Agricultural lands in the steppe Belgorod region: specifics of use and causes of dynamics

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Abstract. The steppe zone of the Belgorod region is the one of the economically important agricultural bases of the Russia. Here, many agribusinesses involved in crop and dairy production are located. The national economy crisis, that took place in 1990s in Russia, led to agricultural lands abandonment and regional food security problems. Most of the agricultural-oriented regions of Russia have faced a choice: to produce more crops on the same arable areas or to increase areas under cultivation by means of conversion of abandoned agricultural lands to agricultural use. Since 2014, an increase in arable lands area has occurred in most of Russian regions, but not in the Belgorod region. The region set a course to intensification of agriculture. The paper focuses in much more detail on studying territorial disproportions of agricultural lands location in the steppe zone of the Belgorod region and deals with investigation of ecological approaches for sustainable use of agricultural lands. The goal of the research is to assess geographical scales of such disproportions and to reveal the determinants leading to agricultural lands dynamics. Estimates are given in the article are based on statistical reports, geospatial data, and personal field research.

1. Introduction
Belgorod region is characterized by high agricultural productivity – about 5% from the total value of agricultural products produced in Russia. According to this indicator, the Belgorod region currently ranks 3rd among the Russian regions (after the Krasnodar Krai and the Rostov Region). Due to the high values of bioclimatic and agroecological potential, the steppes of the Belgorod region are of special interest for the agriculture development at the regional and national levels both. Agricultural lands of the Belgorod region occupy 2088.9 thousand hectares or 77% from the total area of the region. Besides, the region is keep going the course for intensification of agriculture. In 2020 arable lands held 1644.7 thousand hectares, areas under crop occupied 1332.3 thousand hectares, areas of abandoned agricultural lands reached 12.5 thousand hectares [1].

A long-term agricultural activity led to serious and negative actions, such as destruction of landscapes components, land cover fragmentation, biodiversity reduction, and industrial pollution [2, 3, 4]. According to A. Tishkov et al., A. Chibilev Jr. et al., A. Chibilev Jr. and A. Chibilev, and S. Levykin et al., agricultural land use in the steppe zone does not contribute to high biodiversity maintaining, destructs an ecological framework, and enhances environmental damage [4-6]. The economy of the Belgorod region relies also on mineral resources. Industrial and mining lands occupy 38.4 thousand hectares. Iron ore, bauxite, chalk, clay, and sand fields are mining in the steppe zone [1]. Agricultural lands are often located close to the areas of mining [3]. Agricultural and mining activity results in immediate environmental impacts and accelerates destructive natural processes are typical to Belgorod region: karst, suffusion, landslides, erosion, and gullies growth.
The Russian food embargo has been trigged the development of the local agricultural sector. Nevertheless, in contrast to neighboring regions, the Belgorod region has been not increasing agricultural production by means of expanding the massive areas under crop or by converting forest lands or abandoned agricultural lands to croplands to meet the needs of food. The strategy of food security in this region is basing on intensive agriculture and sustainable agricultural land management. The benefits derived from this management have been started as control of soil erosion, improve of soil fertility, and reduce risks of the negative ecological consequences. In so doing, agrarian potential of currently used arable lands is growing. However, this practice is not realized in each district, especially on lands located close to mining areas [3]. In the most areas of the Belgorod region, decline of the areas under crop is observed. Such tendency is driven by impact of the environmental conditions, as well as, by social, economic, and political factors [7-10]. In the last 7 years areas of abandoned agricultural lands in the steppe districts of the region increased by 3% [11]. Such insignificant growth can be regarded as "stabilization of agricultural land areas". In the future, abandoned agricultural lands can be considered as a basis for ecological framework creation and reserve for biodiversity conservation [4].

The goal of the research is to assess geographical scales and disproportions of agricultural lands location in the Belgorod region and to reveal the determinants leading to agricultural lands increasing or decreasing during the sanctions period. Understanding of the causes affecting geographical disproportions of agricultural lands location is a key to solving environmental and economic problems arising during agricultural land use.

To achieve this goal, it was necessary: (1) to collect statistical data, satellite images and cartographic material on agricultural lands located in the steppe zone of the Belgorod region; (2) to analyze trends of agricultural lands dynamics, since 2014; (3) to identify steppe districts where areas under crop, areas of arable lands, and areas of abandoned agricultural lands are decreasing or increasing; (4) to reveal factors leading to dynamics of areas under crop; (5) to set correlation links between changing areas of agricultural lands and factors determining these changes. Moreover, environmental features, social situation, and vectors of economic activities in each administrative district located in the steppe zone of the Belgorod region have been taken into account.

The study is relevant for all agrarian-oriented regions of Russia and has a practical importance in conditions of external political and economic pressure upon this country. Besides, according to the action of the strategic document "Forecast of long-term socio-economic development of the Russian Federation for the period up to 2030" (section "Agricultural complex") the research highlights problems connected to agricultural complex of the Belgorod region. Some results of the research were reported by author of this article at the Ninth International Symposium "Steppes of Northern Eurasia".

