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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

ANTHROPOGENIC TRANSFORMATION AND ASSESSMENT OF THE NATURAL RESERVE POTENTIAL OF MODERN LANDSCAPES OF THE CASPIAN COASTAL PLAINS (BETWEEN PIRSAATCHAY-ASTARACHAY)

Speciality: 5408.01 – Physical geography and biogeography, soil geography, geophysics, and geochemistry of landscapes

Field of science: Geography

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GENERAL CHARACTERISTIC OF THE WORK

Relevance of the topic and degree of elaboration. Due to Azerbaijan's favorable natural conditions, the Caspian coastal plains, which are among the oldest inhabited areas, have undergone intensive development in various economic fields over a long historical period. This has had an impact on different landscapes and landscape components, leading to the degradation of sensitive ecosystems, the formation of re-derivative vegetation complexes, and, overall, a change in the ecogeographical situation of landscapes. In particular, starting from the year 2004, a number of large projects and agricultural activities have been implemented in accordance with state programs for the social-economic development of regions within the territory of the Republic of Azerbaijan. This has led to the intensive appropriation of natural landscapes, resulting in numerous ecological disturbances observed in the natural landscapes.

In order to prevent these problems, the degree of appropriation of modern landscapes and the assessment of their ecological condition stand out for their relevance in our current period. Conducting ecogeographical research is of crucial importance in meeting the increasing demands of the country's population, ensuring food security, optimizing natural landscapes, systematically creating agrolandscapes in various ecosystems, and evaluating the natural resource potential that influences the sustainable development of the territory.

The role of foreign scientists such as F.N. Milkov (1973), D.L. Armand (1975), V.M. Chupakhin (1989), N.L. Beruchashvili (1995), I. Mamay (2005), E.Y. Kolbovski (2006), V.Y. Vanteyeva, S.Y. Solodyankina (2014), Y.V. Vanteyeva (2014), İ.M. Danilin (2015), A.V. Khoroshev (2016) as well as domestic researchers like M.A. Museyibov (1981, 1985), M.A. Suleymanov (2005), B.A. Budagov (1980, 1988)), M.J. Ismayilov (1990, 2014), S.Y. Guliyeva (2022), E.Sh. Mammadbeyov (1992, 1998), M.I. Yunusov (1998), S.M. Zeynalova (1998), A.A. Mikayilov (2001), E.K. Alizade. (2002), I.Y. Kuchinskaya (2003), Y.A. Garibov (2007), E.C. Karimova (2010), is significant in the field of anthropogenic transformation of natural

landscapes, their ecogeographical situation, the evaluation of the natural resource potential of landscapes, and landscape optimization.

The research object is the natural and anthropogenic landscapes of the Caspian coastal plains from Pirsaatchay to Astarachay. The anthropogenic transformation of the landscapes of the Caspian coastal plains from Pirsaatchay to Astarachay, its ecogeographical consequences, and the natural resource potential constitute the subject of the research. The research area covers 6,568 km²

Purpose and objectives of the research. The main goal of the research is to study the regularities of anthropogenic transformation of the landscapes of the Caspian coastal plains from Pirsaatchay to Astarachay, and to develop practical measures for the optimization of the natural resource potential and ecogeographic situation. To achieve this goal, the following tasks have been set:

- Studying the structural-genetic characteristics and differentiation regularities of modern natural landscapes based on large-scale (1:100,000) landscape mapping;
- changes of natural components of landscapes (relief, climate, hydrogeological and hydrological conditions, vegetation and soil cover, animals) with anthropogenic effects and ecogeographical zoning according to the degree of their disturbance;
- Investigation of the directions of anthropogenic transformation of landscapes and preparation of the corresponding content-rich large-scale (1:100,000) maps for the research area;
- Grouping the modern landscapes of the area according to their natural resource potential and studying the diferentiation regularities within the researched area through the preparation of the relevant content large-scale (1:100,000) map.

Research Methods: During the research, various methods have been employed, including new technologies of Geographic Information Systems (GIS), mathematical-statistical methods, observation, comparison, cartographic methods, systematic analysis, historical-geographical approaches, aerospace, and field researches.

Five expeditions have been organized to the research area until the year 2022, conducting comprehensive investigations and creating a large-scale (1:100,000) landscape map. During landscape research,

in addition to field observations, large-scale (1:100,000) topographic maps and high-resolution satellite images have been utilized for the territory. Observation areas have been designated based on the structure of the natural complex. Research has been conducted along transects in six profiles from the Caspian Sea coast towards the west, investigating the variations and mutual relationships of natural components (such as relief, geological and hydrogeological conditions, soil, and vegetation cover). The research also focuses on the interchangeability and differentiation of landscapes.

Using mathematical-statistical methods, the morphometric elements of relief in the structure-genetic units of the landscape have been studied. Additionally, the basic trends of socio-economic development in anthropogenic landscapes and their relationship with the natural resource potential of geosystems have been examined.

Furthermore, through the digital analysis of Landsat 5 and 7 satellite imagery, research has been conducted on the anthropogenic loading, transformation characteristics, and ecological assessment of landscapes within GIS. Corresponding maps have been prepared based on the results of this analysis.

The main provisions of the defense:

- The structural-genetic characteristics and differentiation of landscapes between Pirsaatchay and Astarachay in the Caspian coastal plains.
- Historical-geographical analysis of the anthropogenic changes in the natural components of Caspian coastal plain landscapes.
- Anthropogenic transformation of Caspian coastal plain landscapes and the ecogeographical assessment of its consequences.
- Assessment of the natural resource potential of the landscapes of the Caspian coastal plains and preparing measures for its improvement.

The scientific novelty of the research:

- As a result of the analysis of the natural components of the Caspian coastal plains with a dynamic structure based on ArcGIS technologies, a large-scale (1:100,000) digital map reflecting the diferentiation of the natural landscapes of the area was compiled for the first time. It has been determined that 54% of the research area is

semi-desert, 27% is forest-steppe and dry-steppe, 14% is forest, and shrub-forest, and 5% is covered by hydromorphic-introzonal landscape types.

- For the first time, the regularities of differentiation and transformation of landscapes in the Caspian coastal plains between Pirsaatchay and Astarachay, under the influence of human activities and their economic operations, have been studied and analyzed based on the new technologies of Geographic Information Systems. Using the ArcGIS program network, a multifunctional database (DB) of the research area has been created and mapped.

- Based on the study of the degree of change in natural components within the research area, ecogeographical zoning of landscapes has been conducted, and the corresponding map has been prepared. It has been determined that 24% of the research area consists of practically unchanged specially protected landscapes, 26% has natural components weakly altered, 40% is moderately altered, and 10% represents strongly altered areas.

