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«Қазақстан Республикасы Ұлттық ғылым академиясының Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналы 2016 жылдан бастап халықаралық реферативтік және ғылыметриялық Scopus дерекқорында индекстеледі және тұрақты библиометриялық көрсеткіштерді көрсетіп келеді.

Сонымен қатар журнал Web of Science платформасының (Clarivate Analytics, 2018) халықаралық реферативтік және наукометриялық дерекқоры Emerging Sources Citation Index (ESCI) тізіміне енгізілген.

ESCI дерекқорында индекстелуі журналдың халықаралық ғылыми рецензиялау талаптары мен редакциялық этика стандарттарына сәйкестігін растайды, сондай-ақ Clarivate Analytics компаниясы тарапынан басылымды Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI) және Arts & Humanities Citation Index (AHCI) дерекқорларына енгізу қарастырылуда.

Scopus және Web of Science дерекқорларында индекстелуі жарияланымдардың халықаралық деңгейде жоғары сұранысқа ие болуын қамтамасыз етеді, олардың дәйексөз алу көрсеткіштерінің артуына ықпал етеді және редакциялық алқаның геология мен техникалық ғылымдар саласындағы өзекті, бірегей және ғылыми тұрғыдан маңызды зерттеулерді жариялауға ұмтылысын айқындайды.

Научный журнал «News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences» с 2016 года индексируется в международной реферативной и наукометрической базе данных Scopus и демонстрирует стабильные библиометрические показатели.

Журнал также включён в международную реферативную и наукометрическую базу данных Emerging Sources Citation Index (ESCI) платформы Web of Science (Clarivate Analytics, 2018).

Индексирование в ESCI подтверждает соответствие журнала международным стандартам научного рецензирования и редакционной этики, а также рассматривается компанией Clarivate Analytics в рамках дальнейшего включения издания в Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI) и Arts & Humanities Citation Index (AHCI).

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ECOLOGICAL PROCESSES OF VERTICAL LANDSCAPE TRANSFORMATION AND MANIFESTATION IN NATURAL LANDSCAPES OF NAKHCHIVAN

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Abstract. The main subject of the research is the agrocenoses present in the Nakhchivan Autonomous Republic and the factors affecting their sustainable development. The study addresses the problem of spatial differentiation of natural landscapes and their role in shaping the productivity and stability of agrocenoses under increasing anthropogenic pressure. The primary goal is to determine the impact of the natural landscapes of the research area on the development of agrocenoses and to identify ecologically optimal zones for sustainable management. In this article, the natural landscapes are analyzed in a GIS environment, and their impact on agrocenoses is determined. The study employed GIS technologies and remote sensing indices (NDVI, NDWI, NDMI, SAVI) to assess vegetation and soil cover. These approaches were complemented by historical-geographical, mathematical-statistical, cartographic, field-based, comparative, observational, and systematic methods to ensure reliability and spatial accuracy. A landscape-fragmentation

coefficient was calculated to evaluate the influence of tectonic and morphostructural features on agricultural land productivity. In areas where tectonically active and mobile morphostructures of river valleys intersect the land, fragmentation increases, reducing the productivity of agriculturally significant lands. High vertical fragmentation in mountainous areas makes them unfavorable for agrocenoses. Examining the morphogenetic types of elevation landscapes, steppe-meadow and meadow-steppe types on intrusive outcrops are more widespread. A comparative analysis of previous years' data was conducted to study agrocenoses dynamics. The results reveal that landscape structure, vertical differentiation, and soil composition directly influence productivity and ecological stability. Optimal areas for agrocenoses in the Nakhchivan Autonomous Republic are low mountainous and Araz River plain regions. Soil samples determined mineral composition, humus content, and acidity, and studied changes from intensive anthropogenic impacts. The findings provide a scientific basis for landscape-based agricultural planning and sustainable land-use strategies in arid mountainous regions.

