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ENVIRONMENTAL  
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## Aspects of the Use of Soil and Land Resources of the Nizhny Novgorod Region in Crop Production in the 19th and 21st Centuries

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**Abstract**—This article considers the aspects of agriculture of the Nizhegorodskaya gubernia in the 19th and 21st centuries. It utilizes information contained in historical materials from the reports of the Nizhny Novgorod expedition under the leadership of V.V. Dokuchaev, as well as data on areas of cultivated crops in 2006. In the 19th century, the types of cultivated crops, the planted area, and the proportion of fertilized arable land largely depended on the composition of the soil cover and meteorological conditions, as well as on the harvest of the previous years. In the 21st century, there were no notable influence of differences in natural conditions, the share of fertilized arable land in different parts of the region was practically the same, and it did not depend on the composition of the soil cover.

*Keywords:* land use, soil quality, historical sources, geoinformation systems

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### INTRODUCTION

The territory of Russia is characterized by a variety of natural (soil–climatic) conditions that determine the soil-forming processes, the properties and fertility of soils, and their resistance to various types of degradation, as well as the potential for effective use of soil cover in solving regional agricultural problems.

In the modern world, the independence of any country is primarily determined by its food security. Therefore, the efficient use of production resources, especially land resources, is an important factor in the policy of the state.

According to experts from the Food and Agriculture Organization of the United Nations, the overall indicator of national food security is the production of grain per capita. The rate of self-sufficiency is determined by a grain yield of 500 kg. In countries with a developed grain economy, this ratio comes to 900–1000 kg. In Russia, it was more than 825 kg in 2016. In Nizhny Novgorod region, this indicator in good harvest years only reaches 450 kg and in lean years does not exceed 250–300 kg. In Russia, 2016 was a fertile year: the harvested grain yield became the largest in the recent history of the country. Against this background, in the Nizhny Novgorod region, the production of grain fell by 2% and the potato yield was 7 less than that of the previous year by 7.1% [1].

The most important factor in the effective functioning and development of regional agricultural systems is the natural agropotential of the territory (a combination of natural conditions and resources directly affecting agricultural production), which has a significant impact on both the territorial organization of agriculture as a whole and its individual components. The effectiveness of the natural agropotential can be achieved only by determining the best options for locating selected sectors of agriculture and the rational use of the available material, technical, and labor resources of agricultural production. This requires the development of geographically differentiated programs for the integrated development of rural areas in the territory of Russia as a whole and in its separate regions [5].

The basis for ensuring national food security should be efficient use of the country's land resources, which is possible only with a knowledge of the properties of the soils and the state of the soil cover.

### MATERIALS AND METHODS

Nizhegorodskaya gubernia (governorate) was chosen as the target for the study of the soil and land resources in the 19th and 21st centuries. This is because it was the first one that was studied by an expedition led by V.V. Dokuchaev for the purpose of



Fig. 1. Administrative division of Nizhegorodskaya gubernia.

an accurate assessment of land for territorial taxation, which marked the beginning of the creation of its soil map.

The materials for the evaluation of the gubernia were 14 issues of natural-historical part published in St. Petersburg in 1884–1886 and covering all 11 of its uezds. Each issue had three separate parts concerning 1) the orography and hydrography of the terrain, 2) the geology with a brief outline of minerals, and 3) the soils with a brief overview of the wild vegetation. The editions are accompanied by soil maps of the uezds, based on which, at the end of the expedition, the final map of the gubernia was compiled. The economic volumes provide general data regarding the situation of peasant economy, where information was collected about the areas of arable land, including fertilizer, hayfields, forests, manure stocks, livestock numbers, crop yields, and *proportions of cultivated crops* [3, 4].

The extracted data was processed and analyzed with MapInfo Professional ver. 10.5–12.5.

Nizhegorodskaya gubernia (governorate) at the turn of the 18th century contained 11 uezds (Fig. 1). The study used their boundaries from the Soil Map of European Russia in 1900. Data collected from the Materials for the assessment of land for 8 of the 11 uezds of the gubernia (governorate) (there are no data on the share of fertilized arable land for Makarev, Nizhny Novgorod, and Knyaginina uezds), and the information was visualized using GIS and analyzed.