- The anthropogenic transformation of the landscapes of the Caspian coastal plains between Pirsaatchay and Astarachay has been analyzed based on various factors (slope of the relief, exposure, hypsometric indicators, degradation, productivity of plants, NDVI index, etc.). A large-scale (1:100,000) map with relevant content has been prepared as a result of this analysis.

- In the research area, the natural resource potential of landscape components has been assessed, and based on the results, the natural resource potential of landscapes has been evaluated comprehensively, leading to the creation of the respective large-scale (1:100,000) map. The landscape areas have been categorized into four groups based on their natural resource potential: 1. Landscapes with protected natural resources; 2. Complexes with weak natural resource potential; 3. Complexes with moderate natural resource potential; 4. Complexes with high natural resource potential.

Theoretical and practical significance of the research. The results of the research can be used by the Ministry of Ecology and Natural Resources of the Republic of Azerbaijan, the Ministry of Agriculture's research and project institutes, as well as in the

preparation and implementation of state plans and programs. The obtained scientific outcomes will contribute to the conservation of ecological diversity in the landscapes of the Caspian coastal plains and facilitate the optimization of the natural resource potential of the landscapes.

Approbation and application. Presentations on the topics reflecting the results of the research have been delivered at scientific-practical conferences both in the Republic and abroad: "Human and Nature" scientific-practical conference - Baku, 2002; "Issues of Desertification in Azerbaijan" scientific-practical conference - Baku, 2003; "Geography and Region" international scientific-practical conference - Perm, 2015; "Global Climate Change: Regional Effects, Models, Forecasts" international scientific-practical conference - Voronezh, 2019; "The Role of Haydar Aliyev in the Development of Science and Education in Azerbaijan" Republic scientific-practical conference – Baku, 2023; “Current Issues in Natural Sciences” Proceedings of the 12th International Scientific-Practical Conference dedicated to the 125th anniversary of the birth of the first president of the Academy of Sciences of Kazakhstan, K.I. Satpayev. - Petropavlovsk: 2024.

14 scientific articles and theses have been published, reflecting the main results of the work on the dissertation topic.

The name of the institution where the dissertation was carried out. The dissertation was performed at the Institute of Geography named after academician H.A.Aliyev of the Ministry of Science and Education of the Republic of Azerbaijan

The volume and structure of the dissertation. The dissertation consists of an introduction, 4 chapters, conclusions, and a references. The total volume of the work is 172 pages. Chapter I - 25 pages, Chapter II - 58 pages, Chapter III - 46 pages, Chapter IV - 18 pages, the result is 2 pages. The research work includes 41 figures, 37 tables, and references to 139 sources in the bibliography. The dissertation work consists of 200,843. characters.

THE MAIN CONTENT OF THE RESEARCH

The introduction provides information about the relevance of the topic, the purpose and objectives, research methods, the main provisions of the defense, scientific novelty, theoretical and practical significance, as well as the volume and structure of the dissertation.

The first chapter of the dissertation is titled "**Structural-Genetic Characteristics and Differentiation of Modern Landscapes.**" In this chapter, the relief indicators of the area have been investigated, and the spread characteristics and differentiation of the modern landscape cover have been analyzed.

The research area from the mouth of Pirsaatchay to Astarachay River mainly encompasses semi-desert and partly steppe zones. Scholars such as D.L. Armand, M.A. Museyibov, B.A. Budagov, Y.A. Garibov, M.J. Ismayilov, S.Y. Quliyeva, and others have studied and evaluated the factors influencing the differentiation of landscapes to varying degrees in various aspects.

The research area is characterized by relief features that vary due to fluctuations in sea level during geological-historical periods, the influence of various tectonic movements, and other related factors. The process of periodic fluctuations of the sea level has regularly shown its influence on the structural-territorial differentiation of the plain landscapes around the Caspian Sea, and on the course of natural processes. The traces of these effects are preserved in the modern relief in the form of terraces, abrasion steps, sand ridges, residual lakes, etc. N.Sh. Shirinov and others note that the coastal plains of the Caspian Sea are the geologically youngest formations. The territory is formed from alluvial-proluvial deposits of rivers and accumulative marine sediments[1]. Research has determined that the main factors influencing the differentiation of landscapes in the Caspian coastal plains include the morphometric indicators of the relief, the distance from the sea, the lithological composition of the rocks constituting the area, the degree of

[1] Shirinov N.Sh. New tectonics and relief development of the Kura-Araksin depression. Baku: Elm, 1975

fragmentation by various river valleys, and the interaction of coastal plains with foothills.

The relief's surface inclination in the research area has been calculated to study the differentiation characteristics and structural-genetic features of landscapes. It has been revealed that the maximum slope in the area is 22 degrees. In areas with slopes of 0-5°, accumulation predominates, with an increase in salinization, weak erosion, mainly dominated by agricultural and pasture complexes. On slopes higher than 5 degrees, erosion, denudation, predominantly pasture, as well as agriculture and orchards, are widespread.

In terms of slope aspect, 31% (2024 km²) of the research area is located on northern, 22% (1427 km²) on eastern, 28% (1822 km²) on southern, and 19% (1295 km²) on western exposure slopes. On northern slopes, there is a lack of solar radiation, on eastern slopes, there is a gradual decrease in radiation, on southern slopes, there is intensive solar radiation with weak vegetation cover, and on western slopes, there is a subsequent decrease in radiation with weak erosion processes observed.

There are four landscape types in the area: forest and meadow-forest, forest-steppe and dry-steppe, semi-desert, and hydromorphic-intrazonal landscapes. These landscapes combine into 8 subtypes and 35 species. While the majority of the area (54%) is covered by semi-desert landscapes, 14% (917 km²) is covered by forest and meadow-forest, 26% (1740 km²) by forest-steppe and dry-steppe, and 5% (352 km²) by hydromorphic-intrazonal landscapes.

The second chapter of the dissertation is dedicated to the "**Anthropogenic Transformation of Landscape Components and its Ecogeographic Assessment**". In this section, natural components such as relief, climate, hydrogeological conditions, soil, and vegetation have been investigated from a historical-geographical perspective in terms of anthropogenic changes resulting from human activities.

