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# SOIL FERTILITY ASSESSMENT OF AGRICULTURAL LAND IN THE ALMATY REGION USING GIS TECHNOLOGIES

Being a strategically important and irreplaceable economic resource, today, agricultural land is the main source of raw materials for the agro-industrial complex. These features impose certain obligations on the state and land users to preserve the basic value of this category of land – its fertility. Taking into account the fact that Almaty region occupies an important place in the agricultural sector of the country, the effective use of agricultural land in providing food to the population of the territory remains an urgent problem.

Reducing the utilization of agricultural land may lead to the creation of negative processes and will contribute to the decrease of fertility in the future, excluding farmland from intensive farm turnover. In the article, there are assessed the state of soils of agricultural land in the Almaty region based on the global system of digital mapping of soils using GIS technology, and the issues of improving the rational use of agricultural land in the region are considered. Specifically, maps of the degree of soil density, the content of organic carbon in the soil, the acidity, and characteristics of the distribution of chernozem in this area were developed using GIS technologies and based on data from a digital relief model, as a result of which the lands of the district of the region are classified into three groups and the dynamics of the specific gravity of the lands are presented.

**Key words: s**oil fertility, GIS, Almaty region, agricultural land, soil assessment.

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## ГАЖ технологияларын пайдалана отырып, Алматы облысындағы ауыл шаруашылығы алқаптарының топырақ құнарлылығын бағалау

Стратегиялық маңызды және таптырмас экономикалық ресурс бола отырып, бүгінде ауыл шаруашылығы алқаптары агроөнеркәсіптік кешен үшін шикізаттың негізгі көзі болып табылады. Бұл ерекшеліктер мемлекет пен жер пайдаланушыларға жердің осы санатының негізгі құндылығы – оның құнарлылығын сақтау бойынша белгілі бір міндеттемелер жүктейді. Алматы облысының еліміздің ауыл шаруашылығы саласындағы маңызды орын алатынын ескерсек, аумақтағы халықты азық-түлікпен қамтамасыз етуде ауыл шаруашылығы мақсатындағы жерлерінің құнарлығын сақтап тиімді пайдалану әрқашанда өзекті мәселе болып қала бермек.

Ауылшаруашылық жерлерін пайдалануды азайту теріс процестерге әкелуі мүмкін және болашақта құнарлылықтың төмендеуіне, ауылшаруашылық жерлерін қарқынды ауылшаруашылық айналымынан шығаруға ықпал етеді. Мақалада ГАЖ технологиясын пайдалана отырып, топырақты цифрлық картаға түсірудің жаһандық жүйесі негізінде Алматы облысының ауыл шаруашылығы алқаптары топырағының жай-күйіне баға берілді, сондай-ақ өңірдегі ауыл шаруашылығы алқаптарын ұтымды пайдалануды жақсарту мәселелері қаралды. Атап айтқанда, топырақ тығыздығының дәрежесі, топырақтағы органикалық көміртектің мөлшері, қышқылдығы және осы аумақтағы қара топырақтың таралу сипаттамалары карталары ГАЖ технологияларын қолдана отырып және цифрлық рельеф моделінің деректері негізінде әзірленді, нәтижесінде облыс ауданының жерлері үш топқа жіктеліп, жердің үлес салмағының динамикасы ұсынылды.

**Түйін сөздер:** топырақ құнарлығы, ГАЖ, Алматы облысы, ауылшаруашылық алқаптары, топырақты бағалау.

 

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## Оценка плодородия почв сельскохозяйственных угодий в Алматинской области с использованием ГИС технологий

Являясь стратегически важным и незаменимым экономическим ресурсом, сегодня сельскохозяйственные угодья являются основным источником сырья для агропромышленного комплекса. Эти особенности налагают определенные обязательства на государство и землепользователей по сохранению основной ценности этой категории земель – ее плодородия. Учитывая, что Алматинская область занимает важное место в сфере сельского хозяйства страны, сохранение и эффективное использование плодородия земель сельскохозяйственного назначения в обеспечении продовольствием населения на территории всегда остается актуальным вопросом.

Сокращение использования сельскохозяйственных угодий может привести к возникновению негативных процессов и будет способствовать снижению плодородия в будущем, исключению сельхозугодий из интенсивного сельскохозяйственного оборота. В статье дана оценка состояния почв сельскохозяйственных угодий Алматинской области на основе глобальной системы цифрового картографирования почв с использованием ГИС технологии, а также рассмотрены вопросы улучшения рационального использования сельскохозяйственных угодий в регионе. В частности, карты степени плотности почвы, содержания органического углерода в почве, кислотности и характеристик распределения чернозема на данной территории были разработаны с использованием ГИС технологий и на основе данных цифровой модели рельефа, в результате, которого земли района области классифицированы на три группы и представлена динамика удельного веса земель.

**Ключевые слова:** плодородие почвы, ГИС, Алматинская область, сельскохозяйственные угодья, оценка почвы.

## Introduction

Agriculture is one of the main sectors of the economy of Kazakhstan, providing food and economic security as well as the labor potential of the country, particularly in rural areas and has historically been the backbone of Kazakhstan's economy (Tokbergenova, Kiyassova, and Kairova 2018). According to official data from the National Bank of the Republic of Kazakhstan, in January 2019, the gross output of agricultural products increased by 3.5% and amounted to 3.6 trillion tenge, of which the production of livestock products increased by 2.8% (National Bank of the Republic of Kazakhstan 2019).

During the period of agricultural enterprise reform from 1991 to 2005, the area of agricultural land in the country decreased by 136.2 million hectares. However, from 2005 to 2015, the area of agricultural land increased annually by 18.6 million hectares. The most valuable land for agricultural purposes (97.4% of arable land) is agricultural land, which includes 91.1% of irrigated land, 56.2% of perennials, 51.7% of fallow land, and 42.4% of hayfields, of which 33.6% is land that has been improved and 52.0% estuary irrigation (Tokbergenova, Kiyassova, and Kairova 2018).

However, despite the positive dynamics of gross agricultural output, the volume of production, in general, lags behind the growth rate of consumption and income, maintaining labor productivity and product competitiveness at a low level does not allow for increased production, which leads to a high share of imports in domestic consumption. Moreover, with the accession of Kazakhstan to the World Trade Organisation, the conditions for rising competition in international markets have enhanced.

Digital innovations fundamentally shift this outdated sector, as seen by the observations of developing countries such as the USA, Canada and Australia. Diverse data sources, such as modern geoinformation systems and the Internet of Things, contribute to a high produce without soil degradation and with efficient use of resources. Today, industrial Internet elements allow farmers to create automated farms with remote control. While maintaining quality, a well-developed logistics system and e-Commerce will enable even small farms to reduce the cost of delivering agricultural products to the final consumer. This is an essential factor in preserving and expanding the production of environmentally friendly products, both from the perspective of safeguarding the nation's health and of realizing its export potential (The state program "Digital Kazakhstan").