Up-to-date information was obtained regarding the territorial bodies of the Federal State Statistics Service for Nizhny Novgorod region and the adjacent regions of the Russian Federation (the borders of the present-day Nizhny Novgorod region do not coincide with the borders of the Nizhegorodskaya gubernia (governorate) of the late 19th century; areas of Ryazan oblast, and also of Mordovia, Chuvashia, and Mari El, fall within the latter). The area of cultivated crops in 2006, the number of livestock, and the amount of fertilized arable land were recalculated within the boundaries of the districts of the Soil Map of European Russia. Data on the structure of land in the 21st century was taken from the All-Russian Agricultural Census of 2006 and also recalculated.

The “Agroclimatic areas with the list of general cultured” map was used for the assessment of the effectiveness of land use in the 19th and 21st centuries [2]. In this zoning, each area differs from the others (located in the same large agrogeographic region—Western, Zavolzhsko-Predural, West Siberian, East Siberian, Far Eastern) in at least one of its main agricultural crops or, failing that, in the type of spring wheat (hard and soft), its quality, or the earliness of ripening of the main or less common culture. Nonagricultural areas are mainly divided into areas by natural zones and large geographical areas.

According to this map, the territory of Nizhegorodskaya gubernia (governorate) is located in three agroclimatic areas<sup>1</sup>: Southern taiga (southern); soddy-podzolic with gray forest soils in opolie regions; rye–barley–oats–potatoes and fodder crops (with corn for silage) (no. 9), Northern forest-steppe (European territory of Russia); gray forest soils with inclusions of chernozems; winter wheat–rye–barley–oats–potatoes with corn for silage (no. 11), Forest-steppe (European territory of Russia); leached and podzolized chernozems and gray forest soils; winter wheat–rye–barley–oats–potatoes with sugar beets and corn for silage (no. 12) (Fig. 2).

## RESULTS AND DISCUSSION

In the 19th century, the amount of arable land naturally increased from the northwest to the southeast. Its smallest area was detected in Balakhna uezds (787.6 km<sup>2</sup>) and the largest in Lukoyanov uezds (3295.9 km<sup>2</sup>). Manure was the main fertilizer used. The amount introduced was increased from south to north, reaching a maximum in Balakhna uezds. At the same time, the largest livestock, and therefore manure stocks, was characteristic for mostly southern uezds, such as Lukoyanov, Sergach, Arzamas, and Gorbatov, which bordered on Balakhna uezds.

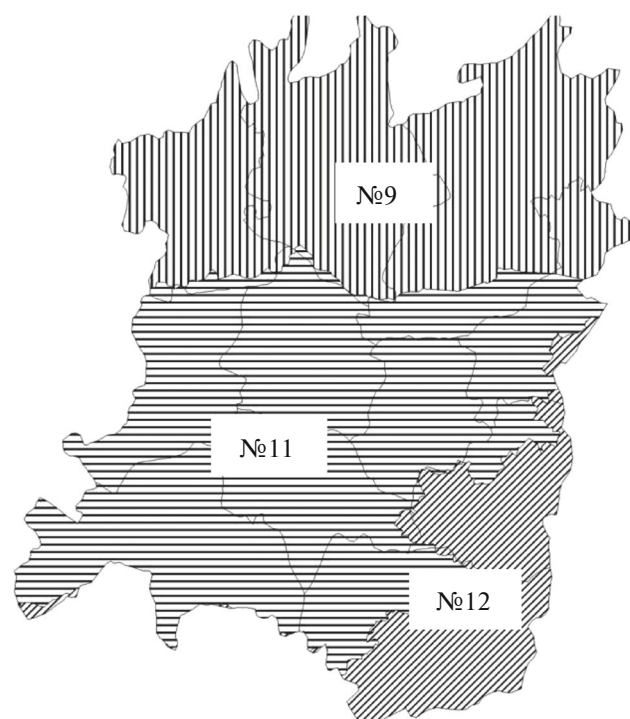
<sup>1</sup> In the description of agroclimatic areas, the orthography of the original is preserved.

In the 21st century, practically throughout the territory of the former uyezds, a significant reduction in arable land was detected, except for Nizhegorodskii and Makarev county, where it slightly increased. To the greatest extent (600–800 km<sup>2</sup>), the arable land area was reduced in the uyezds of Lukoyanov, Arzamas, Ardatov, and Semenov. The areas of haymaking have decreased everywhere, especially in the uyezds of Lukoyanov, Semenov, and Vasilsursky by more than 300–440 km<sup>2</sup> in each county. As in the 19th century, Lukoyanov uyezds remained the leader in livestock, even in this uyezds it was reduced by almost a third. The share of fertilized arable land in all uyezds was practically the same (from 10 to 30%) and did not depend on the composition of the soil cover. Preference was given to mineral fertilizers.