Keywords: Natural landscapes, agrocenoses, transformation, usage of lands, transformation

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НАХЧЫВАННЫҢ ТАБИҒИ ЛАНДШАФТТАРЫНДАҒЫ ТІК ЛАНДШАФТТЫҚ ТРАНСФОРМАЦИЯНЫҢ ЭКОЛОГИЯЛЫҚ ҮДЕРІСТЕРІ ЖӘНЕ КӨРІНІСІ

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Аннотация. Зерттеудің негізгі тақырыбы. Нахчыван Автономиялық Республикасында кездесетін агроценоздар және олардың тұрақты дамуына әсер ететін факторлар. Зерттеу табиғи ландшафттардың кеңістіктік дифференциациясы мәселесін және олардың антропогендік қысымның артуымен агроценоздардың өнімділігі мен тұрақтылығын қалыптастырудағы рөлін қарастырады. Негізгі мақсат - зерттеу аймағының табиғи ландшафттарының агроценоздардың дамуына әсерін анықтау және тұрақты басқару үшін экологиялық тұрғыдан оңтайлы аймақтарды анықтау. Бұл мақалада табиғи ландшафттар ГАЖ ортасында талданады және олардың агроценоздарға әсері анықталады. Зерттеуде өсімдіктер мен топырақ жамылғысын бағалау үшін ГАЖ технологиялары мен қашықтықтан зондтау индекстері (NDVI, NDWI, NDMI, SAVI) қолданылды. Бұл тәсілдер сенімділік пен кеңістіктік дәлдікті қамтамасыз ету үшін тарихи-географиялық, математикалық-статистикалық, картографиялық, далалық, салыстырмалы, бақылау және жүйелік әдістермен толықтырылды. Тектоникалық және морфоқұрылымдық ерекшеліктердің ауылшаруашылық жерлерінің өнімділігіне әсерін бағалау үшін ландшафттық фрагментация коэффициенті есептелді. Өзен аңғарларының тектоникалық белсенді және жылжымалы морфоқұрылымдары жермен қиылысатын жерлерде фрагментация артып, ауыл шаруашылығы үшін маңызды жерлердің өнімділігін төмендетеді. Таулы аймақтардағы жоғары тік фрагментация оларды агроценоздар үшін қолайсыз етеді. Биіктік ландшафттарының морфогенетикалық түрлерін зерттеу кезінде интрузивті шығыңқы жерлердегі дала-шалғынды және шалғынды-дала түрлері кең таралған. Агроценоздардың динамикасын зерттеу үшін алдыңғы жылдардағы деректерді салыстырмалы талдау жүргізілді. Нәтижелер ландшафт құрылымы, тік дифференциация және топырақ құрамы өнімділік пен экологиялық тұрақтылыққа тікелей әсер ететінін көрсетеді. Нахчыван автономиялық Республикасында агроценоздар үшін оңтайлы аймақтар - аласа таулы және Араз өзенінің жазық аймақтары. Топырақ үлгілері минералды құрамды, гумустың мөлшерін және қышқылдықты анықтап, қарқынды антропогендік әсерлерден болатын өзгерістерді зерттеді. Зерттеу нәтижелері құрғақ таулы аймақтарда ландшафтқа негізделген ауыл шаруашылығын жоспарлау және тұрақты жерді пайдалану стратегиялары үшін ғылыми негіз береді.

Түйін сөздер: табиғи ландшафттар, агроценоздар, трансформация, жерді пайдалану, трансформация

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ЭКОЛОГИЧЕСКИЕ ПРОЦЕССЫ ВЕРТИКАЛЬНОЙ ТРАНСФОРМАЦИИ ЛАНДШАФТОВ И ПРОЯВЛЕНИЕ В ПРИРОДНЫХ ЛАНДШАФТАХ НАХЧЫВАНА

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Аннотация. Основным предметом исследования являются агроценозы, функционирующие на территории Нахчыванская Автономная Республика, а также факторы, влияющие на их устойчивое развитие. В работе рассматривается проблема пространственной дифференциации природных ландшафтов и их роли в формировании продуктивности и устойчивости агроценозов в условиях усиливающегося антропогенного воздействия. Целью исследования является определение влияния природных ландшафтов исследуемой территории на развитие агроценозов и выявление экологически оптимальных зон для устойчивого управления. Методологическая основа исследования включает использование геоинформационных систем (ГИС) для анализа природных ландшафтов и оценки их влияния на агроценозы. Для анализа растительного и почвенного покрова применялись индексы дистанционного зондирования, включая NDVI, NDWI, NDMI и SAVI. Для повышения достоверности и пространственной точности результатов использовался комплекс методов: историко-географический, математико-статистический, картографический, полевой, сравнительный, наблюдательный и системный подходы. Для оценки влияния тектонических и морфоструктурных особенностей на продуктивность сельскохозяйственных земель был рассчитан коэффициент фрагментации ландшафта. Установлено, что в районах пересечения тектонически активных морфоструктур речных долин происходит усиление фрагментации, что