Today, the share of agricultural producers of the Republic of Kazakhstan using digital technologies in agriculture is insignificant, which limits the reduction in productivity and costs. In addition, agricultural land is not used for its intended purpose or is used inefficiently, and this is hampered by the low density of a large territory, the population and the lack of the necessary infrastructure for monitoring the condition and use of land, analysis and forecasting in the short and long term. For this reason, the economic assessment of agricultural land is relevant. The use of modern information approaches in the land assessment will improve the quality of work and is a powerful tool for decision-making and management of government decisions. The results of the joint use of GIS technologies and economic assessment methods will help to obtain timely and accurate information about changes in agricultural production, and changes in the level of land fertility by type and degree of degradation.

Special mention should be made of the FAO framework guidelines on agricultural land use, agro-ecological zoning and land assessment, as well as the long-term work on the creation and development of an international database and GIS. In the context of the accelerated growth of informatization and globalization of agricultural production, the global trend towards increasing economic unification, technological unification and functional refinement of information and analytical support for agroecological assessment of lands at various territorial levels is reflected. Spatio-temporal change in land use and quality has contributed to the development of the concept of agroecological land assessment: its algorithms, regulatory framework and assessment technology are constantly being improved, as its tasks and capabilities are specified from the local to the regional, district and economic levels (Kiryushina V.I. and Ivanov A.L. 2005). Land assessment studies require a large amount of spatial data easily and efficiently processed by geographic information systems (GIS). Therefore, many researchers use GIS to assess land as a process that allows combining many attributes and different criteria involved in decision-making (Davidson, Theocharopoulos, and Bloksma 1994; Malczewski 2006). Land assessment can be considered as a multi-element decision analysis (MCDA) process (Joerin etc. 2001) which together with GIS can become a powerful approach to land assessment (Aldababseh, etc. 2018).

Local, regional, national, and worldwide uses of GIS technologies for agriculture have increased significantly during the past three decades. Typically, these applications entail the use of GIS in conjunction with partner technologies like as remote sensing, GPS, and data analytics to get an in-depth understanding of a certain farm or region and to provide intervention or corrective actions for crops and/or soils (Ghosh, Kumpatla 2022).

GIS methods play an indispensable role in spatial analysis, and multi-criteria decision analysis (MCDA) provides a rich set of tools for structuring decision-making problems as well as evaluating and prioritizing alternative solutions (Davidson, Theocharopoulos, and Bloksma 1994).

Over the past decade, the agrarian sector of the economy in the Almaty region has been reformed based on a developed legislative framework that encourages the growth of market relations by incorporating international experience. Consequently, a land market was established, crop production expanded, and the number of livestock in animal husbandry grew. The examination of the state of the agricultural industry revealed, however, that the extremely low level of introduction into production of modern technologies for processing agricultural products and scientifically proven agricultural technologies is the primary reason for this industry's low profitability. Obviously, this decreases the competitiveness of domestic products on domestic and international markets.

Against the backdrop of the region's major achievements, the problem of contradictions between the actual agricultural production sector and scientific research is currently manifesting itself. The yearly fluctuation of the agricultural products market and the increasing demands for its competitiveness necessitate the introduction of new research into the agricultural science of the region's agricultural production.

## Materials and methods

The work of prominent domestic such as Tazabekov T., Gnezdilov L., and Lyubchak M., and international researchers in the field of qualitative and economic evaluation of land serves as the conceptual and methodological foundation for this study. In the process of determining the level and trends of agricultural land use, improving and assessing their quality, the following methods were used: empirical methods (observation, comparison), as well as economic and statistical methods (statistical grouping, tabular and graphical methods) and cartographic methods using the ArcGIS PRO 2.4 software.

ArcGIS is a collection of software products used to develop a geographic information system. It is utilized for the creation, management, integration, analysis, visualization, and presentation of spatial data. ArcGIS software products enable the use of GIS in all areas where functionality and business logic are required, including desktop, server, client, web-based, and mobile applications.

When evaluating the agricultural lands of the Almaty region and mapping all the data about the region, it will be very beneficial to use the desktop GIS included in the ArcGIS PRO 2.4 software package. This is due to the fact that ArcGIS PRO is an application comprised of ArcView, ArcEditor, and ArcInfo that provides a group of programs with suitable functions, general operating principles, and a unified interface, as well as functions that allow to work several times faster and more efficiently than the ArcMap application.

The information basis of the study is reports and consolidated reports of the Ministry of Agriculture of the Republic of Kazakhstan, recommendations of research organizations, and statistics of the Department of Land Relations of the Almaty region.

Almaty region is in the southeast of the Republic of Kazakhstan. In the East, the region borders the People's Republic of China, and in the South with the Republic of Kyrgyzstan (Chui and Issyk-Kul regions). The region has a rather complex geographical characteristic and a very diverse terrain. According to official data from the Department of land relations, as of the first quarter of 2020, the region's land resources amounted to 22 million 357 thousand hectares, 8 million 632 thousand hectares of agricultural land, including arable land – 1 million 056 thousand hectares, irrigated arable land – 480 thousand hectares, perennial plantations – 29 thousand hectares, deposits – 120 thousand hectares, hayfields – 458 thousand hectares, pastures – 13 million 744 thousand hectares, gardens and homesteads – 5356 hectares (Website of Akimat of Almaty region n.d.).

## Results and Discussion

The qualitative state of soils in large areas in the Republic is complicated by the presence of signs that negatively affect their fertility. According to the Republic of Kazakhstan's 2020 annual consolidated analytical report on the state and use of lands, to take into account the quality of agricultural land, the following reclamation groups have been adopted, uniting soils with the general orientation and nature of reclamation measures:

I – uncomplicated by negative signs; II- highly rubbled; III– salted; IV – saline; V– washed away; VI – deflated; VII – subject to water and wind erosion together; VIII – waterlogged; IX – swampy; X – others (Bimendina G.A. et al. n.d.).

Agricultural lands of the Almaty region are classified in the second category according to the state of soil quality. The gravel group includes areas with weak soil, undeveloped, thickets of rocks, and others. The total area of the Republic is 43.1 million hectares or 20.0% of agricultural land, in the Almaty region – 2.7 million hectares.

Let's evaluate the current state of the soil in the Almaty region based on the database of soil networks obtained as a result of joint work of the Food and agriculture organization of the United Nations and the Kazakh Research Institute of soil science and Agrochemistry.