The anthropogenic transformation of the relief in the research area is associated with the beginning of cultivation from ancient times. In terms of natural aspects, the weakly dissected Caspian

coastal plains have been significantly intensified in artificial fragmentation due to irrigation and melioration measures. Research conducted in the Salyan plain shows that the artificial fragmentation of the relief in the area depends on the intensity of meliorative practices. Depending on the meliorative condition, various health measures and irrigation methods should be applied in this region. The rise and fall process of the Caspian Sea level has also influenced the structure-terrain differentiation and the course of natural processes in the coastal plains[2]. In modern relief, traces of this influence are preserved in the form of terraces, abrasion pillars, sand ridges, and so on.

After the analysis of the hypsometric indicators of the area to monitor the anthropogenic change of the relief, it was determined that the cultivated areas are mainly spread more widely (1732 km^2) in the areas whose height is up to 0 m above sea level. Beyond this elevation, the extent of cultivated areas decreases, with an area of 520 km² at elevations between 0-100 meters and reaching 220 km² at elevations exceeding 100 meters.

Comparing the residential areas based on elevation, we observe that in 1970, the area of settlements below sea level was 355 km², and this indicator increased by 17% (60 km²) to reach 415 km² in 2021. In the elevation range of 1-100 meters, the area of residential areas increased by 84% over 50 years, reaching 140 km². This increase accounted for 64 km². Above 100 meters, there was a 25% increase, growing from 24 km² in 1970 to 30 km² in 2021.

Looking at the dynamics of pasture and grazing areas based on elevation, we can see that they are primarily spread below sea level. In this elevation range, the area covered by pastures is 83 km², while grazing areas covers 1048 km². 18% of pastures are spread between 1-100 m and 6% above 100 m, 18% of grazing areas are spread between 0-100 m and 5% above 100 m.

[2] Ismayilov M.C., Mammadbayov E.Sh., Yunusov M.I., Nadirov M.A. - "Ecological Condition and Reconstruction of Modern Landscapes of the South-Western Coastlines of the Caspian Sea (Between Pirsaat and Astara rivers)" // Geography and Natural Resources, - Baku. - 2016, - No.2 (4), - pp. 27-32.

When analyzing the distribution of forests and forest masses based on elevation, it becomes evident that island-shaped forests are primarily spread up to 100 m, while large forest massifs are distributed above 100 m. The reason for this is the relatively decreased intensity of anthropogenic influences above 100 m, leading to the expansion of forest areas in massif forms. Below sea level, 52% of forests and 4% of forest masses are distributed, while above 100 m, 48% of forests and 34% of forest masses are spread.

Changes in microclimate conditions in the research area are significantly influenced by factors such as irrigation, hydrogeological regime, deforestation, expansion of seliteb areas, and other anthropogenic factors present in the area. In order to monitor the change of precipitation in the study area, a map of the distribution of precipitation of the area for the years 2003 and 2021 was drawn up. From the analysis of the maps, it can be concluded that in 2003, the maximum amount of precipitation was 1189 mm, but this indicator decreased to 725 mm in 2021. The minimum amount decreased from 529 mm in 2003 to 243 mm in 2021. In 2003, an increase in precipitation from south to north was observed in the Lankaran plain, but in 2021, on the contrary, an increase in precipitation from north to south is clearly noticeable. Climate aridification is more pronounced in the Salyan Lowland. While in 2003, precipitation in this area reached up to 450 mm, 18 years later, this indicator has decreased to 240-400 mm. In Vilashchai River valley, previously receiving 600-1000 mm, it has decreased to 600-725 mm in 2021. In 2003, the average annual precipitation in the Gizilagaj Gulf shores was 529-800 mm in the west and 800-1000 mm in the east. However, by 2021, this indicator has decreased to 400-600 mm in both the west and east. The climate aridification trends in the research area have led to significant changes in the structure of irrigated agricultural landscapes and natural landscapes.

Hydrological conditions play a significant role in the formation of landscapes in the research area. Changes in hydrogeological conditions are influenced by Caspian Sea level fluctuations, characteristics of irrigation works, proximity of groundwater to the surface, and the degree of mineralization.

In order to clearly monitor the change in the groundwater level, the groundwater levels in the Salyan Plain in 1975 and 2020 were compared based on existing literature, archive materials, and field research results in the study area. It was found that the irrigation and drainage measures implemented in the Salyan Plain did not yield the desired results, and the level of groundwater in most parts of the area rose to a certain extent.

Table 1

Groundwater level in the Salyan Plain in 1975 and 2020[3]

	Groundwater level (m)	Area (In 1975)		Area (In 2020)	
		km²	%	km²	%
1	> 1	192	8	622	27
2	1,0-2,0	1099	48	757	34
3	2,0-3,0	901	40	549	24
4	3,0-5,0	54	2	346	15
5	5,0-10,0	28	2	-	-
	Total	2274	100	2274	100

To study the anthropogenic transformation of vegetation cover, a comparison of Landsat satellite images from 1987 and 2022 was conducted. Through the calculation and analysis of the NDVI index[4], it was determined that there is an increased vegetation cover associated with the expansion of agricultural fields, especially in the coastal plains.

In order to monitor the dynamics in the area of the forest, materials reflecting the areas covered by forests in 1987 and 2022 were analyzed within the research area. A comparison revealed that in 1987, the forest area was 621 km². Due to deforestation, by 2022, 75 km² of these forests were replaced by forest massifs. Thus, over 35 years, the forest area decreased by 325 km².

[3] Aliyev, F.Sh. Groundwater, use of resources and hydrogeological problems of the Republic of Azerbaijan. - Baku: "Chashioglu", - 2000. - 325 p.

[4] Higginbottom T.P., & Symeonakis E. Identifying Ecosystem Function Shifts in Africa Using Breakpoint Analysis of Long-Term NDVI and RUE Data. Remote Sensing, - 2020 - 12(11), - 1894.

Soil is always subject to varying degrees of human economic impact. Events such as the extraction of soil for construction and transportation purposes in agricultural activities, the development of erosion processes, salinization, pollution, etc., have become global concerns as they affect humanity worldwide[5]. The intensification of anthropogenic influences on the landscapes of the research area has led to increased erosion, salinization, and marsh formation processes in the soils. Salinized soils are more widespread in the landscapes of Salyan and Southeastern Shirvan plain.

After evaluating the natural components based on the degree of change, the natural components of the research area have been classified into eco-geographical regions according to the degree of change, and a corresponding content-rich map has been prepared (Figure 1). At this point, natural components - relief, climate, soil, vegetation, and fauna, have been assessed as a complex.

It has been determined that 24% (1585 km²) of the research area belongs to ecologically protected areas. In 26% (1705 km²) of the area, natural components are weakly affected, in 40% (2598 km²) moderately affected, and in 10% (680 km²) strongly transformed[6].