The soil maps of the uyezds contained the boundaries of the arable lands, which were described in detail in the reports, and areas covered by the forest were also marked. Based on the study of the confinement of arable land to certain types of soils and afforestation of the territory, the composition of the arable area for Lukoyanov and Balakhna uyezds was calculated, which significantly differ both in the composition of the soil cover and in the area of arable land, and, consequently, by the means of farming. Thus, in Lukoyanov uyezds, more than half of the arable area consisted of gray forest loams and chernozems. According to the results of the agroecological assessment, these fertile soils were not the most favorable from the point of view of processing, but a large livestock allowed the successful cultivation of these soils. Only 10.3% of arable land was fertilized. In Balakhna uyezds, soils of light granulometric composition not characterized by high fertility were widely distributed. When choosing arable land, preference was given to sod podzolic sandy loam, clay sands, and sandy soils. The livestock here was lower, but enough for cultivation of the land. At the same time, almost all the arable land in the uyezds was fertilized –91.5%.

According to reports [3, 4], in the 19th century, many factors were taken into account when choosing crops: their relation to fertilizers, soil-topographical conditions. For example, lentils belonged to so-called “unfettered crops,” whereas exceptionally fertilized or new land was required for millet and hemp. Oats could be cultivated under any conditions. Flax was planted in the lowlands, potatoes on “soft land,” peas on clay, and wheat on loams [6].

In area 9 with sum of temperatures >10°C equal to 1900–2200°C and with sufficient water supply, late-ripening strains of winter rye can be grown in addition to barley, oats, and potatoes. The climatic conditions are also suitable for growing some legumes (peas, in particular). The growing of wheat is also possible however, the grain quality is low, so that wheat is not included in the list of major crops in these areas.



**Fig. 2.** Agroclimatic areas with a set of leading crops: no. 9, rye–barley–oats–potato and fodder with corn for silage; no. 11, winter wheat–rye–barley–oats–potato with corn for silage; and no. 12, winter wheat–rye–barley–oats–potato with sugar beet and corn for silage

According to studies [3, 4], half of the arable land was allocated for rye in the northern uyezds of the gubernia in the 19th century. Barley should be in second place, but it was absent. Oats, which according to the zoning map, belonged to the leading agricultural crops of this area, occupied more than a quarter of the arable land in all northern uyezds. Potatoes were practically not cultivated. In the 21st century, the share of rye was no more than 4% and of barley up to 10% of arable land. potatoes and oats were cultivated in almost equal proportions and constituted 10–15% of crops, and winter wheat occupied not more than 10%. The area occupied by pea crops in this area in the 21st century doubled, forage crops occupied half of all the acreage, and the share of corn in them was insignificant.

Area 11 is found in the northern part of the forest-steppe zone with a predominance of gray forest soils; chernozems also occur in this area. The sum of active daily temperatures is 2000–2300°C, and the humidity factor somewhat exceeds 1.0. This territory is suitable for many crops grown in northern areas, as well as for various strains of winter wheat. Buckwheat is one of the most economically efficient crops. The conditions are unfavorable for flax growing; its cultivation is unfeasible.

In the 19th century, oats, buckwheat, lentils, barley, flax, peas, millet, potatoes, spring wheat, spelt, and rye were cultivated in this area. In the 21st century, millet, lentils, and spelt already were no longer cultivated, but such crops as winter wheat, sugar beet, rapeseed, sunflower, and other forage crops appeared. Winter wheat composed up to 20%. Buckwheat, which was cultivated in large volumes in the 19th century, in the 21st has an area of <1 km<sup>2</sup>. In the 19th century, the area of flax was noticeably smaller than in area no. 9, but it did not disappear completely, and in the 21st century the flax area in this area was <10 km<sup>2</sup>, while in other areas it was absent.

Area 12 is found in the forest-steppe zone with a predominance of leached and podzolized chernozems; sum of temperatures >10° 2150–2350°C, and the humidity factor is 0.8–1.1. Soil-climatic conditions are suitable for growing various crops, including early-season sugar beets. Mid-season sugar beets can be grown on warm sites. Corn reaches the stage of milky-wax ripeness. In the 21st century, the diversity of cultivated crops in this area was higher than in the 19th–13 versus 11 types. The majority of crops were forage crops, with a significant proportion of winter and spring wheat (more than 25%).