The Soil network (Soil Grids) is a global digital soil mapping system that uses modern machine learning methods to map the spatial distribution of soil properties across the globe. Soil grid forecasting models are constructed from the database of the world soil information service and several ecological covariates under the control of more than 230,000 soil profiles (Pikovskaya O. 2017).

*The level of soil density in the region.* The soil density is the most important characteristic that reflects the conditions under which plants grow and develop. All soil regimes depend on soil density: air exchange, water permeability, water capacity, heat capacity, microbiological, and redox processes. In addition, it affects the technological properties, and quality of soil treatment, which affects the volume and quality of products.

The main causes of soil compaction are:

- high degree of plowing;
- application of intensive tillage;
- failure to observe crop rotation during crop rotation;
- Insufficient amount of organic fertilizers applied to the soil (Pikovskaya O. 2017).

A map of the degree of soil compaction in the region is shown in Figure 1.

As can be seen from the map, even at depths of 2 m and 0.05 m, the soil density in the mountainous and foothill areas of the region is significantly lower than in the plains. The territories with the highest degree of soil compaction include the lands of the northern part of Raiymbek, Uyghur, Zhambyl, Sarkand, Koksu, and Karatal districts. The soil density of these territories is approximately 1.8 g / cm$^3$.

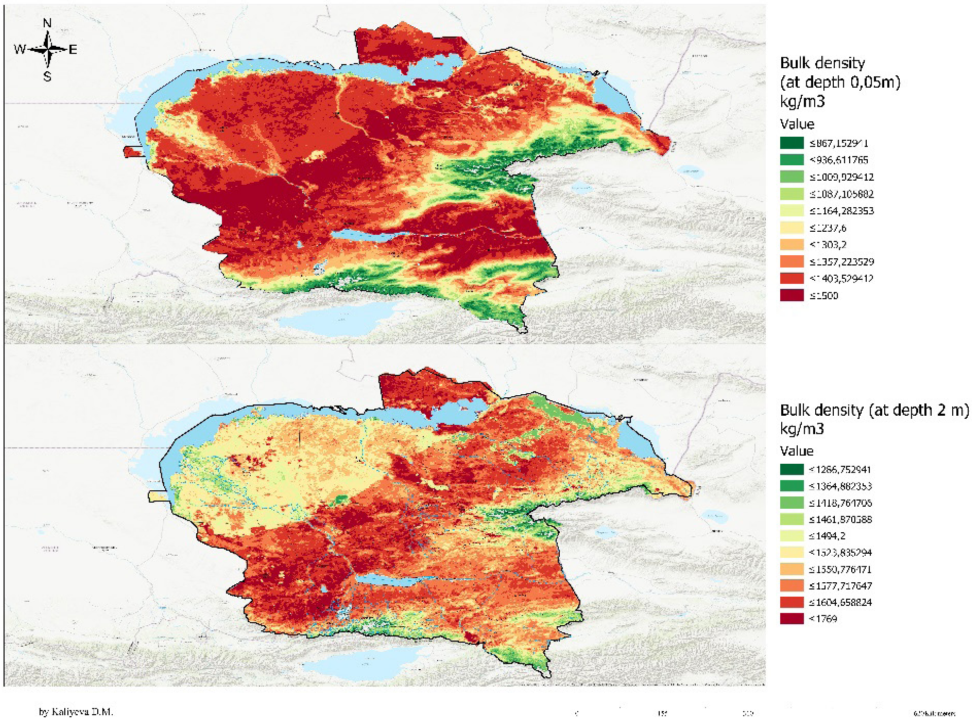


**Figure 1** – The density map of the soils of the Almaty region (at a depth of 0.05 m and 2 m)

During soil compaction, the following occurs:

- increasing the actual weight of the soil;
- reduction of General and especially non-capillary porosity;
- slows down the growth of the root system-reduces the total mass of roots and prevents root penetration into the soil and subsoil;
- reducing the supply of moisture to plants;
- deterioration of the physical properties of water: water capacity, level of irrigation water absorption, reduced water permeability;
- deterioration of aeration and biological processes;
- increase in surface flows and thin ground runoff;
- deterioration of soil nutrition;
- processes such as reduced productivity and quality of agricultural products (Pikovskaya, 2017). High-density soils include loamy, swampy soils. In addition, this type of soil is poorly permeable to water and does not form a well-developed capillary system, resulting in plant roots having difficulty obtaining the moisture necessary for their life. However, when collecting water, loamy soils do not direct it to the lower layers but accumulate in the breeding zone of plants, which leads to disruption and destruction of the root system. The weight of clay in the soil of the region (Fig. 2) is from 15 to 39% of the global soil network (Boekel 1963).

It is known that depending on the mechanical components of the soil are divided into clay, sand-clay and sand. The mass fraction of sand in the soil of the region ranges from 29 to 70 percent. In the above figure, clay soils are distributed mainly in the South-Western, Central and North-Western regions of the region, soils with a 50-70% share of sand are distributed on the lands of Balkhash, Zhambyl, Kerbulak, Enbekshikazakh, Rayimbek districts (Fig. 3).

Organic carbon in soil (carbon in soil organic matter) is critical for soil health, fertility, and ecosystem maintenance, including food production, which places great importance on its conservation and restoration for sustainable development.

High-carbon soils are highly productive and allow the filtering and purifying of water. Poor land-use results in increased soil density, as well as loss of organic matter in the soil/loss of carbon and greenhouse gas emissions (FAO 2020).

