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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

GEOGRAPHICAL BASICS OF ENSURING SUSTAINABLE DEVELOPMENT OF AGROCENOSES OF NAKHCHIVAN AUTONOMOUS REPUBLIC

Specialty:	5408.01 – Physical geography and biogeography, soil geography, geophysics and geochemistry of landscapes
Field of science:	Geography
Applicant:	**Leyla Panah Ibrahimova**

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The dissertation work was carried out at the "Geography" department of the Faculty of Natural Sciences and Agriculture, Nakhchivan State University.

Scientific supervisor: Doctor of Geographical Sciences, Professor
Yagub Ali Garibov

Official opponents: Doctor of Geographical Sciences, Associate Professor
Ilham Ildirim Mardanov

Doctor of Philosophy in Geography, Associate Professor
Museyib Idris Yunusov

Doctor of Philosophy in Geography, Associate Professor
Laman Hasan Hasanaliyeva

FD 2.51 Dissertation Council operating under the Baku State University of the Supreme Attestation Commission under the President of the Republic of Azerbaijan.

Chairman of the Dissertation Council: Doctor of Geographical Sciences, Professor
Chingiz Niyazi Ismayilov

Scientific secretary of the Dissertation Council: Doctor of Philosophy in Geography, Associate Professor
Sahila Abish Allahverdiyeva

Chairman of the Scientific Seminar: Doctor of Geographical Sciences, Associate Professor
Stara Abulfaz Tarikhazer

GENERAL CHARACTERISTIC OF THE WORK

The actuality of the topic and level of research on the topic. In modern times, more attention is paid to efficient use of land, bringing agricultural fields as close as possible to natural analogues, achieving high productivity, introducing new farming systems and switching to innovative technology. Application of intensive technologies to soils and fruit growing, as well as long-term monoculture, leads to soil dehumidification, deterioration of water-physical, chemical and physico-chemical properties, and development of erosion processes. In such conditions, the use of new varieties that are not sufficiently resistant to abiotic and biotic factors to increase productivity, protect plants from pests and diseases, as well as require the use of high amounts of agrochemicals, which causes soil, plant and fruit contamination.

One of the ways to overcome the negative trends prevailing in horticulture, to increase the sustainability and ecological purity of garden agrocenosis is to reduce the chemical load and activate biological processes. These processes include increasing the biodiversity achieved by inter-row sowing of cultivated crops for manure and perennial grasses, as well as increasing their diversity through the use of microbial fertilizers. Microbial fertilizers are used to enhance the environment-forming and protective role of the phytocomponent of agrocenosis, to increase plant nutrition and resistance. Therefore, in order to ensure the sustainable development of agrocenoses, it is important to develop its geographical basis.

Considering that the research area, the Nakhchivan Autonomous Republic, is one of the most important horticultural and agricultural regions of our country, our research is dedicated to the actual topic. Although the socio-economic development of the villages in the Nakhchivan Autonomous Republic has been evaluated as a positive thing in recent years, it has not been possible to fully solve the existing problems. As a result of the agrarian reforms carried out in the country, land was divided into forms of ownership, but it led to a decrease in the prestige of

agricultural labor and a flow of personnel. In this regard, the main goal of the state agrarian policy is the formation of a sustainable and efficient development model of agrocenoses, which is a priority area in the implementation of the Strategic Road Map for the development of agriculture. By using the internal resources of the region, it will allow to diversify the economy and improve quality parameters in agriculture.

The geographical basis of ensuring the sustainable development of agrocenoses has been widely studied by foreign scientists G.K. Zvereva, N.M. Kasimov, V.A. Kulakov, T.V. Leonidova, Z.I. Kurbatova, V.V. Moskvin, V.P. Sutyagin, V.A. Tyulin, V.I. Titova and others, and in the country by Y.A. Garibov, M.C. Ismayilov, G.Sh. Mammadov and others.

Research object and subject. The object of the research work is the agrocenoses existing in the Nakhchivan Autonomous Republic and the subject is the study of factors affecting their sustainable development.

