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АКАДЕМИЯСЫ» РҚБ

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# ХАБАРЛАРЫ

# ИЗВЕСТИЯ

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# THE GROUPING OF MILL LANDSCAPES BY DESERTIFICATION FACTORS AND RISKS

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**Abstract.** The presented article analyses the main factors that play a role in the formation of the desertification process in the landscape complexes of the Mill plain. It has been determined that anthropogenic changes in hydrogeological conditions and cattle-breeding have a special role in the emergence and development of desertification in the area. 85% of all desertification centers in the studied region were caused by these factors.

Natural factors mainly cause the intensification of desertification or the formation of desertification symptoms.

When calculating the total annual income for desertified areas, the intensity of the annual decline in productivity since the beginning of the desertification process should be taken into account. In this case, in addition to anthropogenic factors that directly affect the soil, the influence of meteorological factors that play a significant role in soil productivity is also taken into account.

Taking into account the mentioned factors, using Landsat-8 OLI/TIRS satellite images and Google Earth satellite observation data, a 1:100000 scale map reflecting the degree of desertification of landscapes was drawn up based on ArcGis software.

It was determined that 4,9% of landscape complexes were subjected to varying

degrees of desertification, 0,6% of them were slightly desertified, 29,8% were moderately desertified, and 18,5% were severely desertified. Conditionally non-desert geocomplexes make up 51,1% of the total area.

**Key words:** semi-desert, dry-steppe, intrazonal, anthropogenic, hydrogeological, desertification

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## САБЫНДЫ ЛАНДШАФТТАРЫН ШӨЛЕЙТТЕНУ ФАКТОРЛАРЫ МЕН ҚАУІПТЕРІ БОЙЫНША ТОПТАСТЫРУ

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**Аннотация.** Ұсынылған мақалада Миль жазығының ландшафтық кешендерінің шөлейттену процесінің қалыптасуында рөл атқаратын негізгі факторларға талдау жасалған. Ауданда шөлейттенудің пайда болуы мен дамуында гидрогеологиялық жағдайдың антропогендік өзгерістері мен мал шаруашылығы ерекше рөл атқаратыны анықталды. Зерттелетін аймақтағы барлық шөлейттену ошақтарының 85%-ы осы факторлардың әсерінен болды.

Табиғи факторлар негізінен шөлейттенудің күшеюіне немесе шөлдену белгілерінің қалыптасуына себепші болады. Шөлденген аумақтар бойынша жиынтық жылдық кірісті есептеу кезінде шөлдену процесі басталғаннан бері өнімділіктің жылдан жылға төмендеуінің қарқындылығын ескеру қажет. Бұл ретте топыраққа тікелей әсер ететін антропогендік факторлардан басқа, топырақ құнарлылығында маңызды рөл атқаратын метеорологиялық факторлардың әсері де ескеріледі.

Аталған факторларды ескере отырып, Landsat-8 OLI/TIRS спутниктік суреттерін және Google Earth спутниктік бақылау деректерін пайдалана отырып, ArcGis бағдарламалық қамтамасыз ету негізінде ландшафттардың шөлейттену дәрежесін көрсететін 1:100000 масштабты карта жасалды. Ландшафтық кешендердің 4,9%-ы әртүрлі дәрежеде шөлейттенуге ұшыраған,

олардың 0,6%-ы аздап шөлейттенген, 29,8%-ы орташа шөлейттенген, 18,5%-ы қатты шөлейттенген. Шартты шөлді емес геокешендер жалпы аумақтың 51,1% құрайды.

**Түйін сөздер:** жартылай шөл, құрғақ дала, аймақішілік, антропогендік, гидрогеологиялық, шөлдену.

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## ГРУППИРОВКА МЫЛЬНЫХ ЛАНДШАФТОВ ПО ФАКТОРАМ И РИСКАМ ОПУСТЫНИВАНИЯ

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**Аннотация.** В представленной статье анализируются основные факторы, играющие роль в формировании процесса опустынивания ландшафтных комплексов Мильской равнины. Определено, что особую роль в возникновении и развитии опустынивания на территории имеют антропогенные изменения гидрогеологических условий и животноводства. 85% всех очагов опустынивания в исследуемом регионе были вызваны этими факторами.