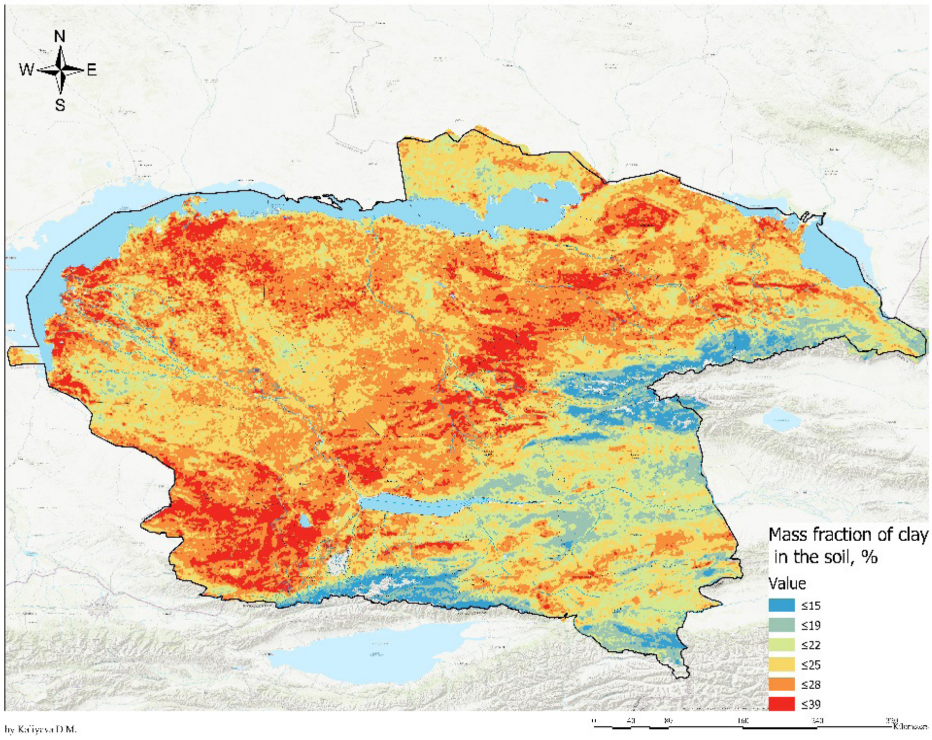


**Figure 2 –** Mass fraction of clay in the soil of the region, %

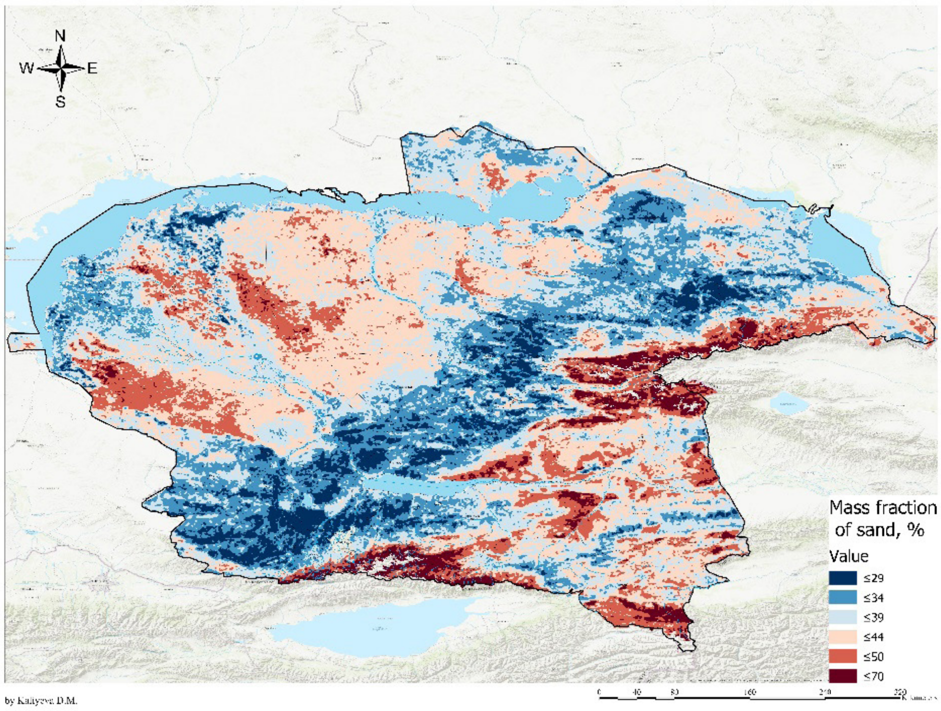


**Figure 3 –** Mass fraction of sand in the soil of the region, %

Below is a map of organic carbon in the region's soil (Fig. 4). As indicated above, the amount of compacted soil is small in mountainous and foothill areas, where, on the contrary, the organic carbon content is high in river and mountain soils.

Today, the main indicator of effective use of arable land is closely related to the annual yield of crops grown in the regions. Crops grown in the region are distributed unevenly, that is, not all 17 districts have the same types of crops, which, in turn, depends on the natural and climatic characteristics of the region, as well as on the physical and chemical properties of the soil. Among the chemical properties of the soil acidity plays a significant role. For example, let's talk about the features of sugar beet sowing.

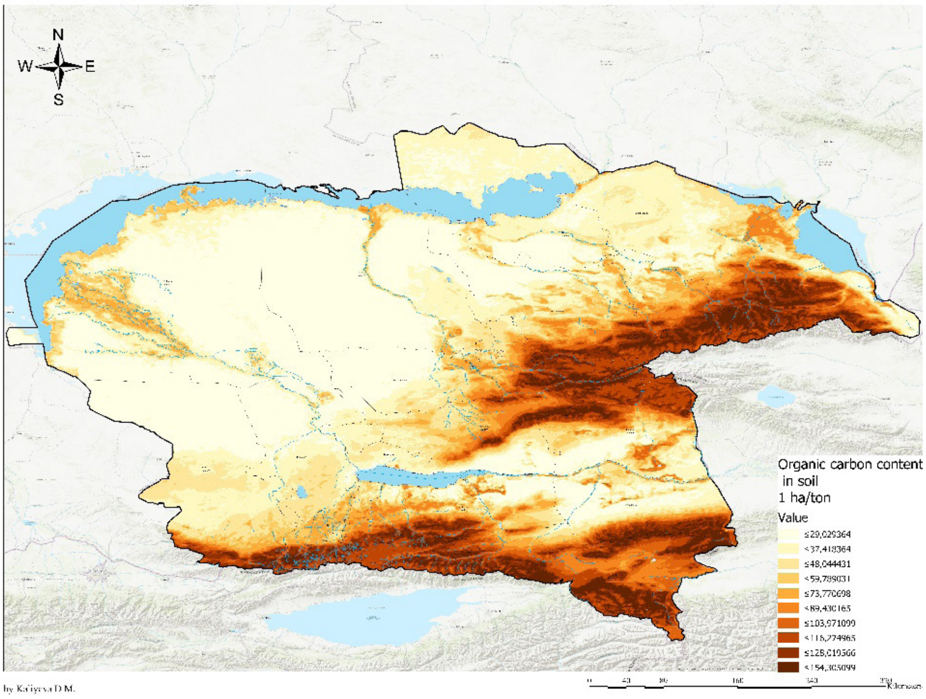


**Figure 4 –** Map of organic carbon content in the soil, ha/ton

Nowadays, more than 440 thousand tons of products are sold in the Almaty region alone. However, according to official data, currently, products collected from all over the country can not meet even half of the total demand. This factor forces buyers to buy raw materials from abroad, which puts us at the top of the world's list of major importers of sugar beet. The list of requirements for sugar beet indicates that the soil acidity should be 6-7 (Velyamov et al. 2020). In addition, even though the crop is resistant to salty soil, it grows well on weak, drainage, aerated ground soils with a large mass of nutrients, – representatives of Kazakhstan industrial chemistry and a company specializing in the sale of products for the agricultural sector note. Therefore, for the yield to be high, it is necessary to pay special attention to the acidity of the soil (Fig. 5).