The purpose and the missions of investigation. The main purpose of the study is to determine the influence of the natural landscapes of the research area on the development of agrocenoses and to develop the scientific and practical basis of their sustainability. In order to achieve the primary purpose, the following missions were raised in the dissertation:

- to analyze the natural landscapes based on the GIS technologies and determine the impact on the development of agrocenoses;
- to study the dynamics of agrocenoses, to study the problems that may arise in their sustainable development;
- to analyze the impact of environmental threats caused by anthropogenic transformation of natural landscapes on the sustainable development of agrocenoses;
- to develop the methodology of sustainable development of agrocenoses and the concept of measures;
- carry out zoning of agrocenoses for the establishment of sustainable agriculture in the region.

The methods of research. GIS (Geographic Information

Systems) technologies used in the study of plant and soil cover in the implementation of the research work are modern (NDVI, NDVI, NDMI, SAVI), as well as traditional historical-geographical, mathematical-statistical, cartographic, field-investigation, comparison, observation, systematic analysis, etc. methods have been applied.

The main provisions to be defended.

1. The effect of vertical differentiation of landscapes on the diversity of agrocenoses (in the GIS environment).

2. Development dynamics and potential opportunities of agrocenoses

3. Environmental dangers caused by the transformation of natural landscapes, sustainable development of agrocenoses

4. Concept and zoning that ensures sustainable development of agrocenoses and improves their productivity in the region.

The scientific innovations of the dissertation:

- the factors affecting the vertical differentiation of natural landscapes were analyzed based on the GIS technologies and the characteristic of the distribution of agrocenoses on each landscape was determined;

- the development dynamics of agrocenoses were studied, the distribution areas of modern agrocenoses were studied;

- the ecological problems caused by anthropogenic transformation in landscapes were studied, and the environmental danger levels of landscapes were determined and the area was divided into weak, moderate, increased risk and crisis categories;

- for the sustainable development of agrocenoses, their regionalization was carried out and a plan of actions to be taken in the future was prepared;

Theoretical and practical significance of research. For the first time, the study of the relationship between the sustainable development of agrocenoses and the vertical differentiation of natural landscapes using modern methods has enriched the study of this problem theoretically.

The results obtained in the research process are of practical importance for the implementation of measures aimed at ensuring

the sustainable development of agriculture. It can be extremely useful for the balanced and sustainable development of the area in the placement of various fields of agriculture, in solving the food security of the local population, in preventing the impact of some frequently repeated natural destructive processes on the sustainable development of agrocenoses, in the efficient use of natural landscapes and in their protection.

Approbation and application of the research. The main results of the dissertation were reported and discussed at the following republican and international conferences: II International Conference of Young Scientists (Baku, 2018), "Young Researchers Conference" (Warsaw, 2018), "Development of Ecologically Clean Agriculture of Azerbaijan" International Conference (Ganja, 2019), "Information, Science, Technology and university perspectives" international conference (Lankaran, 2020), "Scientific research in the 21st century" international conference (Ottawa, 2021), "Modern problems of geography: integration of science and education" I and II international scientific-practical conference (Baku, 2022, 2023), "Environmental restoration of degraded landscapes and natural resource potential" scientific conference (Grozny, 2023).

The use of practical and scientific proposals put forward in the thesis work may be appropriate for the ministries of Agriculture, Ecology and Natural Resources of the Republic of Azerbaijan, local government bodies, investors and organizations.

The entity where the dissertation was developed. Dissertation work was carried out at the "Geography" department of the Faculty of Natural Sciences and Agriculture, Nakhchivan State University.

The total volume of the dissertation with a sign indicating the volume of the structural sections of the dissertation separately. The thesis consists of an introduction, 4 chapters, a conclusion and a list of references, the total volume is 152 pages. The work consists of 16 figures, 21 tables, 2 charts and 4 diagrams, and 129 titles of literature. Introduction – 4 pages (7091 characters), chapter I – 30 pages (55167 characters), chapter II – 39

pages (64991 characters), chapter III – 32 pages (58631 characters), chapter IV – 29 pages (52823 characters), conclusion – 2 pages (2197 characters), proposal 1 page (1561 characters) without tables, graphs, pictures, and bibliography, it consists of 226945 characters.