Environmentally protected areas include the main parts of semi-desert, wetland, meadow-wetland, and forest landscapes in Shirvan, Gizilaghaj, and Hirkan National Parks, respectively. Areas with minimal changes in natural components include shrub-meadow landscapes along the Kura River and semi-deserts in the western part of the Salyan Plain. Moderately altered areas include semi-deserts in the eastern part of the Salyan Plain, meadow-forest, and intrazonal landscapes of the Lankaran Lowland, and the Pirsaatchay Basin. Strongly affected areas include the forest landscapes of the foothill areas in the Lankaran Lowland, where the absolute altitude is relatively high. (Figure 1).

[5] Mammadov, G.Sh., Khalilov M.Y., Mammadova S.Z. Agroecology. Baku: Elm, - 2010, - 552 p.

[6] Nadirov, M.A. Ecogeographical risks and anthropogenic transformation of geosystems on the coastal plain of Caspian sea // География та туризм, – Киев: – 2021, – Vol. 61 – pp. 59-65.

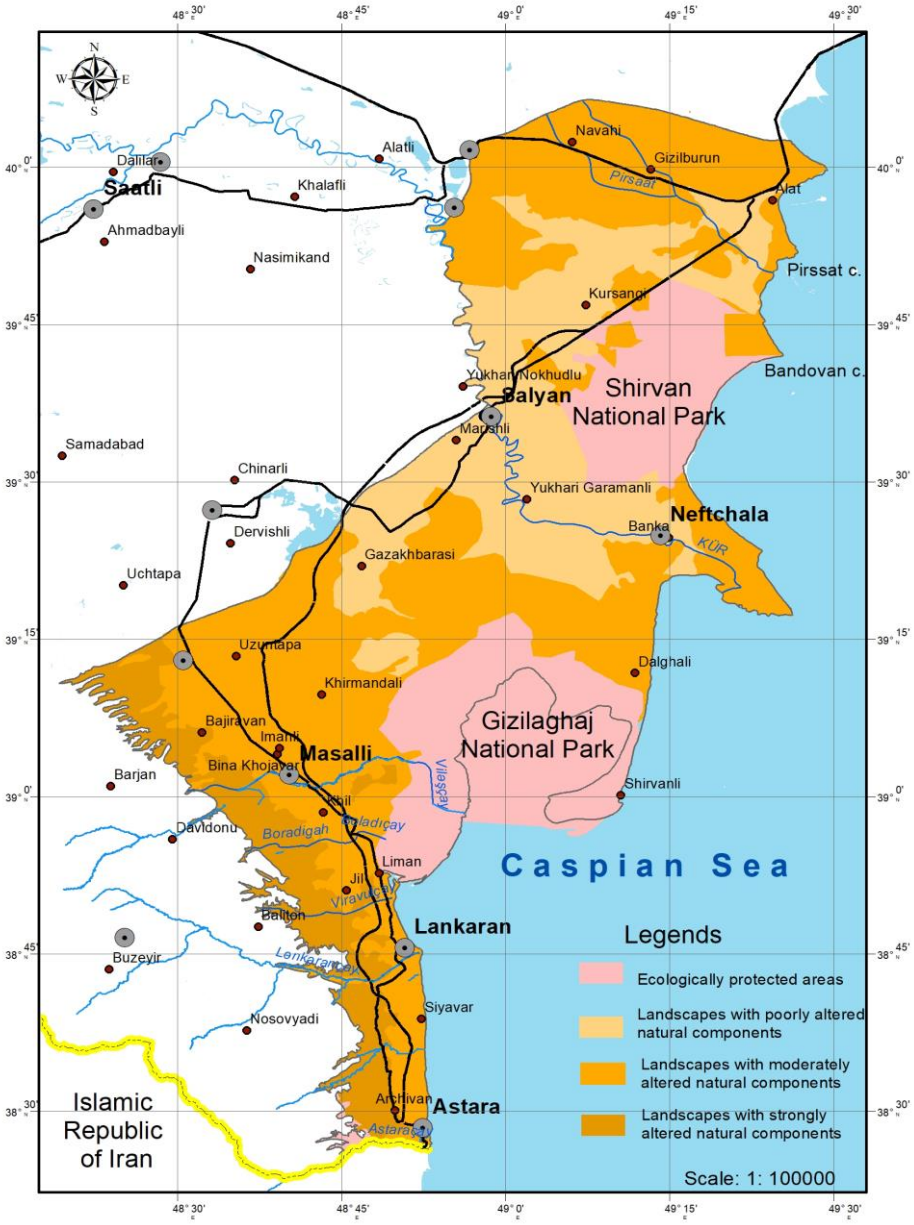

Figure 1. Ecogeographical zoning of the Caspian coastal plains

In the third chapter of the dissertation, "**Anthropogenic transformation of landscapes and its ecogeographic consequences**" was studied.

Anthropogenic landscapes are complexes regulated and managed by humans, performing certain economic and technical functions[7].

The ecology of the investigated area's modern landscapes has emerged as a result of complex, long-term interactions and influences between natural and historical (anthropogenic) factors.

The analysis of landscape anthropogenic transformation is mainly based on field research works and the analysis of satellite images of the area. The majority of the research area consists of winter pastures, grazing areas, and cultivated fields. This requires special attention to the eco-geographical characteristics of landscapes during anthropogenic influences on the area.

Transformed landscapes can restore their previous state after a certain period when the intensity of anthropogenic influences weakens or ceases entirely. However, traces of anthropogenic influences linger in natural landscapes for an extended period in various forms and levels. The intensity of anthropogenic influences on landscapes depends on the current level of socio-economic development. The formation of more environmentally sustainable anthropogenic landscapes is a result of the high development of productive forces and the purposeful and planned application of new technologies and techniques.

Our analysis indicates that in the northern part of the research area, specifically the Pirsaat basin, extensive areas along the Kura River coast, and the Salyan plain are primarily used for agriculture. The eastern part of the Salyan plain and the right bank of the Pirsaat River consist mainly of pasture and grazing areas. In the western part of the Lankaran lowland, where there is significant elevation, forests are widespread, and in areas where forests have been cleared, forest

[7]Ismayilov M.J. The main factors influencing the ecology of Kura depression landscapes / Materials of the scientific-practical conference "Man and Nature", Baku: - 2002, - pp. 23-27.

massifs can be found. Sand dunes along the coast of the Caspian Sea, small streams and oxbow lakes are widespread along the coast of the Kura River.

Agriculture is the most crucial sector in transforming landscapes compared to other economic directions. Plowing of raw and rested lands, sowing, and plantations that cause a change in the physical-chemical structure of the upper horizon of the soil destroy the main mass of wild vegetation and replace the natural cover with agricultural areas.