For investigation of the dynamics and composition of crop areas, the materials of the agricultural survey of the Nizhny Novgorod gubernia local council for 1893 [6] were used. The documents contain data on the change in the planted area for a 5-year period, from 1887 to 1892. They are certificates of correspondents about the reduction or expansion of the area of particular crops. For investigation of the dynamics of crops in the 21st century data for 2012–2015 were obtained. The diagrams plotted according to these data show the change in crop areas in square kilometers (km<sup>2</sup>).

According to the collected data, a reduction in buckwheat crops was observed for the gubernia. Correspondents point to the crop failures of recent years as the main reason for this. As the result of crop failure stock of seeds of farmers finished, and the market price was too high. The second place for crop reduction was occupied by barley, which was also associated with crop failures in recent years. The expansion of lentil crops was explained by the need to replace the harvestless crops of the past. Data on lentils demonstrated that this culture tolerates droughts and has lower demands on soils than do other cultures. In addition, straw from lentils was used for feeding cattle. In seven uyezds, an expansion of potato crops was noted. There is evidence that this culture has become more popular among farmers, sometimes displacing oat and flax crops. The millet, which is an agricultural crop with stable yields was widely distributed. In general, the expansion of millet was due to a reduction in buckwheat and oats. In the gubernia, 89 certificates demonstrating the reduction of planted area were collected and 87 showed the increase of planted area.

The general trend for the whole territory is currently toward a reduction of planted area. For example, in 2012, the total planted area of studied crops was >8200 km<sup>2</sup>, while in 2015 it decreased to 7620 km<sup>2</sup>. The largest reduction was detected for rape, fodder crops, potatoes, and barley. The increase in the area of winter wheat occurred almost in all uyezds, and in some of them the area of peas also increased.

## CONCLUSIONS

As a result of a comparison of the state and peculiarities of the use of soil and land resources of Nizhegorodskaya gubernia, it was established that, in the 19th century, the set of cultivated crops, the planted area, and the proportion of fertilized arable land largely depended on both the composition of the soil cover and the meteorological conditions. In the 21st century, no influence of a difference in natural conditions on the characteristics of agriculture was not observed. In some regions of the studied territory, the share of fertilized arable land in different parts of the region was practically the same and did not depend on the composition of the soil cover.

In the 19th century in Nizhegorodskaya gubernia, the list of cultivated crops as a whole corresponded to the list which modern specialists consider optimal. Exceptions were the sugar beet and corn, which at that time were not common. In the 21st century, the cultivated crops set had a poor correlation with the leading agricultural crops set of agroclimatic zoning. In addition, in the 19th century, the ratio of crops strongly depended on the yield of previous years, and although the planted area was not constant, in general, they remained practically unchanged during the studied 5-year period. There was a decreasing area of some cultivated crops, while farmers expanded the area of other crops. At the same time, the data for 2012 and 2015 indicate a decrease in crop acreage during this period by more than 600 km<sup>2</sup>.

## REFERENCES

1. Vidonova, I.V., In a year of plenty Nizhny Novgorod region not get the full amount of crop, *Novosti Nizhnego Novgoroda*. [http://www.nn.ru/news/more/v\\_urozhaynyy\\_god\\_nizhegorodskaya\\_oblast\\_nedobrala\\_zerna\\_/50294871/](http://www.nn.ru/news/more/v_urozhaynyy_god_nizhegorodskaya_oblast_nedobrala_zerna_/50294871/).
2. Karmanov, I.I., Bulgakov, D.S., Rukhovich, D.I., and Vil'chevskaya, E.V., Agroclimatic areas with the list of general cultured: a map, scale 1:30000000, in *Natsional'nyi atlas pochv Rossiiskoi Federatsii* (Soils of Russian Federation: National Atlas), Shoba, S.A., Ed., Moscow, 2011.
3. *Materialy k otsenke zemel' Nizhegorodskoi gubernii. Estestvenno-istoricheskaya chast'. Vyp. 2. Lukoyanovskii uezd* (Materials for Assessment of Lands in Nizhny Novgorod Gubernia. Natural-Historical Part, No. 2: Lukoyanov Uezd), St. Petersburg, 1884; *Materialy k otsenke zemel' Nizhegorodskoi gubernii. Estestvenno-*