2. Materials and Methods
Basing on official statistical data collected from the Federal State Statistics Service in Russia [1, 11], on state reports on the condition and protection of the environment in the Belgorod region [13], on a large amount of available geospatial and satellite data (open space data from MODIS and AVHRR, Google Earth), on cartographic materials, on personal field research, and on scientific papers [14-19], author identified trends of agricultural lands dynamics for the seven-years period of Russian food embargo (2014-2020).

The article deals with the districts where agriculture is based on steppe. For each steppe district the leading factors decreasing of increasing of areas under crop were discovered. These factors were classified into five types: environmental (erosion and gullies growth; activity of karst, suffusion, landslides, and deflation; changes of forest areas; changes of values of bioclimatic potential – BCP), social (grow or decline of rural population), economic (changes in the number of profitable agricultural and industrial enterprises, changes of investments in the agricultural sector), agricultural (changes of areas under cropping and plowing, crop yields dynamics, land cover fragmentation, biodiversity reduction, and deforestation due to agricultural land use), and mining development (changes of areas where landscape destruction is occurred). On the next step, links between changes of
areas under crop and the main factors responsible for these changes were set by means of correlation analyses. Special attention was paid to changes of the land cover productivity (LCP). To measure the LCP, within the boundaries of each steppe district, the methods of calculation values of Normalized Difference Vegetation Index (NDVI) was applied on the base of space images (open international sources of information MODIS and AVHHR NOAA).

3. Results and Discussion

Field researches have been carried out by author since 2014 in the Belgorod region, analysis of statistical data gathered from Rossstat and statistical reports on the environment [1, 11, 19] allowed author to identify units with different trends of agricultural lands dynamics in Belgorod region and to show them on the map presented on the figure 1.

![Figure 1. Changes of areas under crop in the steppe districts of the Belgorod region from 2014 to 2020.](source: Google Earth)

Since 2014 increasing of areas under crop has been occurring within the boundaries of Belgorodskiy and Krasnoyarskiy districts only (the growth has reached 4%). The largest agricultural enterprises ("Farm named after Gorin", "Belgrankorm", etc.) are located here. They produce 70% of agricultural products of the region [19]. The leader on grain production is "Yasnozorenskoye" (the yield reaches 84 centners per hectare). These two districts also take the first place on vegetable production (almost 70% is produced by "Agro-Belogorye", "Novosadovoye", etc.). Activity of these enterprises is a good example of import substitution. In fact, active mining (development of peat, clay, sand, iron ore, and bauxite fields) and construction materials industry are carried out close to the agricultural lands. Agricultural and mining activities reduce biodiversity (loss...
of species obtain 7 per km$^2$ in Belgorodskiy districts), destruct landcover, contaminate all components of the landscapes [3].

3.1. Agricultural lands dynamics and environmental features
Decreasing of arable lands is observed in the majority parts of the steppe zone of the Belgorod region. At the same time, the area of abandoned agricultural lands rose to about 1% in the seven-year period (2014-2020). These results are striking. Changes of agricultural lands size in the steppe districts of the Belgorod region were not significant in this period. Nevertheless, the region was able to provide the country's domestic food market.

Land cover productivity rose on 50% (from 2014 to 2020) not only on abandoned agricultural lands, but also on croplands areas converted to forest. According to a current research, on abandoned agricultural lands values of NDVI rose by 17% during 2014-2020. Values of NDVI provide an evidence base for sustainable management of arable land; fertilizers can be applied not on the whole area, but only on places with low productivity. On abandoned agricultural lands values of BCP are higher (an increase reached 6% from 2014 to 2020), than on areas under crop (up to 2% during the same period). However, it should be noted, that from 2014 to 2020 growth of values of BCP was accompanied by humidity decreasing [15]. Since 2014, along the rivers where abandoned agricultural lands are located, reforestation have been occurring. Pastures are replaced by field-protective and anti-erosion forest belts [5, 11]. Analysis of satellite and statistical data has shown, that the rates of reforestation are developing rapidly in Shebekinsky and Krasnogvardeyskiy districts, while in Veydelevskiy district the rates are the lowest due to on-going negative natural processes action, such as extensive erosion.

In spite of negative trends in cropland areas dynamics, crop yield is rising in the majority of the steppe districts (figure 2).

![Figure 2](image_url)

**Figure 2.** Dynamics of cropland areas and changes of crop yield in the steppe districts of the Belgorod region from 2014 to 2020.

This fact can be explained by applying of sustainable land management practices on agricultural lands. On the southeastern part of Belgorod region productivity of arable lands are higher than in
western districts due to these practices, regular use of fertilizers, and on-going agrochemical monitoring.