Природные факторы главным образом вызывают усиление опустынивания или формирование симптомов опустынивания.

При расчете совокупного годового дохода для опустыненных территорий следует учитывать интенсивность годового снижения продуктивности с начала процесса опустынивания. При этом, помимо антропогенных факторов, непосредственно влияющих на почву, учитывается также влияние метеорологических факторов, играющих существенную роль в плодородии почвы.

С учетом указанных факторов с использованием спутниковых снимков Landsat-8 OLI/TIRS и данных спутниковых наблюдений Google Earth была

составлена карта масштаба 1:100000, отражающая степень опустынивания ландшафтов на базе программного обеспечения ArcGIS.

Определено, что 4,9% ландшафтных комплексов подверглись разной степени опустынивания, из них 0,6% - слабо опустынены, 29,8% - умеренно опустынены и 18,5% - сильно опустынены. Условно непустынные геокомплексы составляют 51,1% общей площади.

**Ключевые слова:** полупустыня, сухостепь, интразональное, антропогенное, гидрогеологическое, опустынивание

**Introduction.** Mill landscape is one of the main agricultural regions of the country, the total area of studied landscapes is 410209 ha. The plain relief of the area, the arid climate and the location surrounded by large rivers have created a favorable basis for the development of irrigation agriculture. More than 20% of the country's agricultural products are produced in Mill plain (Hajiyeva, et al., 2024).

The territory consists of semi-desert, dry steppe and intrazonal landscapes, its characteristic features are determined by its being surrounded by the Kura and Araz rivers, the abundance of relict river-valley lakes, and its hypsometric location between -10 m and 250 m (Amanova, et al., 2023). The main land cover of the plain is chestnut, grass-gray, gray-grass, meadow-forest, alluvial-meadow, meadow-swamp and swampy soils, and the vegetation cover is sedum, black sedum, davitika, gorse, various types of wormwood, licorice, yarrow, reed, broom, etc. semi-desert, dry steppe plant species form.

In the plain territory, the annual growth of phytomass is 4-6 t/ha, with low productivity and very low productivity (1-2,5 t/ha). Only in the Kurboyu areas, tugay forest soils with a small area are characterized by high productivity (15-50 t/ha).

**Materials and methods.** For researching landscape desertification it is necessary to use modern technologies and methods (Imbrenda, et al., 2018). We have also used field methods. To determine desertification it is usefull to use Landsat images (Lavado, et al., 2009). For investigation of vegetation cover of the area we calculated NDV index. For NDV index following formula is used (Cowie et al., 2018; Briassoulis, 2011).

NDVI= (NIR-Red)/(NIR+RED)

As a result of comparison o many years we determined desertification in plain. For comparison of NDVI we processed many images from different years.

**Results.** The observations and analyzes show that the desertification of the landscapes of the study area with arid climatic conditions is related to a number of local and regional natural and anthropogenic factors (Bajocco, et al., 2011). However, decoding of space images and analysis of large-scale topographic maps show that the main factors of desertification in the general area are soil salinization due to the influence of mineralized groundwater (Braje, et al., 2017), excessive loading of pastures (Kairis, et al., 2015), and continuous grazing (Mao, et al., 2018). In this regard, the landscapes of the Mill plain differ according to the extent

of anthropogenic desertification centers. The superiority of these factors is also proven by the observational data that is obtained in real space.

The mentioned anthropogenic factors create the basis for the formation of desertification centers in semi-desert and dry-desert landscapes with weak stability (Wang, et al., 2006), as well as the development of intrazonal complexes characterized by their sharp contrast (Zambon, et al., 2017). Anthropogenic desertification was not only related to the intensification of anthropogenic activity (Lin, et al., 2010), but it is a violation of the proportionality between anthropogenic load and the potential capabilities of landscape components (Salvati, et al., 2012).