If the pH value is less than 6, it will be acidic soil and in alkaline soils – the pH will be more than 7.0. As noted above, the most effective indicator for sugar beet is the middle of these two values. A significant deviation in both directions leads to a decrease in productivity, mainly to the death of plants. Acidic soil contributes to rotting and damage to the core and nutrition disorders. Alkaline soil disrupts the absorption of many minerals and reduces the formation of chlorophyll. Plants form weak roots, and leaves often turn yellowish (Dedov A.V., Nesmeyanova M.A., and Khryukin N.N. 2018).

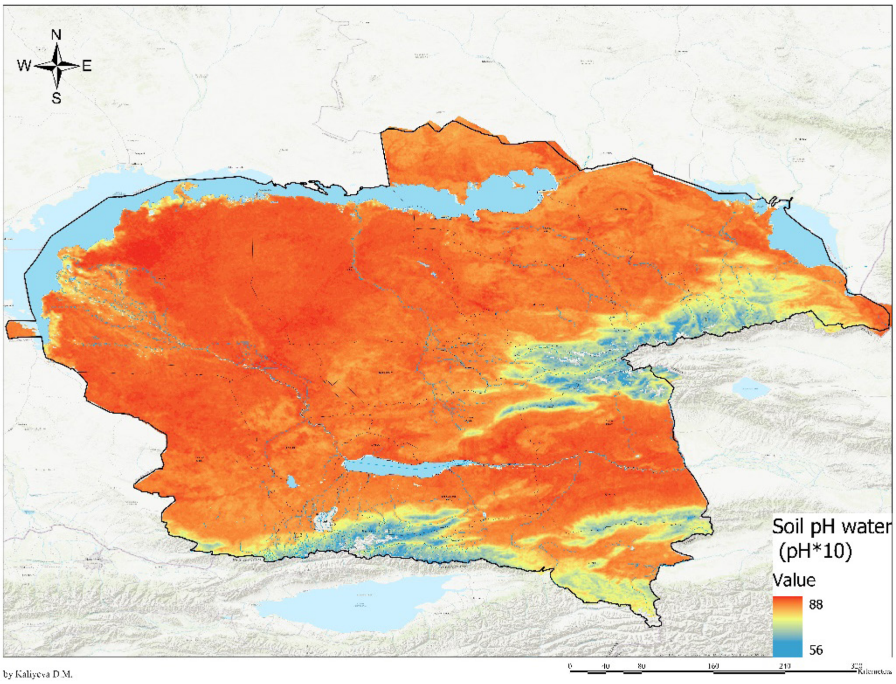


**Figure 5** – Map of soil acidity

In the Almaty region, there are a few districts that grow beets Eskeldi, Koksu, Karatal, Aksu, and Sarkand. In this regard, it should be noted that in this map of soil acidity indicators of land in this area are ambiguous. So, in the map given above, the soil acidity of the Koksu district at a depth of 2 m is 7.6, and in the Aksu, Sarkand and Karatal districts, a significant area shows an acidity of 7.6 to 8.7. It can be noted, that the Eskeldi district has an inherent acidity of 5.6-6.4 indicators.

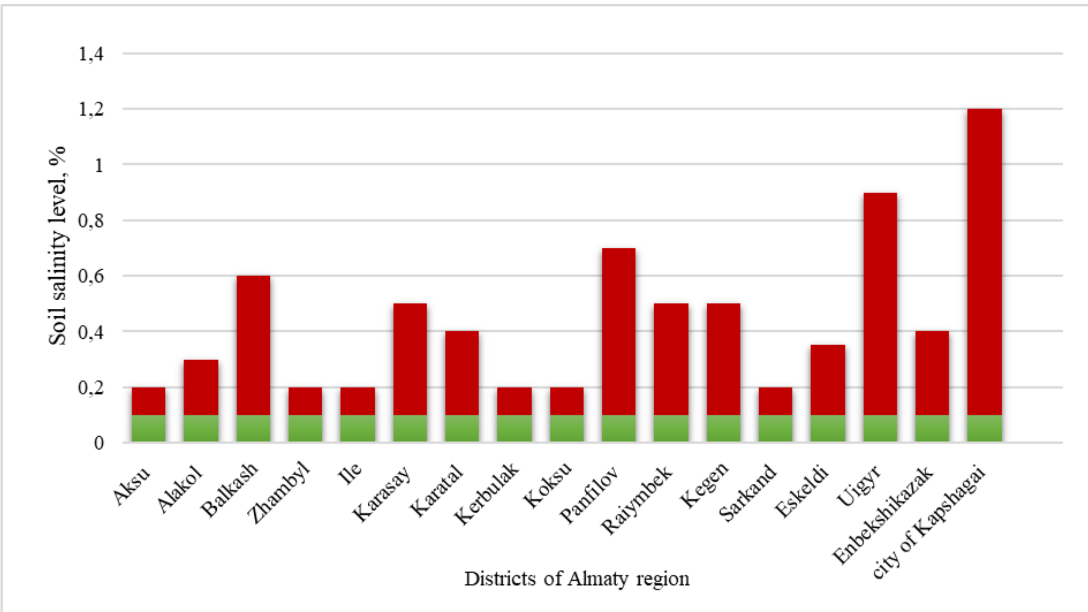


**Figure 6** – The level of salinity of soils in the districts of the Almaty region, %

In the statistical data provided by the Department of land relations of the Almaty region, the level of soil salinity by the district is different for each district (Fig. 6). In particular, the level of salinity (0.1%) is observed in the lowest areas in the farmlands of Aksu, Ile, Zhambyl, Kerbulak, Koksu and Sarkand districts, the highest in Kapchagai (1.1%), Uigyr – about 0.8%, Panfilov – 0.6% and Balkash district (0.5%) (Report of the mayor of Almaty region for 2019, 2020).

Special attention should be paid to calcium as an element that affects the ratio of H+ and OH-ions, which regulates the acidity of the total soil solution-pH. One aspect of the ecological relationship between soil and plants depends on the amount of calcium in it. In addition, the role of calcium in the formation of the earth's crust and the life of biological organisms allows us to consider it one of the most important elements in nature. Humus compounds enriched with calcium ions have a black color, which well withstands the sun's rays, which contributes to increasing the heat capacity of the soil and also favorably affects the growth and distribution of heat-loving plants in them (Rahman et al. 2018). In the Almaty region, the area of calcian chernozems is not very large. As the area of these soils, we can distinguish the lands of the Raiymbek district, the riverbanks of the Balkhash district and a significant part of the lands of the Kerbulak, Aksu, and Alakol districts (Fig. 7).