During the research, it has been determined that coastal plains have undergone varying degrees of anthropogenic transformation. The amount of aboveground phytomass is several times lower compared to undisturbed grass and shrub complexes (Shirvan and Gizilaghaj National Park). The ecological condition of the landscapes in the researched area has been significantly altered not only by anthropogenic influences but also by natural factors such as strong winds from the sea, abrasion, etc. A notable example is the impact of sea level fluctuations that have persisted since 1978.

Due to the arid climate in the research area, irrigated agro-landscapes have been characteristic here since ancient times. Despite the ongoing intensive irrigation systems causing significant structural changes in landscapes, the newly created agro-irrigation complexes consistently maintain higher productivity compared to the past. This is mainly attributed to the abundance of water in the rivers during the spring months, enriching the ecosystem with nutrients carried by the waters themselves. As a result, despite increasing anthropogenic influences, these complexes can relatively preserve and protect their productivity and ecological balance. However, the recent occurrence of drying in the lower part of the Kura River has posed serious problems for the development of modern landscapes.

Based on satellite data, it has been determined that within the research area, the area of cultivated lands is 2472 km² (37.6% of the research area), pasture and grazing complexes cover 147 km² (22% of the research area), residential areas occupy 585 km² (9% of the research area), roads cover 12 km² (0.2% of the research area), protected areas encompass 1,585 km² (24% of the research area), and

the area of forests and forest massifs is 325 km² (5% of the research area).

Intensively irrigated agrocomplexes in the study area are more widespread in Salyan, Neftchala and Jalilabad districts. These areas encompass a significant portion of the Salyan and Shirvan plains, as well as the majority of the Lankaran lowland and only Salyan distcrit. According to the information from the State Statistics Committee of the Republic of Azerbaijan[8], the cotton cultivation area increased 3.4 times to reach 5010 ha, while fruit and berry crops increased by 11% to reach 894.2 ha between 2010 and 2020. However, the cultivation areas for wheat, sunflower, potatoes, vegetables, and melons decreased during this period. Wheat cultivation decreased to 5556 ha, potato cultivation decreased by 5.3% to 428 ha, vegetable cultivation decreased by 9.8% to 1385 ha, and melon cultivation decreased by 16% to 1007 ha. The cultivation area of sunflower crops has significantly decreased.

According to statistical data, in the Neftchala region, the wheat cultivation area has decreased, while the cultivation areas for cotton, potatoes, fruits and berries, and grapes have expanded. The wheat cultivation area has decreased by 36.7%. Potato crops increased by 55.5%, fruit and berry crops by 3.7%, melon crops by 4.8 times, and cotton crops by 3.2 times. Our calculations indicate a 34% increase in wheat productivity, a 3.5% increase in vegetable cultivation, and a more than 4.5 times increase in productivity for melon crops and cotton cultivation.

Industrial-technogenic complexes include road complexes with various technogenic covers. The construction, operation, and restoration of various types of railways and roads with different coverings have varying degrees of negative impact on different components of the landscape. The construction and use of these roads fragment forest and steppe landscapes, altering the distribution of relief, soil composition, lithological basis within the landscape,

[8] Agriculture of Azerbaijan, State Statistical Committee of the Republic of Azerbaijan, Baku, 2023, 709 p.

disrupting habitats for animals and migration routes, and changing microclimatic conditions.

In the study area, depending on the structure and function of the road complexes, different degrees of anthropogenic type facies and species were formed in the landscapes. In this case, the soil-plant cover of the landscapes, which forms the background in road complexes, undergoes significant changes, and an entirely new artificial cover is created.

Depending on the natural-geographical conditions of the area, swampy areas have formed as a result of collecting surface waters along the edges of roads during various-purpose road construction. It should be noted that, mainly in the areas of Badalan, Babaser, Gizlavar, Khil, and Girdani villages along the Baku-Astara highway, swamp-bush and swamp-meadow complexes with an area of 0.2-0.8 hectares have formed due to the collection of various surface waters along the roadside. In addition to this, in swamp-meadow, steppe-meadow complexes, etc., artificial ridges with a height of 1.5-2 meters are formed during road construction. In the bushy-dry steppe, semi-desert, and bush-meadow complexes, the height of these road ridges is 0.5-1 meter.

The study area is rich in oil and gas reserves. This sector has developed in the Salyan and Neftchala districts. Additionally, in Salyan, there are plastic mass production plants (producing plastic mass, polyethylene covers, pipes, etc.), and in Neftchala, there are plants producing iodine-bromine (based on mine-bore waters). In recent years, there has been an increase in the number of industrial parks in operation.

To track the development dynamics of urban complexes, the area dynamics of residential areas with urban characteristics located in the research area were analyzed using the ArcGIS program. As seen in Table 2, over the past 47 years, the area of residential areas has significantly expanded, especially noticeable in the area of district centers.

Table 2

The dynamics of urban areas in 1975-2022

The name of the cities	Area (km²)		The growing area during the period 1975-2022	
	In 1975	In 2022	km²	%
Lankaran	7,5	12	4,5	60
Astara	6,5	9,9	3,4	52
Jalilabad	11,6	20	8,4	72
Neftchala	8,8	10,5	1,7	19
Salyan	8,4	16	7,6	90
Masalli	7,6	10,3	1,7	36

In order to determine the level of anthropogenic transformation of natural complexes and development trends in the Lankaran natural-geographical region, the digital map of landscapes that can be formed from the ratio of heat and humidity in the conditions of natural climate humidification and the large-scale (1:100,000) map layers of existing natural landscapes compiled in 2020 were compared with ArcGIS software. Result of comparison determined that, the area of forest landscapes that can be formed under natural humidification conditions is 4427.8 km^2. According to this indicator, the forest coverage index of the study area is equal to 0.73. 1,986.2 km^2 (or 44.9% of the total forest area) of forests formed under Natural Humidification Conditions were arid forest landscapes. During the past historical periods, forests were cut down by humans and transformed into different anthropogenic and natural-anthropogenic landscapes. As a result, arid mountain forests (transformation index 0.2), arid (0.0), semi-humid (0.0), humid (0.0) and extremely humid (0.01) forest landscapes of the plains can be formed under natural humidification conditions. accordingly, there was a substantial transformation into xerophytic dry steppe and grassland-shrub landscapes.