приводит к снижению продуктивности сельскохозяйственных угодий. Высокая вертикальная фрагментация в горных районах также ограничивает развитие устойчивых агроценозов. Анализ морфогенетических типов высотных ландшафтов показал преобладание степно-луговых и лугово-степных комплексов, формирующихся на интрузивных породах. Для изучения динамики агроценозов проведён сравнительный анализ многолетних данных. Результаты исследования свидетельствуют о том, что структура ландшафта, вертикальная дифференциация и почвенный состав оказывают прямое влияние на продуктивность и экологическую устойчивость агроценозов. Оптимальными зонами для их развития в пределах Нахчыванской Автономной Республики являются предгорные территории и равнинные участки долины реки Араз. В почвенных образцах определялись минеральный состав, содержание гумуса и уровень кислотности, а также анализировались изменения, вызванные интенсивным антропогенным воздействием. Полученные результаты формируют научную основу для разработки ландшафтно-ориентированных подходов к сельскохозяйственному планированию и стратегий устойчивого землепользования в засушливых горных регионах.

Ключевые слова: природные ландшафты, агроценозы, трансформация, землепользование, трансформация

Introduction. The total land fund of the Autonomous Republic amounts to 550.2 thousand hectares, of which 29% is suitable for agricultural use. The main reason why this figure is significantly lower compared to other regions of our republic is due to the unfavorable physical-geographical conditions of the area under study. Thus, 36% of the arable land is used for crop cultivation, while a portion is utilized as hayfields and pastures. Perennial and annual agrocenoses dominate across 60,000 hectares of land used for agriculture. However, 70,000 hectares of soil in the study area are not suitable for the development of agrocenoses. These lands include badlands, bare rocky areas, watersheds, regions affected by severe salinization, and areas covered with stony-gravelly ridges (Mammadov and Khalilov, 2004).

Our research and statistical data once again confirm that the arable lands of the Autonomous Republic must be used efficiently, while minimizing the negative processes that may arise—such as salinization, erosion, and degradation. To achieve this, particular attention should be paid to the recommendations outlined in the report on the "Ecological Assessment of the Araz River Basin Areas," which was initiated by Decision No. 80 of the Cabinet of Ministers of the Nakhchivan Autonomous Republic, dated August 29, 2017. This report emphasizes the need to restore and enhance the fertility of arable lands, establish agricultural sectors adapted to arid conditions, and expand cultivation areas for agrocenoses such as forage crops and legumes.

This program represents a significant step toward fundamentally transforming, restoring, and preserving the economic structure of the Araz River region. In the

specified area, agrocenoses such as barley, sesame, soybean, alfalfa, and others—which are highly productive, adapted to local conditions, and cultivated through irrigation—are among the key factors contributing to the enhancement of the plains' natural potential, the preservation of ecological balance, and the sustainable, long-term development of the region.

Additionally, the program also places strong emphasis on improving various categories of land that are currently underutilized in agriculture—such as saline, eroded, slightly swampy, stony, bush-covered lands—through the application of reclamation, corrective-drainage, and other methods (Hajiyeva and Jafarova, 2024). The implementation of these methods will enable the integration of these lands into production, which in turn will support the sustainable development of agrocenoses and ultimately lead to the expansion of arable land area.

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).

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

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

Results. One of the significant steps taken in the Nakhchivan Autonomous Republic through land reforms is the restoration of degraded soils and the prevention of further degradation processes. To achieve this, special attention must be paid to reducing the negative impacts that trigger soil degradation processes—such as surface runoff, wind and water erosion, intensified slope processes, salinization, deforestation, destruction of shrublands, and the irregular and unregulated use of summer and winter pastures (Ismayilov and Amanova, 2015). Naturally, a thorough study of the problems listed above will create conditions for the restoration of the physical and chemical composition of soils in the research area, ensuring the supply of essential nutrients. This, in turn, will contribute to the expansion of arable lands and help prevent both direct and indirect food shortages.