The fact that anthropogenic impacts are higher than the potential capabilities of landscapes leads to a fall in productivity and the creation of ecologically unstable complexes (Xie, et al., 2020).

The analysis of materials on the change of the Mill plain landscapes by anthropogenic influences shows that a deep structural change has occurred in all landscape units. In the region, irrigation farming and pasture breeding have a special role and have a history of 3-4 thousand years.

During the historical period, the existence of unsystematic irrigation agriculture in the lowland caused a radical transformation of the soil-vegetation cover and led to the creation of ecologically tense agro-landscapes of various sizes. The analysis of historical materials shows that during the period from the introduction of primary irrigation to the 50s of the last century, cultivated areas covered only natural depressions and hollows that could be filled with water. Irrigations were carried out unsystematically, without taking into account the chemical and mechanical composition of the soil, the depth of groundwater and the degree of mineralization, and the amount of water required by plants. In the period between 1950 and 1990, the completion of the construction of the Mingachevir reservoir led to the creation of main and multiple sprinkler irrigation systems, thus further expanding the cultivated areas.

In the irrigated areas, the irrigation systems are soil channels, the water distribution systems are not properly operated, the canals are not cleaned for a long time, the retail situation of water consumption, the water carrying capacity and operational quality of the existing canal, collector-drainage systems are at a low level, and the application of the traditional flooding method during irrigation, not taking into account the vegetative characteristics of plants, not carrying out leveling works in areas with uneven surfaces are among the anthropogenic factors that cause changes in the level of groundwater.

The natural drainage characteristics of the area are also unfavorable (streamless lakes-Sarisu, Mehman, Aghgol, Shorgyol, distribution of quaternary continental and marine sediments-alluvial, alluvial-proluvial, alluvial-deluvial, sand, clay, etc.), neotectonic subsidence area, the hydrostatic pressure of the Kura and Araz rivers in the abundant season, the fact that the parent rocks consist of ancient Caspian sediments, etc. naturally cause the level dynamics of groundwater. The indicated

natural features significantly affect the rise of the groundwater level against the background of anthropogenic influences.

Our statistical analyzes based on hydrogeological map data show that the depth of groundwater in the studied area decreases from 5-10 m to 0,5-2 m from the foothills of the Lesser Caucasus towards the Kura and Araz rivers. The degree of mineralization increases from 0,5-1 g/l to 50-100 g/l.

The ground water collected in the central regions of the studied area is practically non-flowing and is mainly used for evaporation. Evaporation of mineralized groundwater causes accumulation of salts in the soil. The location of these waters close to the surface, their unstable condition, has led to desertification by causing salinization, salinization and re-salinization of the soil.

In the studied area, the total area of soils with varying (Fig.1) degrees of salinity is currently 62211 hectares.

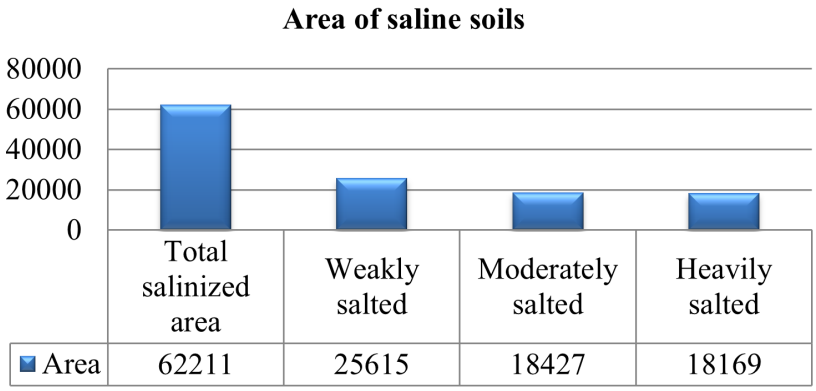



Figure 1 − The area of saline soils in Mill plain

Of them, 25615 ha were exposed to weak, 18427 ha to moderate, and 18169 ha to severe salinization.

