}
\]

Due to the fact that the proposed calculations are based on the consideration of the atmospheric factor, two aspects should be taken into account:

1) everything that is in the atmosphere will sooner or later settle on the soil;
2) there are no necessary sources of opposition to this process. It should also be noted that the distance from the road is the determining factor that should be taken into account.

In this study the authors applied the zoning based on the distance of the object being assessed from the road with traffic intensity sufficient enough to produce a negative impact. The proposed zoning is presented in Figure 1.

![Figure 1](image_url)

**Figure 1.** a, The drawing illustrates conditional zoning of the territory. b, The drawing illustrates zoning of the territory with the account of wind directions.

Zoning of the territory is based on the distance from the “polluter” to the land object. We suggest identifying the following zones of exposure: I – radius up to 50 meters, II – radius up to 200 meters, III – radius up to 400 meters, IV – radius of more than 400 meters.

Taking into account that the intensity of pollutants exposure is influenced by the direction of the wind and the fact that in winter the pollution of agricultural lands is minimal, let us plot the diagram of the effect of pollutants on the soil with the account of the summer wind pattern (Figure 1, b).

The greatest amount of pollution is observed in the area highlighted in blue in Figure 1, b. The zone is plotted with the account of wind direction. In accordance with the performed zoning several conditional pollution factors can be distinguished.

The first zone is exposed to the greatest pollution. Its conditional pollution coefficient can be set as equal to 1. The conditional coefficient of 0.7 will correspond to the second zone of pollution. The impact of pollution on the third zone will be minimal with the coefficient of 0.2. As for the fourth zone, it can be stated that here the impact of polluting elements will be at the level of the natural background.

Taking into account the proposed zoning, the calculation of the value of environmental damage (losses) in monetary terms may be as follows:

$$E_{nd} = Ce \times \Sigma E \times Ef$$

where $Ce$ and $\Sigma E$ are the cost characteristic of emissions and the total amount of emissions, respectively, and $Ef$ is the emission factor.

The cost characteristic of emissions is approved by Regulation of the Government of the Russian Federation No. 913 “On the Rates of Payment for Negative Impact on the Environment and Additional Coefficients” and amounts to 99,172.1 rubles per ton of lead oxides in 2018 prices [6].

The appraised object is located in the southwestern part of Semiluksky District of Voronezh Oblast (Russian Federation) within the boundaries of the Agricultural Artel named after the October Revolution 3,800 meters south-west of the house No. 10a, Zavodskaya Street, Latnaya Village. The southern boundary of the object adjoins the Kursk-Voronezh Federal highway (Figure 2).
In the area of location of the appraised land plot the total amount of emissions over the calendar year is 7.023 tons, which amounts to the average of 3.511 tons when taking into account the right-of-way and forest belts along the boundaries of the appraised land plot. Imposing the diagram of the effect of pollutants on the soil with the account of the summer wind pattern (Figure 1, b), the zone of pollution in the area of the appraised land plot can be obtained (Figure 3).

Figure 2. Location of the appraised land plot.

Figure 3. The zone of soil pollution by motor vehicle emissions in the area of the appraised land plot.

3. Conclusions

Thus, taking into account the weighted average value of $F_p = 0.36$ (formula 4), the environmental damage caused by motor vehicles to the appraised land plot is equal to 125,363 thousand rubles annually. The authors believe that the cadastral value of the object selected as an example should be reduced by this amount, according to formula (1).

In conclusion, it should be noted that the cadastral value should include not only the future revenues, but also the future potential costs that directly depend on the anthropogenic factor.

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