A BRIEF SUMMARY OF THE DISSERTATION

The **introduction** provides information about the actuality and research level on the topic, the purpose and missions, methods, the main provisions defended, scientific novelty, the theoretical and practical significance of the research, approbation, and application.

The first chapter of the dissertation work is called "**Differentiating features of modern natural landscapes of Nakhchivan Autonomous Republic**". In this chapter, it was determined that the main reason for the height differentiation of landscapes in the research area depends on the geographic latitude zone and hypsometric height of its location. The absolute elevation of 67% of the region is higher than 1000 m above sea level, and the relationship between heat and humidity has formed different types of vertical structure here.

In addition to the above, the north and south, east and west direction of the slopes, as well as their inclination, create certain differences in the distribution of landscapes. This diversity manifests itself both in the sequence of landscapes, in their replacement, in their areas, and in the separation of subtypes, species, zones and facies within the landscape. Thus, 54 landscape subtypes are distributed in the study area.

The inclination and slope of the topography also have an effect on the development of agrocenoses. The fact that the landscape complex is higher on the north-facing slope than on the south side causes the latter to receive more sunlight than the former. This, in turn, affects the duration of the vegetation phase of flora. 20.4% of the study area is located in south and southeast, and

5.8% of the area is located in north-facing slopes. The fact that the northern and northeastern exposure slopes are a minority creates certain difficulties in the development of agrocenoses in the area.

This chapter also explores the differentiation of each landscape type. 10% of the total area is occupied by subnival and nival landscapes, which have relief features rich in concave-protruding watersheds, steep and precipitous mountain slopes, river valleys, cirques. In 98% of these landscape types, the slope inclination is above 16º. Unfavorability of relief and climatic indicators has caused agrocenoses not to develop here.

13.1% of the agricultural land in the region is located in subalpine and alpine meadow landscapes. The mountain-meadow landscapes located between the subnival landscape and the forest landscape in the highlands are spread between the arid-sparse forests and the landscapes of the middle highlands due to the lack of mountain forests in the territory of Nakhchivan AR. Depending on orographic features and anthropogenic influence, sometimes the lower border of this landscape zone drops to 1600 m above sea level. Arid sparse forests and landscapes of medium highlands are sharply divided, formed in narrow and steep watersheds and steeper slopes, therefore, they have relatively poor productivity and are not suitable for the development of agrocenoses.

In the Nakhchivan Autonomous Republic, the mid-mountainous zone covers a large area with an absolute height of 1500-2500 m in Ordubad and Shahbuz districts. The relief of ridges and ranges separated by rivers and their tributaries, complicated by erosion-denudation processes, plays an important role in the formation of mountain steppe landscapes. These landscapes cover 2,042 km^2 of the study area, and most of the slopes in the area where they are spread are south, south-west and south-east. In the mid-mountainous part of the research area, there are settlements along the river valleys, and in the surrounding areas are surrounded by gardens and greenery. Here, agrocenoses (cereal growing, fruit growing, tobacco growing) and livestock farms have developed.

The dry-desert, arid sparse forest-shrub and semi-desert

landscapes of the lowland and foothill plains include sloping plains of the studied region, lowland and plateau depressions, widened flow cones of rivers, small arid-denudation hills and ridges, as well as smooth plains. Covering a wide area at an altitude of 650-1300 m above sea level, these landscapes extend from the Sadarak plain, which covers the western part of the Autonomous Republic, to the sloping plain. In 85.9% of these areas, the inclination of the slopes is lower than 15°, and in 60.1%, the aspect of the slopes is south, southeast and southwest. Such relief conditions are favorable for the development of various agrocenoses within the studied landscape type. The Sadarak Plain is suitable for growing fruits, grapes, grains, tobacco, sugar beets, fodder crops and others. In the Sharur and Nakhchivan plains, it is possible to develop cereal crops, sugar beet, grapes, tobacco and fruit growing. In the terraced sloping plain of Nakhchivanchay and Jahrichay, located south of Vayxir and Payiz villages, the poor division of the terrain is partially favorable for agrocenoses, technical and cereal crops are planted. It is impossible to grow agrocenoses in the primitive gray soils of intensively fragmented sloping plains, arid-denudation low mountain areas and badlands. The light chestnut and gray-brown soils of the relatively intensively divided mountains are suitable for the planting of various orchards, melons and vegetables, and grain cultivation.