The analysis of space images shows that within the semi-desert landscapes of the area, severely salinized soils mainly manifest as moderate and severe desertification centers.

One of the main anthropogenic factors leading to the desertification of the Mill Plain landscapes is livestock farming, which has developed rapidly in recent years. The plain is used year-round as it is an important winter pasture. It is known that excessive loading of pastures and year-round grazing are dangerous situations that lead to desertification. Overloading leads to the degradation of landscapes characterized by poor stability. In the grazed areas, the grass layer and the upper part of the soil are destroyed, the intensity of the process of dusting, molding, erosion and denudation on the sloping areas increases, the root system of the plants is damaged and destroyed by coming to the surface. During overgrazing, productivity decreases sharply, and the species composition of the pasture also changes - edible

plants decrease as a result of degradation, and poisonous, sulphurous, rough-stemmed, thorny, pungent-smelling weeds with low forage quality increase their dominance year by year. Grazing during the initial vegetation period of vegetation is considered more dangerous.

According to the data from State Statistics Committee 974867 large and small cattle are grazed in the pastures of the plain. However, nomadic animals are brought from other regions for grazing in the area during the winter months, and are grazed in the area until the end of summer. Since the growth of plants stops during the winter months, their overgrazing leads to the intensification of degradation. The year-by-year decrease in biological potential leads to the creation and expansion of desertification centers (Table 1).

Table 1 − Desertification of pastures in the Mill plain

| Total pasture area (ha) | |
|---|---|
| 171868 | |
| The countryside | Let's winter |
| 76357 | 95511 |
| Total area of grasslands subject to desertification (ha) | |
| The countryside | Let's winter |
| 44274 | 45369 |
| Total area | |
| 89643 | |

Anthropogenic factors in the studied area are characterized as the main desertification factors and account for 85% of the development of the process compared to natural factors. Natural factors (changes in climate characteristics, neotectonic, natural exodynamic geomorphological processes, changes in the hydrological regime) mainly lead to the intensification of the process or the formation of local symptoms.

Taking into account the mentioned factors, using Landsat-8 OLI/TIRS satellite images and Google Earth satellite observation data, a 1:100000 scale map reflecting the degree of desertification of landscapes was drawn up based on ArcGis software (Fig.2).

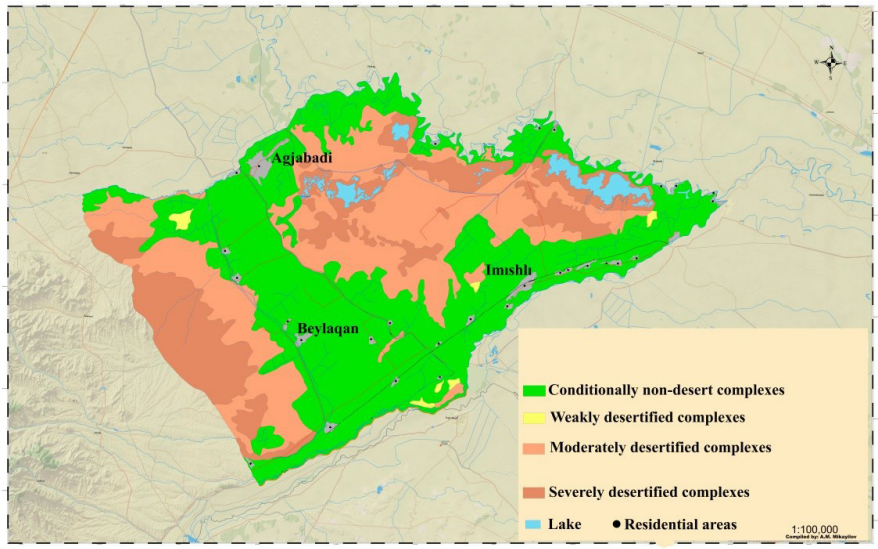



Figure 2 − The state of desertification of the Mill plain

ArcGis analysis of map data shows that 48,9% of landscape complexes in the area have been subjected to varying degrees of desertification. 51,1% of the plain area is conventionally not desertified, 0,6% is slightly desertified, 29,8% is moderately desertified, and 18,5% is severely desertified (Fig. 3).

