Suggestions for mainstreaming agro-climatic zone of the subject in order to assess the integrated land quality indicator

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Abstract. The results of the studies are presented, during which it was found that in recent years the Russian Federation constituent entity climatic conditions have changed significantly. This is confirmed by the data provided by the Roshydromet and the given calculations. All this influenced the agroecological potential, which is involved in assessing the integrated agricultural land quality indicator. A climatic indicators comprehensive study result was the three agro-climatic zones identification on the subject territory with agroecological potential 8.1-9.2. The basis for identifying new agro-climatic assessment zones was the change in the agroecological potential indicator by 0.5 units or more. The above calculations confirm the assumption about the subject zoning the territory possibility into the three zones. A territory new zoning is proposed, and, consequently, the agroecological potential new values.

1. Introduction
Over the past decades, the Russian Federation has gained quite a huge experience in agroclimatic zoning [1], which lies in dividing a limited area according to climate features that are important for solving specific management problems, for example, for calculating the cadastral cost of agricultural land as a taxable base. In the territory of the former USSR, maps of agroclimatic zoning were first compiled by G T Selyaninov (1955), and then by P I Koloskov (1958). As a result zones and areas were identified. Agroclimatic zoning, fulfilled by D I Shashko (1967), differs by great detailing, a combination of the typological basis and regional content, conjugation with the natural and soil zoning of the USSR. Agroclimatic zoning is distinguished with novelty, which was carried out in 1972 by A M Shulgin [2]. Using general criteria, he additionally took into account: soil temperature, soil moisture reserves, unfavorable agrometeorological phenomena and other tracers that are indicators of the natural environment. Such maps of agroclimatic zoning were created concerning to various tasks.

Over the past decades, the warming of the climate has been raised, which is obvious. Regarding to this fact, it is necessary to foresee changes in agro-climatic conditions, which significantly affect at the assessment of the integrated quality indicator of agricultural land [3]. Therefore, it is proposed to revise the agroclimatic zoning maps compiled in 1972 based on the averaged data of meteorological characteristics, which were obtained before 1970, and were used by S I Nosov in the development of agro-climatic assessment zoning of the subjects of the Russian Federation [4].

Thus, the goal was set to research and update changes in the agroclimatic zoning of the subject, in particular, to make a conclusion about the possibility of changing the number of agroclimatic zones and to develop a new map.
2. Methods, materials and results

During the formulation of a map (scheme) of agroclimatic zoning, we used an indicator such as agroecological potential (AP), which characterizes the influence of climatic conditions. The AP indicator was developed by the Soil Science Institute. V V Dokuchaev (I I Karmanov) and is calculated by the formula:

\[ AP = \frac{\sum t > 10^\circ (PE - R)}{CC + 100} \tag{1} \]

where \( \sum t > 10^\circ \) is the sum of temperatures above \( 10^\circ \) taken from climatic (agroclimatic) reference books; \( PE \) - precipitation-evaporation ratio (the ratio of precipitation to evaporation); \( PE \) values over 1.1 are taken equal to 1.1; \( R \) - correction to \( PE \), with \( PE > 0.76: R = 0.20 - 0.6 \) (1.1-\( PE \)); at \( PE = 0.76 - 0.36: R = 0; \) at \( PE = 0.35 - 0.30: R = 0.35 - PE \); at \( PE < 0.30: P = 0.05; CC \) - coefficient of continental climate, calculated by the formula:

\[ CC = \frac{360(t^\circ \text{max} - t^\circ \text{min})}{\lambda + 10} \tag{2} \]

where \( t^\circ \text{max} \) is the average temperature of the warmest month, \( t^\circ \text{min} \) is the average temperature of the coldest month, \( \lambda \) is latitude of the area.

The value of the AP indicator is taken from the reference book of agroclimatic assumption of zoning of the constituent entities of the Russian Federation, according to which the subject is considered in the article and it is divided into 5 agroclimatic subzones (figure 1a) [4].

Saying it again that in the recent years there has been a climate warming and the conditions for humidification of the territory have changed, that means two of the three indicators changed, which are involved to the calculations. Therefore, we recommend revising the agro-climatic zoning maps that were compiled in 1972 and applied by S.I. Nosov in the designing of agro-climatic assessment zoning [5].

The same assumptions are confirmed by the results of the analysis of the weather and climatic conditions of the subject under consideration at the end of the 20th century by the authors [6], who carried out agroclimatic zoning of the territory, which differs from similar zoning carried out in the late 60s of the twentieth century. The outcome of it was identification of three agroclimatic regions (figure 1b). Analyzing the data shown in figure 1, the question arose of allocating the regions of the studied subject to agroclimatic zones.