In the second chapter of the thesis called **"Anthropogenic transformation of the natural landscapes of the Nakhchivan Autonomous Republic"**, the change of the mountain geosystems of the research area during historical periods was analyzed and divided into 4 periods. Each of the most ancient and ancient, medieval, new and modern stages of transformation has been extensively interpreted.

In the first period, the area of agrocenoses was not very wide. The population, whose main occupation is hunting and gathering, began to develop cattle breeding and agriculture over time. Natural ecosystems in the foothills, river valleys, and low mountainous areas have been replaced by agro-landscapes.

In the II stage (the end of the III-XVIII centuries), the area of

agrolandscapes expanded and began to cover the middle mountainous areas. Cereal crops and orchards have been planted here.

In the 3rd period (until the middle of the 18th-20th centuries), the growth of agriculture and animal husbandry stimulated the rapid development of agrocenoses. In this period, the field of fruit growing, especially subtropical fruit growing, vegetable growing, horticulture, cotton growing, and viticulture began to cover a wide area.

The last modern stage IV covers the period from the middle of the 20th century to the present. In this period, the creation of Araz water junction, Jahirli, Ordubad, Nehrem water reservoirs, increased the area of irrigated lands, which in turn opened a new stage in the development of agrocenoses. For the sustainable development of agrocenoses, extensive farming has been switched to intensive farming. Orchards, grain crops, vegetables and melons began to be replaced by new, more productive types of agrocenosis.

The formation of modern landscapes of Nakhchivan AR was formed as a result of the activity of natural processes and anthropogenic influences during a long historical period. The degree of anthropogenization of the landscapes of the studied area varies depending on the relief and climatic characteristics of the ecosystems, the degree of stability, and the structure. So, in the weak and moderately fragmented parts of Garachoban, Karabakhlar, Tepali massifs at an altitude of 800-1000 m above sea level, seliteb-garden complexes were formed. Seliteb-garden complexes are also spread in the river valleys of Jahri, Khalkhal and Payiz villages. In the lower and middle streams of Duylunchay, Garadarechay, Gilanchay, Vanandchay, arid-denudation, erosion-denudation mountain massifs of Kasandag, Uchagandag, Lzundag, fruit and mulberry orchards, walnut trees, melons, vegetables and grain crops cover a wide area. It is possible to observe that the unfavorable conditions of the semi-deserts of Dastebaşı, Pishikdirnag, which are moderately fragmented with wormwood-ephemeral, bushy, and heathery semi-deserts, cover

small areas of irrigated and sorghum crops, seletieb-garden complexes. In river valleys surrounded by dry and mountain steppes, on relatively low, smooth terraces and around settlements, various grain fields, orchards, and grape plantations have been established. The replacement of natural ecosystems with anthropogenic landscapes in the mentioned areas has led to a decrease in their stability and the loss of their initial state over time.

As a result of our research, we determined that the anthropogenic transformation of landscape types did not proceed to the same extent. Most agrocenoses are distributed in shrub-meadow landscapes on alluvial stony meadow soils of river beds; in an intensely fragmented mountain landscape of light chestnut and wormwood on gray-brown soils; in meadow-shrub landscapes on intensively fragmented upland montane-meadow grassland and montane-meadow primitive soils; least common in heathland and sedgeland landscapes on open chestnut montane soils on intensively fragmented sloping plains; in intensively fragmented montane landscapes on montane-brown former forest soils (Figure 1).