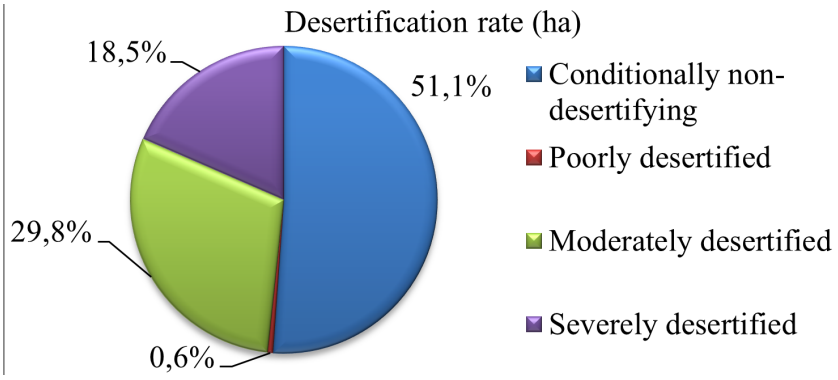



Figure 3 − The state of desertification of the Mill plain

*Complexes that are conditionally not subject to desertification.* These complexes were completely anthropogenically replaced by irrigated farmlands, artificial greens, gardens, and residential complexes (city, village, etc.) They are located mainly along the Gargarchay, Kura, Araz rivers and large irrigation canals (Upper Karabakh, Old Khan Gyzi, Rasularkh, etc.) does. The provision of humidity mainly as a result of purposeful economic activity of people has created a sharp contrast

in the arid climate of the area. Mainly due to the widespread use of irrigation, sustainable humid landscapes with high biological productivity have been formed, which prevents desertification of the area.

*Weakly desertified complexes.* Since these complexes consist of small areas and are formed in areas of the plain where irrigation is developed, they have relatively high stability, so the potential for desertification is not high. Although the soil in such areas is characterized by weak salinization, surface stripping is not observed. The coverage of plants (on 1 $m^2$ area) is up to 25-50%. These complexes cover a total area of 2587 hectares and constitute 0,6% of the total area.

*Moderately desertified complexes.* These complexes have a total area of 122188 hectares and constitute 29,8% of the total area. Landscape areas subjected to moderate desertification were mainly formed under the influence of anthropogenic factors (intensive grazing, raising the level of groundwater due to irrigation, re-salinization of soils, etc.).

The desertification centers in these complexes are spread in the intensively irrigated surrounding areas of the Aggol, Sarisu, Mehman, Shorsu lakes located in the area, as well as the Bash Mill-Karabagh collector and the canal named after the Upper Karabakh, Old Khan Gyzi. Due to the fact that moderately desertified landscapes have high dynamics and weak stability, there is a great danger of their transformation into acute desertified landscapes as a result of negative anthropogenic effects.

*Severely desertified complexes.* The total area of these complexes is 76016 hectares, covering 18,5% of the plain area.

The landscape areas that were subjected to desertification in the acute period mainly covered the areas adjacent to Sarisu, Shorsu, Mehman, Aghgol and lakes of various sizes spread around these lakes, as well as the foothills areas where intensive grazing and erosion-denudation processes are developed in the western part of the plain. The process of desertification in sharply desertified landscapes developed mainly under the influence of anthropogenic and partly natural factors.

Many sharply desertified areas (surrounding areas of lakes, areas of practically unused sharply saline soils, bare surface, stony areas with numerous animal trails in the western foothills) are completely devoid of vegetation.

In general, severely desertified landscapes have a very poor species composition, with less than 10% plant cover.