The necessary data was requested from Roshydromet for the calculation. Taking into account the entire experience of agroclimatic zoning, the work was based on the following factors:

1) the sum of temperatures above \(+ 10^\circ \) C,
2) the average temperature of the warmest month,
3) the average temperature of the coldest month,
4) \( HC \) which represents the ratio of the sum of precipitation to the sum of temperatures during the vegetation period, reduced by 10 times.

Since the indicator of moisture availability is also the hydrothermal coefficient (HC), which is equal to the ratio of the total precipitation to their evaporation, we used it instead of \( PE \) (see formula 1).

In accordance with the obtained data, meteorological observations are carried out at six meteorological stations on the territory of the studied subject (figure 2).

Even in the first approximation, there are differences in the original (updated) data and the data that was used and given in the zoning according to S.I. Nosov, in particular, for instance: Rovensky district and Alekseevskiy district are referred to the 5th subzone with the sum of temperatures above \( 10^\circ \) C - 2625-2700° C by S I Nosov . However, according to the actual data obtained from Roshydromet, the average value for the Rovensky region is 3076° C, and for Alekseevskiy - 2976° C.
Figure 1. Agroclimatic zones by S I Nosov (a), by G N Grigoriev and I V Voloshenko (b).

For updating of the agro-climatic zoning, further information was used for the five-year period since the last cadastral valuation of agricultural land. Let us provide the calculations of the agroecological potential of the AP for the Alekseevsky district (M-2 Novy Oskol) according to the formula (1), where $\Sigma t>10^\circ$ is the sum of temperatures above $10^\circ$, $\Sigma t>10^\circ = 2964$ C; $PE = HC$ - hydrothermal coefficient; values of $PE$ is more than 1.1 are taken equal to 1.1: for the Alekseevsky region, $HC = 1.6 > 1.1$, therefore, for calculations, we take $PE = 1.1$; $R$ is an adjustment to $PE$, with $R > 0.76$: $R = 0.20 - 0.6 (1.1 - PE) = 0.20 - 0.6 (1.1 - 1.1) = 0.2$, $CC$ - coefficient of climate continentality.
Figure 2. Areas of responsibility of meteorological stations.

We calculate the CC according to the formula (2), where $t^\circ_{\text{max}}$ is the average temperature of the warmest month, $t^\circ_{\text{max}} = 20.9^\circ \text{C}$; $t^\circ_{\text{min}}$ - average temperature of the coldest month, $t^\circ_{\text{min}} = -4.4^\circ \text{C}$; $\lambda$ - latitude of the area (for the Alekseevsky district - 50.6).

$$CC = \frac{360 (20.9 + 4.4)}{(50.6 + 10)} = 150,$$

$$AP = \frac{2964 (1.1 - 0.2)}{(150 + 100)} = 10.7$$

An example of calculations for the Alekseevsky district is provided in table 1.

Table 1. Calculations for the Alekseevsky district.

| Period (year) | Average value |
|--------------|---------------|
| Average value | 2975.8 |
| $\Sigma t^\circ > 10^\circ$ | 2964 | 3044 | 3091 | 3055 | 2725 |
| $t^\circ_{\text{min}}$ | -4.4 | -8.2 | -4.1 | -7.9 | -6.2 |
| $t^\circ_{\text{max}}$ | 20.9 | 22 | 21.1 | 22.1 | 21.8 |
| HC (PE) | 1.6 | 0.7 | 0.6 | 1.4 | 0.5 |
| $\lambda$ | 50.6 | - | - | - | - |
| R | 0.2 | 0 | 0.2 | 0 | - |
| CC | 150 | 179 | 150 | 178 | 166 |
| AP | 10.7 | 7.6 | 7.4 | 9.9 | 5.1 |
The result of the study of the climatic indicators and calculations provided by Roshydromet was the identification of three agro-climatic regions on the territory of the subject. Based on the results of the study, cartographic material was formulated (figure 3).

Figure 3. Recommended agroclimatic zoning.

Based on the provided data which was updated, a new zoning of the territory of the Belgorod region is possible, and, consequently, new values of AP for further calculations.

3. Conclusions

It can be concluded that all presented areas can be attributed to 3 agroclimatic zones with $AP = 8.1-9.2$. The given calculations confirm the assumption made by the authors [6] about the possibility of zoning the territory into 3 zones (figure 3).

S I Nosov claims [4] “… the territorial zoning unit is the municipal district. The basis for identifying new agroclimatic estimated subzones is a change in the set of assessment crops or the indicator of the agroecological potential of the AP ”(by 0.5 units or more). In the recent years, climatic conditions have changed significantly, which is confirmed by the data provided by Roshydromet and the given calculations.

All of these have had impact at the agroecological potential of AP: there was a change in AP by more than 0.5 units. We suggest that it’s necessary to make calculations for each municipal district of the subject, taking into account the data required for calculations for each territorial unit, and not for 6 meteorological stations [7]. For doing this, we recommend restoring the offices of meteorological stations in each municipal district of the studied subject to monitor climatic conditions.

References

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