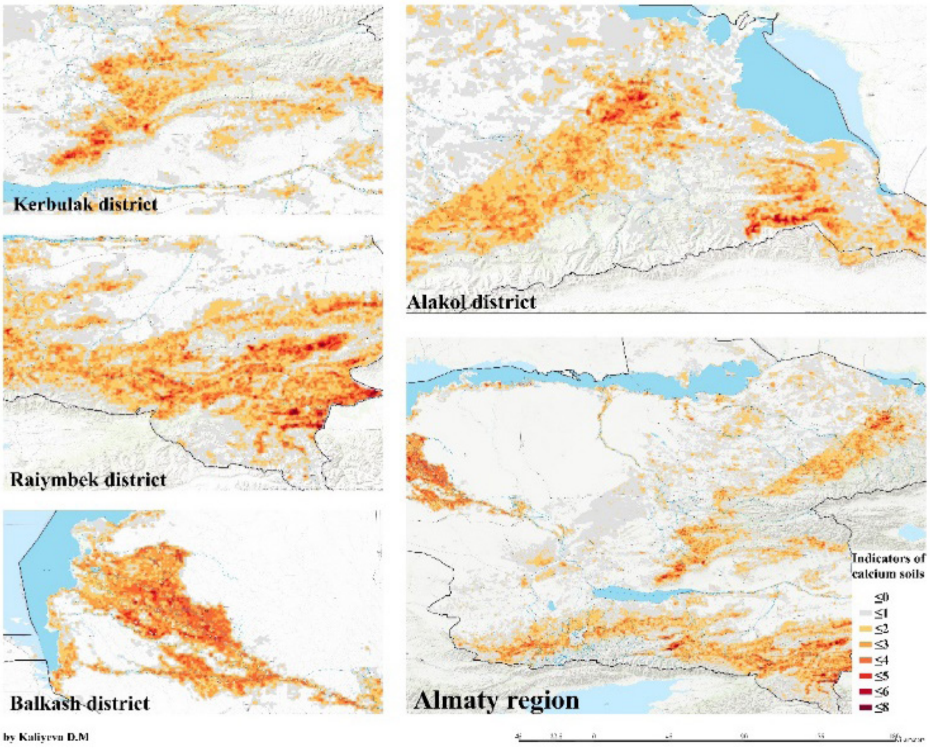


**Figure 7** – Map of the area of calcium chernozems in the region

Based on the conducted research, the agricultural lands of the districts were classified and considered into 3 groups depending on the level of soil quality degradation:

- complicated – 40-60 %;
- satisfactorily – 20-40 %;
- sustainable – 0-20%.

The main indicators of the state of land resources and priority areas of land degradation in the districts of the Almaty region are shown in table 1 and figure 8. As a result of this classification, Aksu, Balkhash, Kerbulak, Koksu, Eskeldi, Zhambyl, Sarkand, Ile and Talgar districts were classified as group I (complicated).

As can be seen from the above graph, about 50% of the farmland of each district that is part of group 1 is more susceptible to severe degradation. The main areas of land quality degradation are shown in table 1 below.

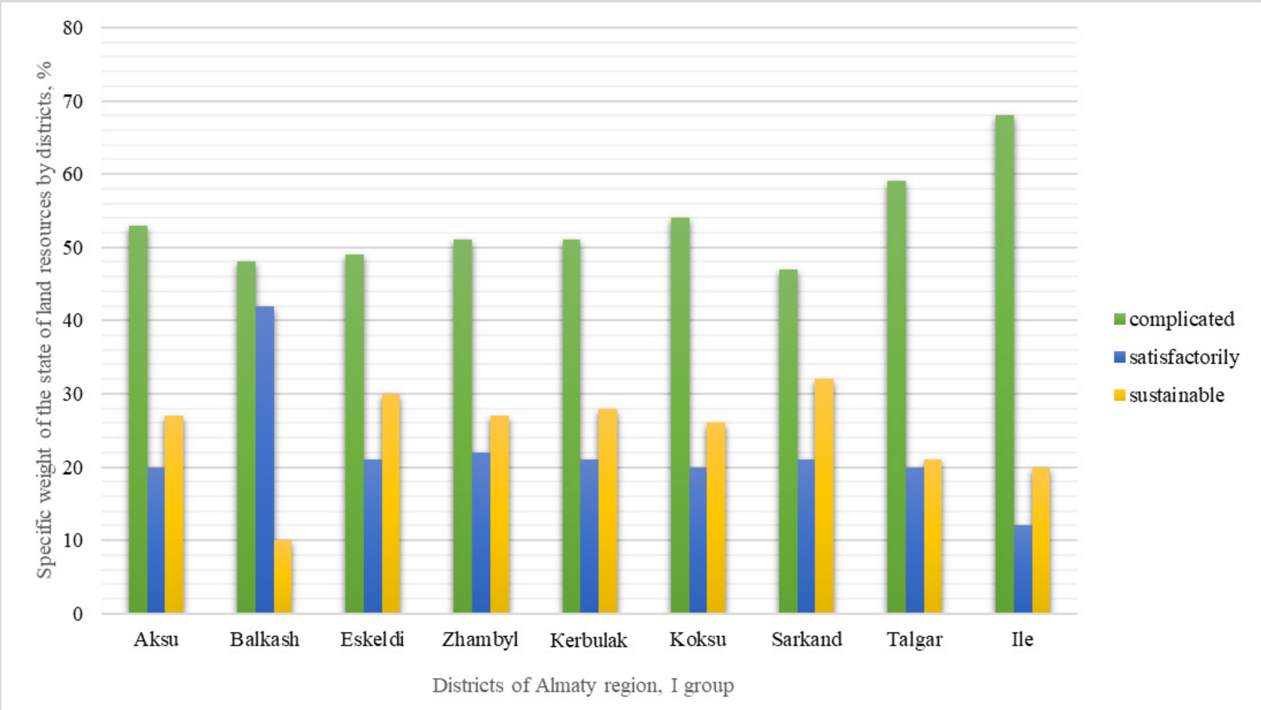


**Figure 8 –** The specific weight of the state of land resources by districts, % (group I)

**Table 1 –** Indicators of the state of regional district's land resources, the group I

| Name of district | The main directions of agricultural land quality deterioration |
|---|---|
| Aksu | the degradation of grasslands, soil erosion (wind, water) |
| Balkhash | pasture degradation, soil erosion, weeding of saxaul forests. |
| Eskeldi | soil erosion, pasture degradation, felling of trees |
| Zhambyl | pasture degradation, soil degradation, soil erosion |
| Kerbulak | pasture degradation, soil erosion |
| Koksu | pasture degradation, soil degradation, soil erosion |
| Sarkand | pasture degradation, soil erosion |
| Talgar | soil erosion, pasture degradation |
| Ile | soil erosion, pasture degradation |

The second group (satisfactorily) includes Alakol, Karasay, Enbekshikazak and Karatal districts. The main areas of deterioration of agricultural land and the share of the total land situation are shown in table 2 and figure 9 below.