Depending on the degree of influence of desertification factors in the studied area and the characteristics of the assimilation of landscapes, sometimes all categories of degree of desertification are observed within one landscape type.

The desertification risk analysis of the NDVI maps (Fig. 4, 5) we prepared shows that the area of desertification risk areas has expanded depending on the impact characteristics of natural and anthropogenic factors.

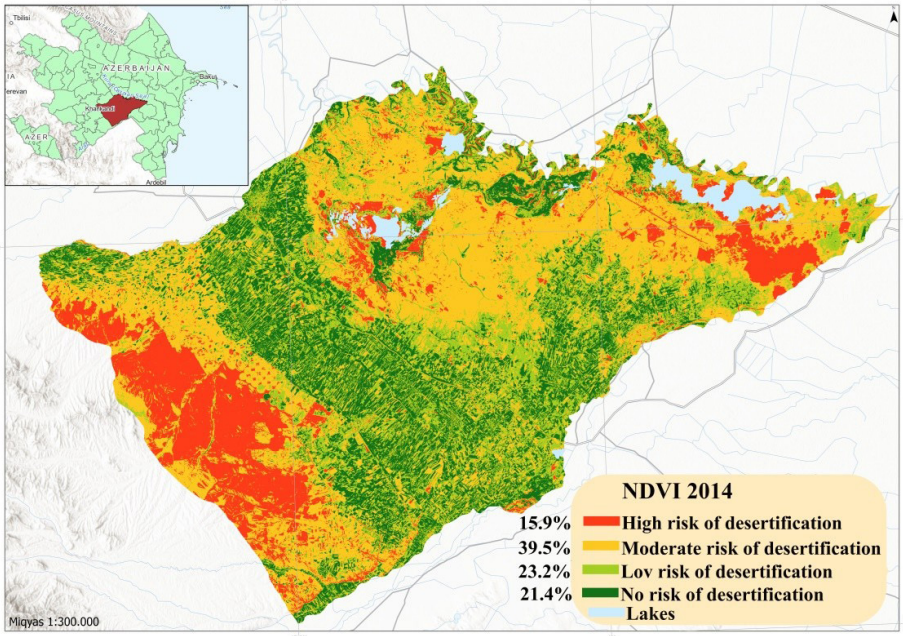



Figure 4− Desertification risk in Mill plain landscapes-2014

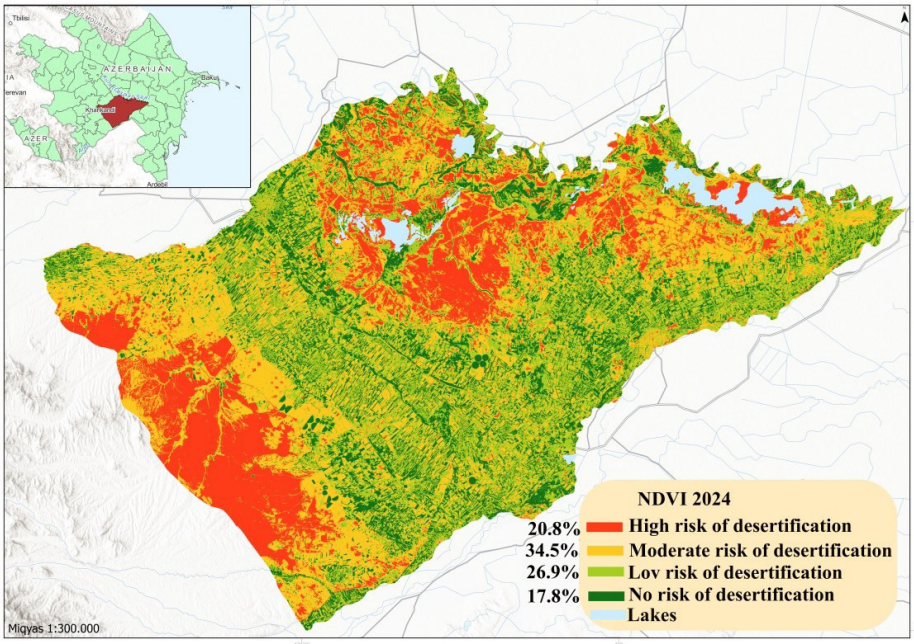
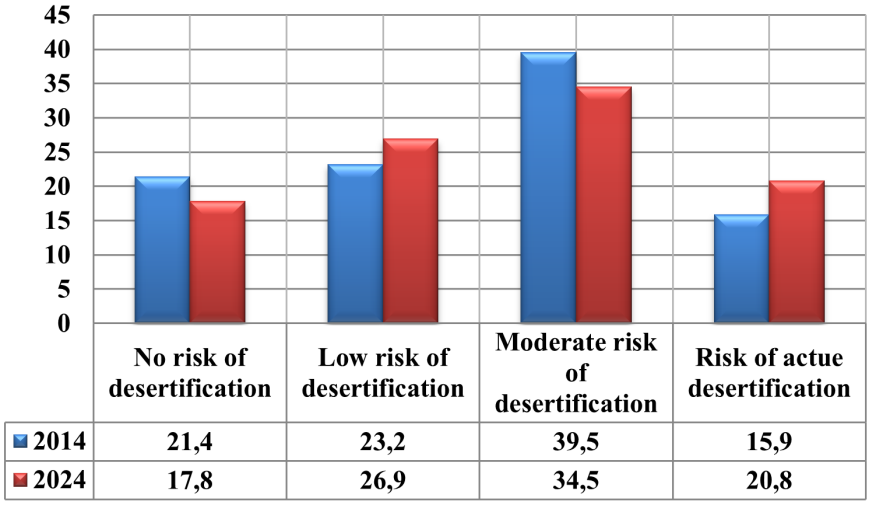



Figure 5 − Desertification risk in Mill plain landscapes-2024

In 2014, areas without the risk of desertification constituted 21,4% of the total area, while in 2024, this quantity was 17,8% (Fig.6).




| | No risk of desertification | Low risk of desertification | Moderate risk of desertification | Risk of actue desertification |
|---|---|---|---|---|
| 2014 | 21,4 | 23,2 | 39,5 | 15,9 |
| 2024 | 17,8 | 26,9 | 34,5 | 20,8 |

Figure 6 − Desertification risk in Mill plain landscapes (2014-2024)

Areas at risk of weak desertification will be 23,2% in 2014, 26,9% in 2024, areas at risk of moderate desertification will be 39,5% in 2014, 34,5% in 2024, high desertification risk areas were 15,9% in 2014, and 20,8% in 2024.

Since desertification is a complex environmental problem, its prevention requires a long time, labor and high resources. In this regard, it is important to use natural resources on a rational and scientific basis.

**Discussion.** Previous studies have been based mostly on field surveys. For the first time, we have conducted this study based on both field surveys and satellite images. We have determined that salinization is occurring more intensively compared to previous years. This is related to both the lack of proper irrigation systems and climate change. Because our study area is the most important agricultural zone of the country.

**Conclusion.** Risk maps for the years 2014 and 2024 were prepared to determine the dynamics of the potential development of the desertification process in the landscapes of the study area. The analysis of the maps shows that depending on the impact of natural and anthropogenic factors, the area of areas at risk of desertification has expanded. In 2014, the areas without the risk of desertification constituted 21,4% of the total area, and in 2024, this quantity was 17,8%. Areas with a low degree of desertification risk will be 23,2% in 2014, 26,9% in 2024, areas with moderate desertification risk will be 39,5% in 2014, 34,5% in 2024, areas with a high degree of desertification risk amounted to 15,9% in 2014, and 20,8% in 2024. It has been determined that currently the main areas where desertification has developed to a

moderate and severe degree have developed in medium and high risk areas. In the areas with no risk of desertification and low risk of desertification, the manifestation of desertification centers has a local character and has developed mainly within agro-irrigation landscapes.The control and improvement of reclamation conditions in these landscapes reduces the risk of desertification.

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