- istoricheskaya chast'*. Vyp. 10. *Balakhninskii uezd* (Materials for Assessment of Lands in Nizhny Novgorod Gubernia Natural-Historical Part, No. 10: Balakhna Uezd), St. Petersburg, 1886.
4. *Materialy k otsenke zemel'; Nizhegorodskoi gubernii. Ekonomicheskaya chast'*. Vyp. 2. *Lukoyanovskii uezd* (Materials for Assessment of Lands in Nizhny Novgorod Gubernia. Economical Part, No. 2: Lukoyanov Uezd), 1897; *Materialy k otsenke zemel'; Nizhegorodskoi gubernii. Ekonomicheskaya chast'*. Vyp. 3. *Sergachskii uezd* (Materials for Assessment of Lands in Nizhny Novgorod Gubernia. Economical Part, No. 3: Sergach Uezd), St. Petersburg, 1898; *Materialy k otsenke zemel'; Nizhegorodskoi gubernii. Ekonomicheskaya chast'*. Vyp. 4. *Knyagininskii uezd* (Materials for Assessment of Lands in Nizhny Novgorod Gubernia. Economical Part, No. 4: Knyagin Uezd), St. Petersburg, 1888; *Materialy k otsenke zemel'; Nizhegorodskoi gubernii. Ekonomicheskaya chast'*. Vyp. 5. *Arzamasskii uezd* (Materials for Assessment of Lands in Nizhny Novgorod Gubernia. Economical Part, No. 5: Arzamas Uezd), St. Petersburg, 1900; *Materialy k otsenke zemel' Nizhegorodskoi gubernii. Ekonomicheskaya chast'*. Vyp. 6. *Ardatovskii uezd* (Materials for Assessment of Lands in Nizhny Novgorod Gubernia. Economical Part, No. 6: Ardatov Uezd), St. Petersburg, 1899; *Materialy k otsenke zemel' Nizhegorodskoi gubernii. Ekonomicheskaya chast'*. Vyp. 7. *Gorbatovskii uezd* (Materials for Assessment of Lands in Nizhny Novgorod Gubernia. Economical Part, No. 7: Gorbatov Uezd), St. Petersburg, 1892; *Materialy k otsenke zemel' Nizhegorodskoi gubernii. Ekonomicheskaya chast'*. Vyp. 8. *Nizhegorodskii uezd* (Materials for Assessment of Lands in Nizhny Novgorod Gubernia. Economical Part, No. 8: Nizhny Novgorod Uezd), St. Petersburg, 1895; *Materialy k otsenke zemel' Nizhegorodskoi gubernii. Ekonomicheskaya chast'*. Vyp. 9. *Vasil'evskii uezd* (Materials for Assessment of Lands in Nizhny Novgorod Gubernia. Economical Part, No. 9: Vasil Uezd), St. Petersburg, 1890; *Materialy k otsenke zemel' Nizhegorodskoi gubernii. Ekonomicheskaya chast'*. Vyp. 10. *Balakhninski uezd* (Materials for Assessment of Lands in Nizhny Novgorod Gubernia. Economical Part, No. 10: Balakhna Uezd), St. Petersburg, 1896; *Materialy k otsenke zemel' Nizhegorodskoi gubernii. Ekonomicheskaya chast'*. Vyp. 11. *Semenovskii uezd* (Materials for Assessment of Lands in Nizhny Novgorod Gubernia. Economical Part, No. 11: Semenov Uezd), St. Petersburg, 1893; *Materialy k otsenke zemel' Nizhegorodskoi gubernii. Ekonomicheskaya chast'*. Vyp. 12. *Makar'evskii uezd* (Materials for Assessment of Lands in Nizhny Novgorod Gubernia. Economical Part, No. 12: Makarev Uezd), St. Petersburg, 1889.
  5. Nosonov, A.M., Natural agriculture potential as a base of Russian food safety, *Nats. Interesy: Prioritety Bezop.*, 2012, no. 38.
  6. *Peremeny v zemledel'cheskoi tekhnike krest'yan Nizhegorodskoi gubernii, otmechennye korrespondentami Gubernskoi Zemskoi upravyy* (Changes in Peasants Farming Technique in Nizhegorodskaya Guberniya Mentioned by Gubernskaya Zemskaya Uprava Reporters), Shmidt, O.E., Ed., Nizhny Novgorod, 1893.

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