The third group (with the sustainable state of land resources) includes relatively Panfilov, Raiymbek (Kegen), and Uyghur districts of the region located in mountainous areas (table 3, Fig. 10).

**Table 2 –** Indicators of the state of regional district's land resources, group II

| Name of district | The main directions of agricultural land quality deterioration |
|---|---|
| Alakol | soil erosion, pasture degradation |
| Enbekshikazak | pasture degradation, felling of trees |
| Karasay | soil erosion, pasture degradation, felling of trees |
| Karatal | soil erosion, pasture degradation, felling of trees |

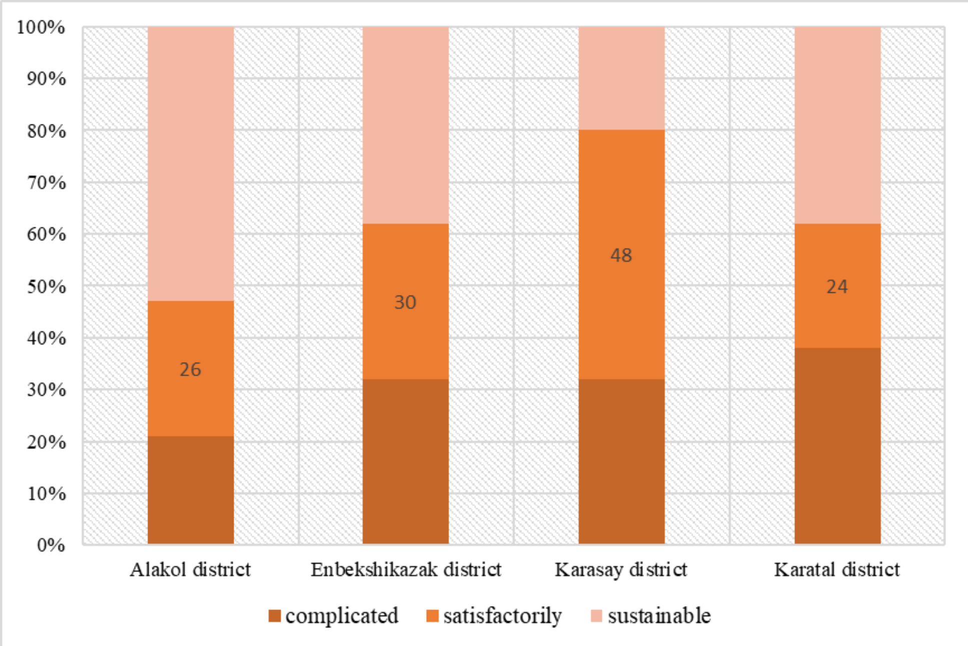


**Figure 9** – Specific weight of the state of land resources by districts, group II, %

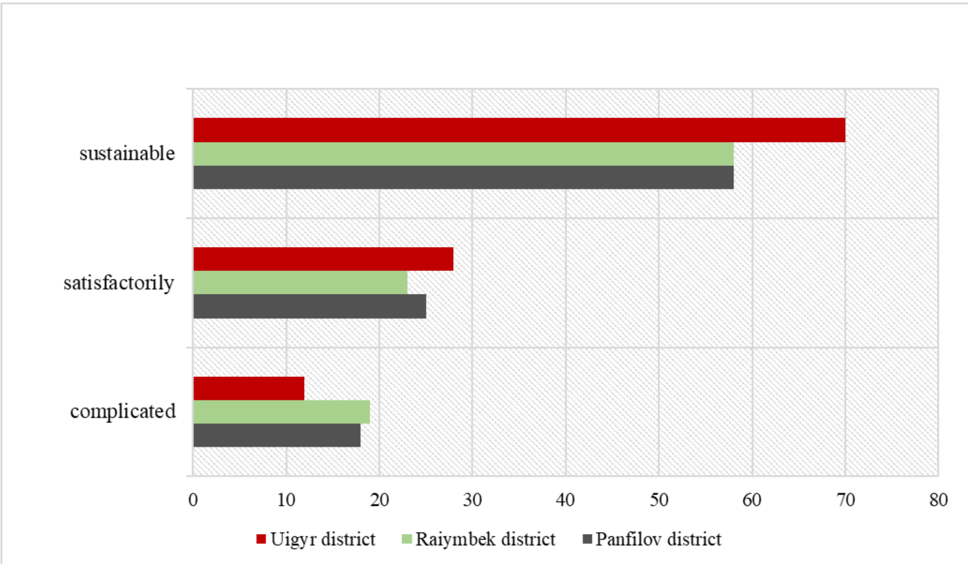


**Figure 10 –** Specific weight of the state of land resources by districts, group III, %

**Table 3 –** Indicators of the state of regional district's land resources, group III

| Name of district | The main directions of agricultural land quality deterioration |
|---|---|
| Panfilov | pasture degradation, soil degradation soil erosion |
| Raiymbek | pasture degradation, soil erosion |
| Uigyr | soil erosion |

According to research, the fertility of arable land is reduced because farmers in the districts of the Almaty region do not pay attention to the importance of increasing soil fertility. Land degradation damages the agriculture of the districts. The damage caused by the withdrawal of arable land from agricultural turnover is reflected in 3 directions.

→ Damage to agriculture: the quality of crops is deteriorating; there Will be additional costs associated with the development of new land due to missed production. As a result, the area of arable land will be reduced, and the tendency of soil to the environmental crisis will increase.

→ Environmental and economic damage to the social environment – as a result of land degradation, the local natural balance is disrupted, the number and type of diseases in the population increases, and life expectancy decreases (Molzhigitova D.K. 2014).

→ Environmental and economic damage-additional costs to increase the fertility of low-yielding land.

In the Almaty region, the soil of land withdrawn from agricultural turnover is classified into 4 main groups: grey; light brown; black; red-brown. There are 4 reasons for the withdrawal of arable land from agricultural turnover:

- unused vacant land;
- land allocated for other industries;
- contaminated land;
- various eroded lands.