The study of ecological stability and ways of its optimization is one of the important directions in the sustainable development of the region. For this purpose, the role of forest ecosystems in ecological stability was evaluated. Currently, the total area of forests in the Lankaran natural-geographical region is 1472.3 km^2, which constitutes 24.3% of the total area of the region. The forest cover in the research area is twice as high as the average national indicators, but it lags behind the global average by 1.5 times. Currently, the ecological condition of the region is closely linked to the structural-functional characteristics of forest ecosystems. To investigate this problem, the forest cover and ecological stability indices have been determined for the administrative districts of the researched area.

Conducting the calculations for the administrative districts enhances the innovativeness of the obtained results and contributes to making timely political decisions (Table 3).

Table 3

The distribution of ecological stability across administrative districts in the Lankaran natural-geographic region[9]

Districts	**Total area (S_2) km^2**	**Forested area (S_1) km^2/ %**	**Forest cover index (M_1)**	**Agroecosys-tems (S_3) km^2/ %**	**Ecological stability index $\Sigma_i = S_1 / S_3$**	**Difference of Σi from average region level**	**Assessment**
1. Astara	616,4	371,8 / 60,3	0,6	175,6 / 28,5	2,1	+1,6	Normal favorable
2.Yardimli	667,2	172,6 / 25,9	0,3	418,9 / 62,8	0,4	-0,1	Weakly favorable
3. Lerik	1083,6	358,9 / 33,1	0,3	577,9 / 53,3	0,6	+0,1	Moderately favorable
4. Lankaran	1539,4	290,5 / 18,9	0,2	272,6 / 17,7	1,1	+0,6	Normal favorable
5. Masalli	720,9	168,8 / 23,4	0,2	358,9 / 49,8	2,0	+1,5	Normal favorable
6. Jalilabad	1441,4	110,1 / 7,6	0,1	1081,8 / 75	0,1	-0,4	Weakly favorable
7.General region	6069,04	1472,8 / 24,3	0,2	2885,8 / 47,5	0,5	=	Moderately favorable

[9] Nadirov, M.A. "Ecodynamic Problems of Forest Landscapes in the Lankaran Natural-Geographical Region and Their Improvement" // Proceedings of the Azerbaijan Geographical Society. Geography and Natural Resources, – Baku: – 2019, – No. 1(9) – pp. 33-39.

As analyzed in Table 4, the ecological stability index varies between 0.1 and 2.1 across the region. Astara district has the highest value of 2.1, Masally and Lankaran districts have values of 2.0 and 1.1, respectively. Overall, ecological stability in these districts has been assessed as normal. In Lerik district, the ecological stability is moderately favorable with an index of 0.6, while Yardimli and Jalilabad districts are considered weakly favorable with values of 0.4 and 0.1, respectively.

The fourth chapter of the dissertation is titled "**Classification of Modern Landscapes According to Natural Reserve Potential**". For the evaluation of the ecological potential of the landscapes in the research area, natural components were assessed in a complex manner. During the assessment, each component was individually evaluated using a scoring system based on its role in human life. As a result, a large-scale digital map (1:100,000) reflecting the evaluation of the natural reserve potential of modern landscapes in the research area has been prepared (Figure 2).

Landscapes with weak natural resource potential cover 23% of the research area, with an area of 1500 km². These landscapes encompass the Jalilabad district, the Pirsaat River basin, and the narrow strip of the Caspian coast. The productivity ranges from 5-6.5 s/ha, and is included in the low-productivity group.

The soil cover includes gray-brown, salt marshes, flooded alluvial-meadow, and the vegetation consists mainly of semi-deserts and restored plants in former semi-desert areas. The road density is rated at 5-7 points. The tourism-recreation potential is assessed at 3-6 points.

Landscapes with a moderate level of natural resource potential cover 42% of the research area, with an area of 2787 km². These landscapes encompass parts of the Salyan and Southeast Shirvan plains, as well as the northern-eastern parts of the Lankaran lowland. The productivity of the aboveground portion of natural phytomasses is 4-5 s/ha or less, categorizing them as very weak and weakly productive landscape groups.

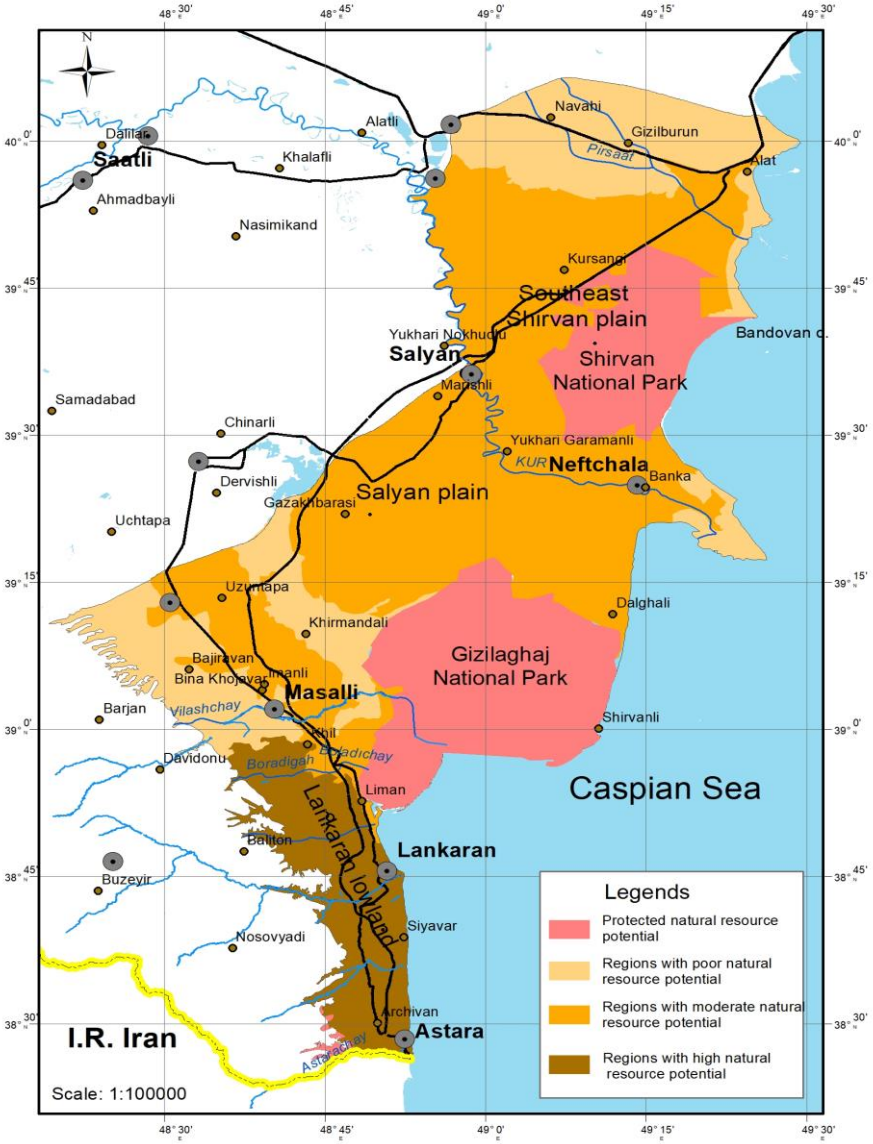

Figure 2. The map of the assessment of the natural reserve potential of modern landscapes in the coastal plains of the Caspian Sea

The soil cover includes areas with gray-meadow, sandy areas, and salt marshes, while the vegetation consists mainly of semi-deserts and restored plants in former semi-desert areas. The road density is rated at 3-5 points. The tourism-recreation potential is assessed at 1-3 points.