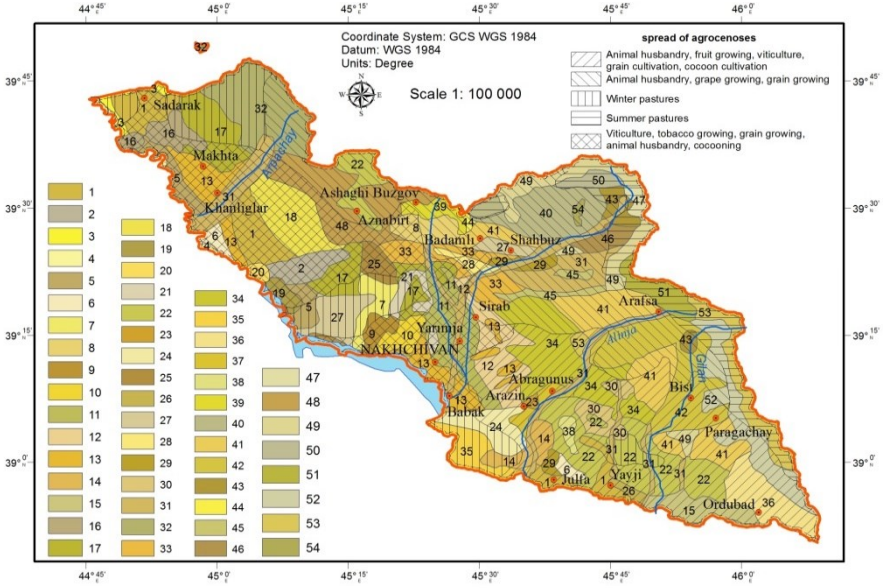

Figure 1. Distribution of agrocenoses by landscape types in Nakhchivan AR

In 2012-2020, as a result of the application of new techniques and technologies in the fields of agriculture and animal husbandry in the research area, the share of arable land, summer and winter pastures, hayfields and other useful areas increased. If we pay attention to the dynamics of the area of agrocenoses in the study area for the years 2000-2021, we will see that in 2000, the corresponding area of Nakhchivan AR was 3.6% of the republic, and in 2021, it increased to 3.9%. If we look at their distribution in individual regions, most of them are in Sharur, Babek and Kangarli regions. Here, the area of agrocenoses is 25%, 25% and 16% of the territory of the administrative regions, respectively. The lowest indicator belongs to Nakhchivan city and Shahbuz administrative district. The reason for this is unfavorable natural conditions.

If we look at the dynamics of individual agrocenoses in the last 21 years, the area of potato cultivation in the low mountainous and foothills, plain areas located in arid climate conditions has expanded significantly. Compared to 2000, the average annual growth of potato crops for 20 years was 1.5% to 2.1 thousand ha in 2020. While the average yield of cereal crops was 25.1 centners per hectare, in 2000, this indicator was 29.5, and in 2021, it was 32.0 s/ha. The cultivated area of tobacco plants in the study area has decreased significantly during the last 21 years. For comparison, let's note that in 2000 it was 2395 ha, but in 2021 it decreased 11 times to 221 ha. In particular, the reduction of this type of arable land intensified after 2010. In the area of vegetable crops, an increase of 1340 ha was observed in 21 years, which means an average annual increase of 1.3%. If we pay attention to the dynamics of garden and berry planting area in the study area, we will see an increase of 98.7% of their area during 2000-2021, this indicator was 135% for the country (average annual increase of 4.7%). If we pay attention to the comparison of the cultivation area of gardens and berries by separate administrative regions, we will see that there is a large cultivation area of them in Sharur, Shahbuz, Ordubad, Kangarli and Babek regions. In recent years, we are observing intensive growth in the area of almond, hazelnut, apricot and plum orchards. The area of vineyards has increased by 0.3% in

21 years, and this indicator is 640% in almond orchards. The cultivated area of almond orchards increased intensively after 2005. Thus, as a result of the processing of satellite images, we have determined that in 2021, in Nakhchivan AR, the cultivated areas cover 55.4 thousand ha, perennial crops cover 2.8 thousand ha, pastures and meadows cover 74.6 thousand ha, backyard plots cover 6.4 thousand ha, forest complexes cover 2.2 thousand ha, and the artificial forests cover 0.66 thousand ha.