According to the official data of 2019, the area of land that was withdrawn from circulation in the region was 120,552 ha, for some districts it looks as follows (Fig. 11): Aksu – 16820 ha; Alakol – 3345 ha; Eskeldi – 2652 ha; Zhambyl – 9496 ha; Kerbulak – 11848 ha; Koksu – 11991 ha; Karasay – 7242 ha; Karatal – 1403 ha; Panfilov – 1348 ha; Raiymbek – 13301 ha; Kegen – 1566 ha; Sarkand – 6515 ha; Talgar – 1142 ha; Uigyr – 1063 ha; Ile – 12447 ha; cities of Kapchagay – 18306 ha and Tekeli – 89 ha ('The Report of the Akim of Almaty Region to the Population on February 19, 2020' n.d.).

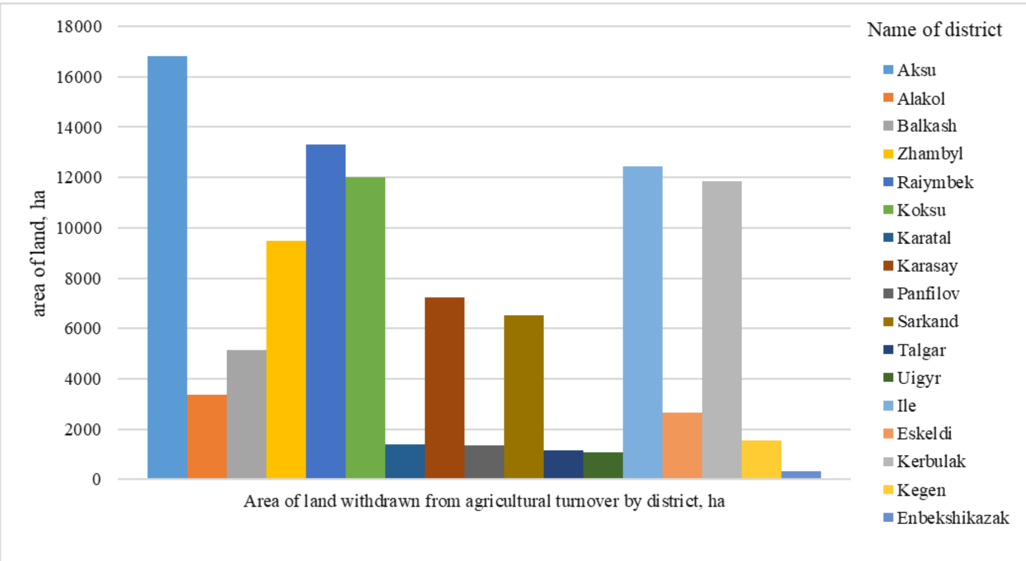


**Figure 11** – The area of land withdrawn from circulation in districts, ha

Today, the introduction of land is one of the priorities and strategic tasks of agricultural production in the region. In turn, untimely and incorrect land development is one of the factors that lead to deterioration of the quality of agricultural land in General, a sharp decrease in soil fertility. The prevention of such cases is, of course, part of the functions of special state bodies. The state, as the owner, independently exercises state control and protection of land use. State control is a previously structured and well-developed institution for regulating land relations. At the same time, state control, being an integral activity of the state administration, is aimed at achieving the goals of management, and solving the tasks facing the state (Saimova S.A. 2020).

At present, state control over land is the most effective measure. However, in some parts of the country, the requirements for the correct and efficient use of land specified in the law are now completely ignored. This, in turn, leads to the opinion that state control is not carried out to a significant extent, while it is not carried out in all conditions of land use and the controlling authorities do not fully cover the totality of land relations. At the same time, it can be assumed that a system of public land control was introduced to achieve high results in the effective use and protection of land, as well as to prevent and mitigate legally harmful effects of land. Public control is characterized by the prevention of violations in the sphere of executive power through the use of measures of public influence. Public control, like state control, is based on a legal basis. The advantage of this proposal is that the State responds quickly, which in turn guarantees minimal damage to land users (Saimova S.A. 2020).

The high percentage of unused land, the negative dynamics of the main acreage of crops, and the growth of shrubs and ponds on the land indicate the need for measures to improve the quality of land resources and involve highly productive agricultural land in the turnover. When solving problems of land use in agricultural production, it is necessary to take into account natural and climatic, soil, spatial conditions and economic feasibility, labor resources and other factors (Iovlev, Goldina, and Zorkov, 2020).

The introduction of unused land plots into agricultural circulation will increase the area of agricultural land. An increase in the area of the developed land will increase crop productivity, which has a positive impact on the provision of food to the population. The introduction of large areas of land into agricultural circulation will not only ensure employment of the population of the region but also increase investment interest in the region and contribute to increasing the incomes of the population. Thus, the full use of arable land will have a positive impact not only in the field of agriculture but also in other sectors of the national economy (Zhelyaskov A., Denisova N., and Seturidze D. 2014).

## Conclusion

Today, the main condition for the sustainable development of the agro-industrial complex is the preservation, cultivation and effective use of land. Therefore, improving soil fertility of agricultural land, without loss and effective use of land, is a prerequisite for management decisions. Geographic information systems, as the basis for combining various data and information based on a spatial component, are the main element for making administrative decisions. Effective management of infrastructure, natural resources, the environment and territories, as shown by world experience, is based only on the ability to integrate GIS. In general, the introduction of GIS in the practice of assessing agricultural land, and soil fertility will increase the quality of storage of information on the state of soil fertility and accessibility to consumers, the use of which will improve the validity of management decisions both in a particular farm and by representatives of executive authorities at all levels. It is necessary to intensify research in the following main areas:

- development of theoretical foundations and methodologies for enhancing soil fertility in intensive agricultural systems;
- improvement and implementation of integrated methodologies for grouping agricultural soils;
- implementation of innovative remote sensing and GIS technologies in agriculture;
- development of effective methods for desalinization of saline soils and restoration of their eroded, highly compacted, degraded, and technologically contaminated soils;
- the development of new systems for the use of mineral fertilizers on a variety of crops, taking into consideration the use of new forms of organic fertilizers, organomineral compositions, and local mineral raw materials;

- to enrich the soil with organic matter, preserve and increase its fertility, it is necessary to apply recommended agricultural techniques and, annually for three to four years, apply high rates of organic fertilizers in the range of 20 to 40 tons per hectare, along with reduced rates of mineral fertilizers;

- in order to monitor the state of soil fertility, it is necessary to monitor plowed lands based on their humus and fundamental nutrient composition.

Along with the indication of traditional rules, it is necessary to take into account the totality of controlled agrochemical, agrophysical, and biological indicators of soil fertility for a more comprehensive assessment and expansion, as well as the need to improve the efficiency of the use of fertilizers and other elements in agricultural systems; the development of rational (scientific) methods of soil fertility evaluation.

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