It is important to note, that even sustainable agriculture is subject to destructive natural processes as shown on figure 3.

![Figure 3](image.png)

**Figure 3.** Negative natural processes restricting agricultural development in the steppe districts of the Belgorod region from 2014 to 2020.

According to statistic data and satellite images, erosion and gullies are accelerating rapidly from north to south and from west to east (the leaders are Belgorodskiy, Alekseevskiy, and Valuyskiy districts). Karst is widespread in Rakityanskiy, Prokhorovskiy, and Krasnoyaruzhskiy districts. Erosion and gullies distribution is strongly associated with the intensification of man-induced activities, such as agriculture and mining [3]. Increasing of areas under crop is observed only in Belgorodskiy and Krasnoyaruzhskiy districts. However, this growth is nonessential: areas under crop in these 2 regions expanded on 3.5 thousand hectares, while the areas under crop in all 11 steppe districts decreased on 18.6 thousand hectares during 2014-2020.

### 3.2. The main factors leading to agricultural lands dynamics

Analysis of statistical data [1, 11, 13, 19] allowed author to set correlation links between changes of areas under crop and the main environmental, social and economic factors, determining agricultural development in the steppe districts of the Belgorod region from 2014 to 2020 (figure 4, figure 5).
Figure 4. Relations between changes of areas under crop and changes of rural population in the steppe districts of the Belgorod region from 2014 to 2020.

Figure 5. Relations between changes of areas under crop and changes of values of bioclimatic potential (BCP) in the steppe districts of the Belgorod region from 2014 to 2020.
Data on figure 4 and figure 5 indicate that the one powerful factor of abandoned croplands appearance is decline of rural population. As rural population is declining, areas under crop are decreasing ($r = 0.70$). As expected, this tendency corresponds to areas under mining (especially in Shebekenskiy, Gubkinskiy, and Yakovlevskiy districts). A large number of profitable agricultural enterprises (-30% since 2014) and values of subsidies on agricultural development (-17% since 2014) are decreasing in the majority steppe districts that led to decreasing of areas under crop [19]. As values of BCP are rising, areas under crop are not increasing ($r = -0.31$). In the districts where BCP values are rising, land cover productivity is rising too ($r = 0.30$). Only in the Belgorodskiy and Krasnoyarskiy districts as rural population is rising areas under crop are increasing ($r = 0.65$), however crop yield is not stable. Number of profitable agricultural enterprises grew by 20% during 2014-2019 [11].

3.3. Sustainable agricultural land management: practices and technologies

The most of the districts of the steppe zone in the Belgorod region have high values of bioclimatic and agroecological potential. The sustainable agricultural land management practices applying for a long time allowed to increase the thickness of humus horizons, to reduce crop loss, and to make agricultural complex more efficient. A detailed analyses of satellite images has shown that quality of soil on areas of sustainable agricultural management is higher than on areas where such practices are not used. In many agrarian-oriented districts of the Belgorod region, a landscape-adaptive system of agriculture and biological agriculture is used that allows maintaining soil fertility, increasing area of perennial grasses, introducing sideral crops, and reducing the negative impact of the climatic and natural factors [13]. Also, farming management in the Belgorod region is based on precision agriculture, satellite farming or site-specific crop management. Such management includes observing, measuring and responding to inter and intra-field variability in crops. The precision agriculture allows to increase production efficiency, to improve product quality and to reduce cost of production. The sustainable land management practices allow to produce more crops on the arable lands that have been using for a long time. It should be emphasized that districts with high values of agroecological potential are often placed near to industrial lands [3]. In such areas land cover transformation and landscape contamination are broadly occurred [15]. Minimization of these harmful impacts could be achieved by regular environmental monitoring and land remediation that maintain agricultural land in productive condition. It is necessary to analyze the relations between various factors (environmental and man-made) affecting crop yields. This analysis will be done in the forthcoming works.

4. Conclusion

Dynamics of agricultural lands in the steppe zone of the Belgorod region during the period of sanctions are strongly depends on environmental, social, and economic factors, as well as, on applying of agricultural land management practices. Basing on conducted research author comes to some conclusions: (1) In spite of rising values of bioclimatic potential in the steppe zone of the region, areas under crop are not extending. For seven-years period 2014-2020 area under crop even decreased by 15.115 thousand hectares. In turn, crop yield grew in the majority steppe districts. This fact can be explained by applying of the adaptive landscape farming systems and precision agriculture management (satellite farming or site-specific crop management) on arable lands that allows to achieve sustainable agricultural production. (2) The leading natural factors limiting of agricultural lands extension and limiting of abandoned agricultural lands involvement in agricultural use are following: erosion, karst, suffusion, and deflation. The main role among the social factors is given to declining rural population. The major economic factor is a lack of investments in the agricultural sector, in contrast to financial support of mining industry. Conducted research is relevant to all steppe regions facing to tasks of strengthening the regional food security.

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