These degradation processes are primarily observed in gray, gray-brown, and meadow-gray soils of gently sloped plains with weak and moderate fragmentation, as well as in primitive gray, light kastanozem, and gray-brown soils found in moderately and heavily fragmented terrains.

To mitigate soil degradation, the first step is to accurately study the type of soil in question (Arestova, 2009). This process involves considering the components of physical-geographical factors—such as relief, climate, vegetation cover, and surface and groundwater. Therefore, the morphometric indicators of the relief

(slope, aspect, vertical and horizontal dissection) in the areas where the soil types are distributed must be studied, along with the geological base of the soil.

Climatic indicators such as temperature, precipitation, and evaporation also play a crucial role in the vertical and horizontal zonal distribution and development of soils, making the analysis of these factors essential.

One of the main parameters of degradation is the variation in the mineral composition of horizons within the vertical structure of the soil. The presence of different characteristics in soil layers—such as clay, loamy clay, heavy and light loam, sandy, and sandy-loam textures—leads to differences in soil compaction and water permeability. This, in turn, results in processes such as salinization, alkalization, and waterlogging in low-lying areas.

In the low-lying parts of the Araz River plains, which exhibit these characteristics, it is necessary to implement deep plowing, apply fertilizers using modern technologies, and cultivate agrocenoses with branched root systems. In particular, the cultivation of legumes and perennial forage crops in this zone is considered highly appropriate. These agrocenoses have the ability to absorb atmospheric nitrogen and enhance soil productivity.

One of the negative factors contributing to the intensification of degradation processes in the Araz River plains of the Nakhchivan Autonomous Republic is the secondary salinization and alkalization of soils. This process increases ecological risks and hinders the development of agrocenoses. The results of conducted studies indicate that soil salinization in the region occurs in two genetic types: automorphic and hydromorphic (Sadigov and Mustafayev, 2024).

Automorphic salinization is primarily observed in the Araz River basin areas of Nakhchivan, including Julfa, Boyukduz, Yaycı-Diza plains, and around alluvial fans. This type of salinization itself is divided into two subtypes: typical saline soils and takir-like saline soils. The typical subtype appears in microdepressions in patch form, while the takir subtype forms a clayey crust and salt crusts, and is mainly observed in the eastern and southern parts of the Boyukduz area within the research zone. The second genetic type, hydromorphic salinization, is found along the banks of the Araz River, particularly in areas where agrocenoses are intensively developed. These saline soils form under the influence of groundwater. They are widespread in gray, primitive, and saline soils of gently sloped plains with low dissection, as well as in primitive gray soils of more intensively dissected sloped plains.

The majority of saline and alkaline soils are found in the Araz River plains, as well as in the foothill and intermountain depressions, occurring within soil types such as gray-brown, gray, light gray-brown, gray meadow, light gray-brown, and others. These soil types are particularly prone to salinization. Analysis of statistical data shows that the highest concentrations of saline soils are located in Boyukduz, the Sharur plain, Culfa, and the Yaycı plains. An analysis of materials reflecting salinization levels across individual administrative districts indicates that in

Babek District, 5.9% of cultivated lands and 23.4% of pasturelands are affected by salinization to varying degrees. The situation is even more alarming in the Sharur District, where 32.9% of cultivated lands and 35.2% of pasture and grazing lands are affected by varying degrees of salinization (Mammadov and Khalilov, 2004).

Overall, 5,694 hectares of land in the Babek District and 13,272 hectares in the Sharur District are affected by varying degrees of salinization (Bababeyli and Imat, 2010). This salinization is also characteristic of the Sadarak, Kangarli, Julfa, and Ordubad districts of the Autonomous Republic. The primary factor driving this process is the high mineralization level of groundwater. In areas such as between the villages of Ibadulla and Didadin in the Sharur plain, as well as in the Yaycı and Julfa plains, the shallow depth of groundwater has led to a wider spread of salinization.