Landscapes with a strong natural resource potential cover 11% of the research area, with an area of 696 km². These landscapes include the Lankaran lowland, plain forest and meadow-forest landscape, and areas along the Kura River. The productivity of the phytomass ranges from 6-6.5 s/ha, sometimes reaching 28-30 s/ha, classifying them as highly productive landscape groups. The soil cover includes podzolized yellow, flooded alluvial-meadow soils, and the vegetation consists mainly of coastal Tamarix and psammophytes, as well as plain forest plants. The road density is rated at 8-10 points, and the tourism-recreation potential is assessed at 6-8 points.

Landscapes with a protected natural resource potential cover 24% of the research area, with an area of 1585 km². These landscapes encompass the main part of the Shirvan, Gizilaghaj, and Hirkan National Parks. The soil cover includes meadow-swamp, marsh, gray-meadow, sandy areas, and salt marshes. The vegetation consists mainly of semi-deserts, restored plants in former semi-desert areas, coastal psammophytes, and reed beds. The road density is rated at 0-2 points, and the tourism-recreation potential is assessed at 8-10 points.

Study of the sensitivity of landscapes' natural resource potential to anthropogenic impacts is crucial for enhancing the effectiveness of their sustainable use and management. The sensitivity of landscapes to edge effects influences their ecological resilience. Ecological resilience refers to the ability of different landscapes to maintain their structure and functionality in the face of various impacts.

Landscapes' resilience is subject to various degrees of degradation due to the impact of natural, ecological, and socio-economic anthropogenic factors. This impact is observed, particularly in the Neftchala and Salyan districts, where the most significant industrial complex in the studied area has developed, as

well as in the portion of the research area falling within the Baku economic region.

Baku economic region stands out with a tense ecological condition compared to other areas. This region hosts industrial zones exerting strong technogenic influences on the surrounding environment. Additionally, the observed fluctuations in the Caspian Sea level, natural-anthropogenic desertification processes, and other conditions contribute to increased ecological tension in the research area.

Antropogenic factors play a dominant role in the degradation of the ecological sustainability of the geosystem. The geographic location of the research area, its direct contact with the Caspian Sea, the extensive transportation network connecting it with neighboring states to the north and south, seliteb complexes covering large areas, and the oil and gas fields in the Southeast Shirvan and Salyan plains all significantly impact the ecological sustainability of the studied area. In this context, the resilience characteristics of landscapes are closely related to their ability for self-regulation and self-restoration against the mentioned anthropogenic influences.

Considering the resilience and sensitivity of the landscapes in the studied area to ecological tense, 4 landscape zones have been identified, and a digital ecological stress map has been prepared (Figure 3).

The landscapes in sufficient and satisfactory condition cover 24% of the research area, with an area of 1585 km². This includes the entire Gizilaghaj and Shirvan National Parks, as well as a part of the Hirkan National Parks. The degree of environmental degradation in these landscapes is determined to be between 0-40 points (Table 4).

Landscape zones with relative tense cover 41% of the research area, with an area of 2713 km². This includes the Pirsaatchay basin and parts of the Salyan and Southeast Shirvan plains. The degree of environmental degradation in these landscapes is determined to be between 41-60 points.