In these regions, where the population is densely and compactly settled and where intensive irrigation is practiced, the salinization of soil increases over time, leading to a reduction in the productivity of agrocenoses. If this process continues, it results in secondary salinization and the expansion of degraded land areas (Shukurov et al., 2025). From this perspective, a systematic and regular monitoring of salinized soils must be carried out. Through the interpretation of aerial and satellite imagery, these soils should be mapped, and their general physical and chemical properties, humus content, and granulometric composition should be analyzed under laboratory conditions. Furthermore, incorporating the scientific findings from advanced research conducted in leading countries in this field would be highly commendable. Taking all this into account, our research has paid particular attention to identifying the factors contributing to the risk of salinization. Salinization primarily manifests in the landscapes of plains, depressions, and low mountainous areas. In these regions, alkalization processes become more active in areas where groundwater lies close to the surface. In such landscapes, irrigation is crucial for the development of agrocenoses, as their cultivation is only feasible through irrigation.

Another factor contributing to soil degradation in the territory of the Nakhchivan Autonomous Republic is the process of waterlogging. Waterlogging occurs in relatively limited areas, particularly in carbonate-rich marsh-meadow soils, and is found in small patches. Due to prolonged irrigation, groundwater levels have risen in the Ordubad, Sharur, and Boyukduz plains, leading to the activation of this process. In the Nakhchivan plain, marsh and marsh-meadow soils with varying degrees of carbonatization and humification are distributed. These soils are found in small areas on leveled river terraces, in low-lying depressions where rivers can directly infiltrate, and in lower relief zones. They form as a result of both seepage from rivers and rising groundwater levels. For instance, 15 km from Nakhchivan city, water seepage from Lake Sirab has led to the emergence of waterlogging in the surrounding area (Bababayli et al., 2026). It should also be noted that the mineralization of groundwater causes the progressive alkalization of meadow-

marsh soils. This phenomenon mainly occurs in the alluvial stony-meadow parts of riverbeds and floodplains.

In addition to natural factors, anthropogenic influences play an undeniable role in the activation of soil degradation (Abramova, 2012). The impact of anthropogenic factors on degradation occurs in two ways. The first way is through direct human intervention in natural landscapes, which leads to an imbalance in natural components and accelerates the already existing natural degradation. This process results in the formation of new complications in the soil. The second way is through unsuccessful projects carried out due to improper agricultural practices. These projects are planned and executed without considering any natural factors or their potential. In such cases, the irregular appropriation of natural ecosystems, such as the establishment of new agricultural lands and vineyard plantations, leads to landscape degradation, intensified erosion, hillside washing, increased salinization of plains and depressions, and a decrease in vegetation cover in pastures and meadows, among other negative phenomena (Amanova and Hajiyeva, 2023). The result of the processes mentioned above is the emergence of alien synoses in the area, which further exacerbate the ecological situation. The increase in these anthropogenic influences leads to the expansion of degraded land areas. To prevent this, it is crucial to adhere to proper agro-technical practices, plant agrocenoses that are suited to the natural conditions of the area, and regulate the irrigation system.

The haphazard and irregular anthropogenic impacts resulting from projects carried out without adhering to agro-technical practices accelerate degradation. This, in turn, leads to the development of erosion and negatively affects the productivity of agrocenoses (Zvereva, 2006). Additionally, in the low and mid-mountainous regions of the Autonomous Republic, which have weak forest and plant cover, the destruction of forests, burning and devastation of shrubs, and the expansion of erosion are common consequences. In the studied area, which differs due to its arid ecological environment, anthropogenic processes contribute to the expansion of desertification (Guliyeva, 2011).

To study how the development of agrocenoses in the Nakhchivan Autonomous Republic contributes to the degradation of the soil cover in the region, we focused on analyzing the ancient irrigated kastanozem soils and alluvial meadow soils that have been most affected by human intervention. We collected samples from these soils and performed the corresponding analyses. Kastanozem soils are found in the foothill areas and in the lower parts of the relief. These soils become narrower as they approach the plain. The favorable relief in this area has created favorable conditions for the development of irrigated agriculture, while the natural conditions have led to the formation of dry-steppe biosenoses.

In the flat areas, there is a favorable environment for the thickening of the humus layer of the soils. However, compared to other regions of our republic, this indicator is low. Over a long period, the dominance of irrigated agriculture and the cultivation of corresponding agrocenoses has led to a complete change in the natural structure

of the mentioned soils. In the upper layers of kastanozem soils, brown spots can be found, which have been formed as a result of long-term irrigation.

Historically, open kastanozem soils have played a significant role in the development of agrocenoses due to irrigation. H.A. Aliyev and E. Zeynalov (1988) noted that the upper horizon of these soils is characterized by high carbon content and heavy clay composition. They also determined that the soil contains 7.1% nitrogen, 1.28% humus, 21.37% CaCO3, 4.61% hydrophilic moisture, and a pH of 7.4 (Table 1).