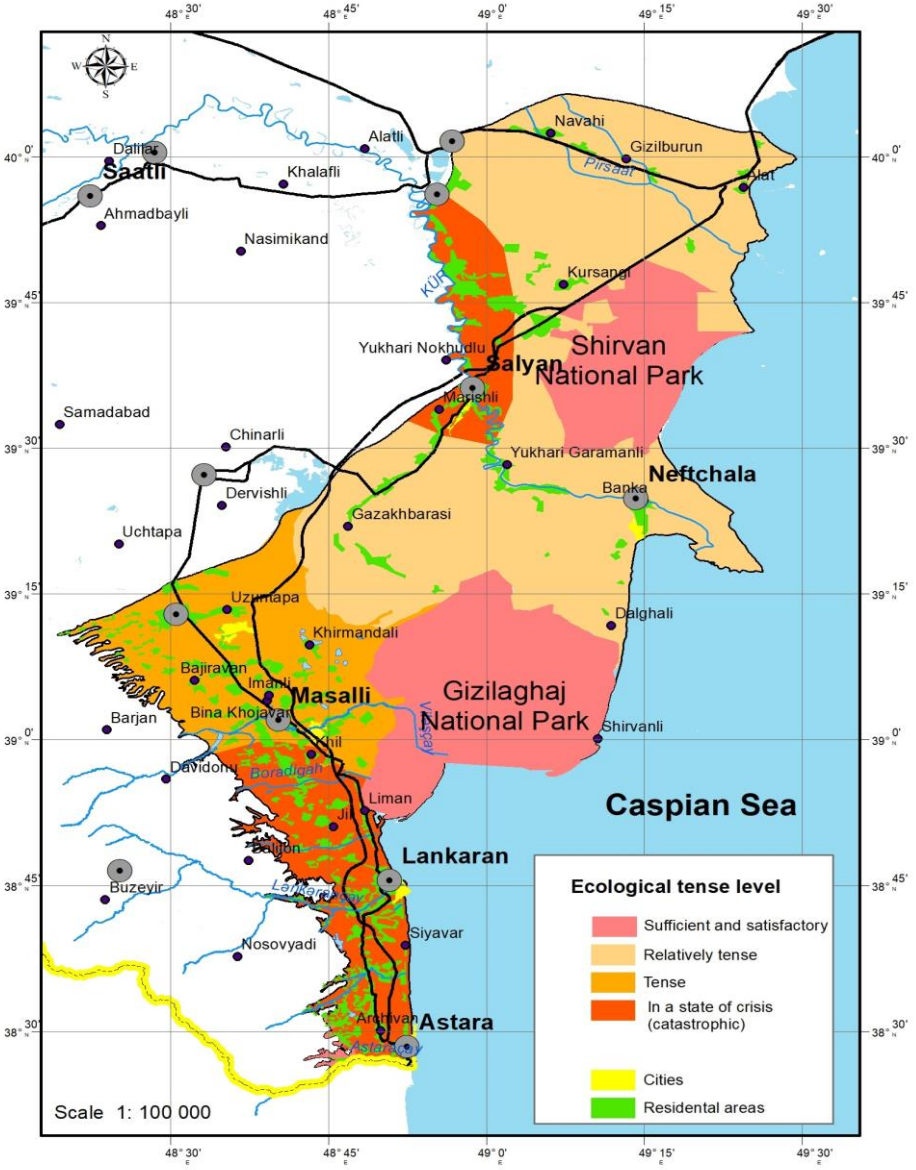

Figure 3. Ecological tension map of Caspian coastal plains landscapes

Table 4

The degree of ecological stress of the landscapes of the Caspian coastal plains

Degree	Ecological tense level	Areas covered	Area		Environmental degradation, points
			km²	%	
I	Sufficient and satisfactory	Specially protected areas	1585	24	0-40
II	Relatively tense	Pirsaatchay basin, part of Salyan and Southeastern Shirvan plains	2713	41	41-60
III	Tense	Jalilabad district and its adjacent areas	1120	17	61-80
IV	In a state of crisis (catastrophic)	Plain forests, Salyan city and surrounding areas	1150	18	81-100

Landscape zones under tension cover 17% of the research area, with an area of 1120 km². This situation encompasses the Jalilabad district and its adjacent areas. The degree of environmental degradation in these landscapes is determined to be between 61-80 points.

Landscape zones in a crisis state cover 18% of the research area, with an area of 1150 km². This includes the city of Salyan and its surrounding areas, as well as the plain forests. The degree of environmental degradation in these landscapes is determined to be between 81-100 points.

Therefore, after determining the natural landscape potential and the degree of ecological stress of geocomplexes, preparing a system of measures aimed at optimizing ecosystems is an important factor. For this purpose, it is recommended to consider the following measures for the optimal management of landscape complexes in the research area:

- Implementation of landscape-ecological planning during the organization of recreational complexes, infrastructure projects,

industrial parks, agro-parks, etc., especially in landscape complexes, including plain forests, the coastal sandy areas of the Caspian Sea;

- Taking into account the structural and functional characteristics of natural landscapes during the development of agricultural areas, cleaning the old collector drainage network against salinization and other problems, and creating new ones, installing covers on irrigation canals and applying modern irrigation technologies;

- Establishing a centralized electronic database at the administrative levels (district, municipality, etc.) tailored to the existing water reserves and the demands of water users in response to climate changes;

- Strict adherence to grazing norms determined by the Cabinet of Ministers with relevant documents in landscapes prone to desertification, weak stability, and sensitivity;

- To ensure ecological stability, it is essential to increase the forest cover in areas deforested due to anthropogenic activities by planting drought-resistant trees and shrubs suited to local conditions. In the near future, this would aim to achieve forest cover of 30% in Masalli, 20% in Jalilabad, and 10% in Salyan and Neftchala.

- The organization of implementing tourism-recreation complexes that meet modern standards in existing settlement complexes, including 'smart' village projects;

- Recording, preserving, creating an electronic database, and mapping selected natural monuments with unique features and importance are crucial directions for maintaining ecological balance in the area and promoting ecotourism.

- It is important to reduce the pollution of ecosystems by applying modern and ecologically clean technologies in oil and iodine-bromine production mines against the risks of man-made disruption, recultivation of 1550 ha of severely polluted lands, and application of waste-free technology in the Neftchala iodine-bromine plant.

CONCLUSION

1. Factors affecting the differentiation of landscapes in the Caspian coastal plains have been studied based on modern methods and field research. These factors include morphometric indicators of relief (such as elevation, slope, and aspect), the lithological composition of rocks, the characteristics and interactions of mountain ranges, various air masses affecting the area, and anthropogenic activities. The study identified regular changes in the landscapes from south to north, including forest and meadow-forest, forest-steppe, dry steppe, semi-desert, and hydromorphic-intrazonal landscapes. A corresponding large-scale (1:100,000) digital natural landscape map was also developed. The analysis of the map revealed that the landscapes are classified into 4 types, 8 subtypes, and 35 species, with 54% of the area being semi-deserts, 14% forests and forest-meadow, 26% forest-steppes, and 5% hydromorphic-intrazonal landscapes.

2. The structural-functional and genetic characteristics of landscapes in the Caspian coastal plains have been analyzed in the modern environment of Geographic Information Systems using mathematical-statistical methods. The distribution of morphometric indicators of the relief based on the DEM (Digital Elevation Model) of the area has been examined by landscape types, and the regularities of their influence on the differentiation and transformation of natural landscapes were determined.

3. Based on the study of the degree of natural component changes in the research area, a classification of landscapes has been conducted for eco-geographical zoning, and the corresponding map has been prepared. It has been determined that 24% (1585 km²) of the research area consists of ecologically protected areas (Shirvan and Gizilaghaj National Parks). 26% of the area (1705 km²) has weakly changed natural components (mainly the shores of the Kura River); 40% (2598 km²) is moderately changed (Salyan plain, Pirsaatchay basin); and 10% (680 km²) represents strongly changed areas (Lankaran lowland).

4. For the first time, the landscapes of the research area have been evaluated in terms of their structural-genetic characteristics, climate, soil cover, biological productivity of plants, and tourism-recreation resources, leading to the creation of a corresponding large-scale map. The landscapes of the area are classified into four groups based on their natural resource potential. 1. Landscapes with preserved natural resource potential; 2. Landscapes with weak natural resource potential; 3. Landscapes with moderate natural resource potential; 4. Landscapes with high natural resource potential.

5. The ecological tension level of the area based on the ecological resilience to natural and anthropogenic impacts has been determined in the Caspian coastal plains, and the respective map has been prepared. Four groups have been identified according to ecological tension: I. Landscapes with sufficient or satisfactory ecological conditions, covering 24% of the total area with environmental degradation rated 0-40 points; II. Landscapes in an ecological relatively tense state, representing 41% of the total area with environmental degradation rated 41-60 points; III. Landscapes in a tense state, constituting 17% of the total area with environmental degradation rated 61-80 points; IV. Landscapes in a crisis state, making up 18% of the total area, with environmental degradation rated 81-100 points.

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