Table 1. Main Composition (%) of Historically Irrigated Kastanozem Soils.

	Nitrogen	pH	Humus	$CaCO_3$	Hygroscopic moisture
0-15	7,1	7,4	1,28	21,37	4,61
15-35	10,7	7,6	1,96	22,01	4,57
35-50	7,2	7,7	1,06	19,03	4,58

Source: Based on the calculations of H.A. Aliyev and E. Zeynalov.

On the same soil, at an altitude of 1187 m above sea level on the Tivi road, we took a soil sample and conducted our research (Table 2). Compared to 1988, the amount of humus has increased, and the soil has become weakly alkaline. In contrast, calcium carbonate and nitrogen have decreased. Of course, the main reason for these changes is anthropogenic influences and the rapid development of agrocenoses.

Table 2. Main Composition (%) of Historically Irrigated Kastanozem Soils.

Depth in cm	Nitrogen		pH		Humus		$CaCO_3$		Phosphorus		Potassium	
	%	Group	%	Group	%	Group	%	Group	%	Group	%	Group
Tivi road at an altitude of 1187 m												
0-10	0,30	High	7,4	Neutral	4,8	High	15,4	Highly calcareous	11,1	Low	347	Medium
10-25	0,26	High	7,6	Weakly alkaline	2,7	Medium	15,7	Highly calcareous	15,3	Medium	435	High
Tivi road at an altitude of 1187 m on the right bank of the bridge												
0-15	0,36	Very high	7,5	Weakly alkaline	2,2	Medium	15,5	Highly calcareous	15,6	Medium	427	High
15-20	0,27	High	7,4	Neutral	1,9	Low	16,4	Highly calcareous	12,8	Low	365	Medium
20-40	0,22	Medium	7,6	Weakly alkaline	3,4	Medium	17,2	Highly calcareous	11,9	Low	356	Medium

Note: Based on the soil samples taken during field research.

Other soil samples were taken from the left bank of the river to the north of Bash Diza, at an elevation of 900 m above sea level. We compared the samples of alluvial-meadow soils with those from 1988 (Tables 3, 4).

Table 3. General Composition of Alluvial-Meadow Soils.

Depth in cm	Nitrogen		pH		Humus		$CaCO_3$		Phosphorus		Potassium	
	%	Group	%	Group	%	Group	%	Group	%	Group	%	Group
0-15	0,26	High	6,9	Neutral	5,1	High	13,6	Highly calcareous	16,3	Medium	428	High
15-22	0,29	High	7,1	Neutral	2,6	Medium	12,8	Highly calcareous	15,8	Orta	446	Medium

Source: Based on the calculations of H.Aliyev and A.Zeynalov.

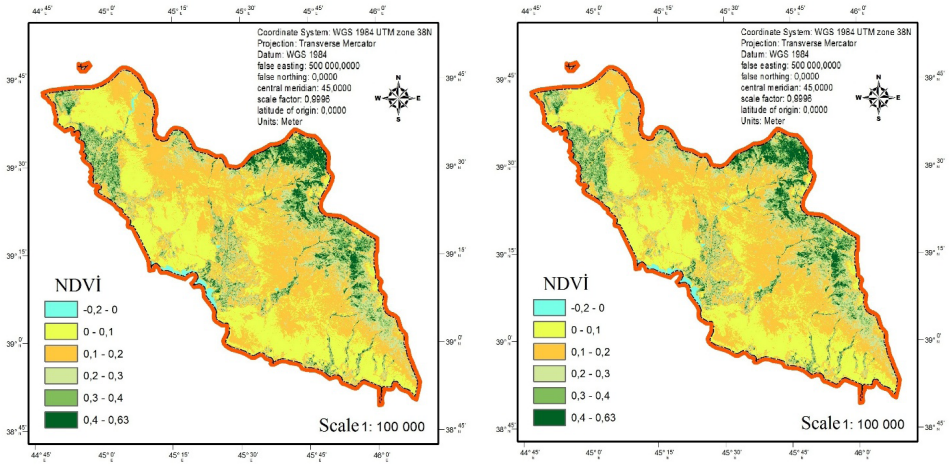
Table 4. Alluvial-meadow soils spread on the left bank of the river north of Bash Diza.

Depth in cm	Nitrogen		pH		Humus		$CaCO_3$		Phosphorus		Potassium	
	%	Group	%	Group	%	Group	%	Group	%	Group	%	Group
From Bash Dize to the north, the left bank of the river.												
0-15	0,26	High	7,1	Neutral	4,8	High	12,8	Highly calcareous	15,8	Medium	446	High
15-22	0,29	High	6,9	Neutral	2,7	Medium	13,6	Highly calcareous	16,3	Medium	428	High

Note: Based on the soil samples taken during field research.

Compared to the year 1988, an increase has been observed in all indicators within the overall composition of the land. As mentioned above, the reason for all these changes is the development of agrocenoses without adhering to agrotechnical regulations. If this continues, problems will arise in the sustainable development of agrocenoses.

The intensive anthropogenic transformation of our research area has negatively affected not only the soil cover but also the vegetation, leading to the emergence of ecological problems in biotopes (Allbed et al., 2013; Bellard et al., 2012; Deng et al., 2018). To analyze this factor, the dynamics of vegetation in the research area were observed, and satellite images from Landsat 5 (June 1987) and Landsat 8 (June 2022) were processed (Figure 1). During image processing, Bands 3 and 4 of the Landsat 5 satellite and Bands 4 and 5 of the Landsat 8 satellites were used. The processing results of the satellite images from the two periods were compared (Berra et al., 2019). It was determined that, compared to 1987, the minimum value of the index has increased, while the maximum value has decreased. Specifically, the minimum value, which was -0.5 in 1987, increased to -0.2 in 2022, while the maximum value decreased from 0.75 to 0.63. This dynamic indicates that the water level in water bodies, as well as the density of forests and shrubs in the area, has decreased".



a) b)

Figure 1. NDVI (Normalized Difference Vegetation Index) map based on satellite images from the month of June: (a) 1987, (b) 2022.
Note: Prepared based on Landsat 5, 8, and 9 satellite data.

If we compare consecutively according to the classification, the area with an index of less than 0 has decreased by 73% compared to 1987, now covering 266 km², while areas with an index of 0-0.1 have decreased by 25%, covering 1562.7 km². As a result, we determine that areas which were previously not utilized and were somewhat unsuitable for utilization have also been utilized to some extent over the past 35 years (Table 5).

Table 5. Dynamics of the NDV index in the years 1987-2022.

№	NDV index	Area (km²)	
		Year 1987	Year 2022
1	0 or lower	989,4	266
2	0-0,1	2086,5	1562,7
3	0,1-0,2	910,3	2088,3
4	0,2-0,3	669,6	772,3
5	0,3-0,4	382,6	503,7
6	0,4-0,7	464,4	309,8
Total		5502,8	5502,8

Note: It has been compiled based on Landsat 5, 8, and 9 satellite data.

Conclusion. As a result of the research, it should be noted that in the Araz Plains, areas with a negative index covered a large area in 1987, but the results of processing satellite images from 2022 show that these areas have now become permanently utilized lands. Areas where the index is between 0.1 and 0.2 generally correspond to the land areas of settlements, roads, and other construction and catering facilities, and the area of these lands has increased by 129.5%. These changes in

vegetation cover indicate that great attention needs to be paid to environmental protection in the Autonomous Republic, and special attention must be given. If such utilization continues, it will negatively affect the quality parameters of the soil and the development of agrocenoses, which may lead to future food shortages.

The natural geosystems of the Nakhchivan Autonomous Republic have undergone complete changes in the structure of all geocomplexes due to the development of agrocenoses. The area of agro-irrigation geosystems has significantly increased, and accordingly, the area of irregularly used agrocomplexes has significantly decreased. In 1981, the area of agro-irrigation complexes was recorded as 23.28 thousand ha, and dry farming complexes were 4.92 thousand ha, while today the areas of these complexes are 31.97 thousand ha and 5.56 thousand ha, respectively. For the first time in the Nakhchivan AR, the zoning of agrocenoses was carried out, and it was found that 33% of the areas had more stable landscapes, 20% had moderately stable landscapes, 26% had weakly stable landscapes, 13% had unstable landscapes, and 8% were areas where the natural conditions were unfavorable.

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