The third chapter of the dissertation work is called **"Ecological processes caused by anthropogenic transformation in geosystems of Nakhchivan Autonomous Republic and their manifestation in natural landscapes"**. In this chapter, the ecological processes caused by the vertical transformation of landscapes and their natural landscapes have been analyzed. Due to the unfavorable physical-geographic conditions of the study region, suitable lands for the development of agrocenoses make up 29% of its total area. 36% of this land is cultivated, and part of it is used as backyard, forest, park and bushes. Perennial and annual agrocenoses make up 60,000 ha of the land used for cultivation, and 102,000 ha are summer and winter pastures. 70,000 ha of land in the studied area is covered by badlands, bare rocks, watersheds, areas subjected to severe salinization, stony-gravel ridges.

The efficient use of the available resources of the small number of fertile areas for the development of agrocenoses brings to the fore the improvement of their ecological condition. For this reason, land reforms have been carried out in the Autonomous Republic and it is important to continue the process. One of the first steps is to pay special attention to the restoration of degraded lands and the reduction of their inefficient use.

One of the first factors causing land degradation is re-salination, which is widespread in the plains along Araz river of the Autonomous Republic. This process prevents the increase of ecological and development of agrocenoses. There are two genetic types of soil salinization in the study area - automorphic (in the Arazboyu, Julfa, Buyukduz, Yayci-Dize plains of Nakhchivan and around the bringing cones) and hydromorphic (on the banks of the

Araz River). Most of the salinized soils are registered in Babek (5694 ha) and Sharur regions (13272 ha).

As a result of the development of agrocenoses, long-term irrigation of the Ordubad, Buyukduz and Sharur plains, as a result of the groundwater approaching the surface, the process of swamping in the form of small areas is found mainly in carbonate swampy-meadow soils, the area of which covers about 12% of the plains. This creates an obstacle to the sustainable development of agrocenoses and increases the ecological danger.

In order to find out to what extent the development of agrocenoses of Nakhchivan AR led to the degradation of the widespread soil cover in the region, we took and analyzed samples from ancient irrigated chestnut soils and alluvial meadow soils that were subjected to more exploitation. Chestnut soils are common in the foothill zone and also in the lower part of the terrain. The mentioned lands become narrower towards the plain. Here, favorable terrain has created conditions for the development of irrigation agriculture. Natural conditions have led to the formation of dry-desert biocenoses.

Light-colored chestnut is one of the fertile soils for the development of agrocenoses. H.A.Aliyev and A.K.Zeynalov (1988) noted that the mentioned soils are distinguished by their high carbonate content and heavy siltiness in the upper horizon[1]. They also determined that nitrogen is 7.1%, humus is 1.28%, $CaCO_3$ is 21.37%, hydrographic moisture is 4.61% and pH is 7.4%[2]. On the same land, we took a soil sample from the part of the Tivi road at an altitude of 1187 m above sea level and conducted our own research. Compared to 1988, the amount of humus has increased and the soil has become weakly alkaline. In contrast, calcium carbonate and nitrogen decreased. Of course, the main reason for the mentioned changes is anthropogenic effects and intensive development of agrocenoses. We took the other soil samples from 900

[1] Aliev, G.A., Zeynalov, A.K. Soils of the Nakhichevan Autonomous Soviet Socialist Republic / G.A. Aliev, A.K. Zeynalov. − Baku: Azerneshr, − 1988. − 238 p.

[2] Aliev, G.N. Ecological features of the soil in the arid foothills of the Greater Caucasus / G.N. Aliev, S.G. Khalilov, R.M. Abdueva. – Baku: Elm, – 2001. – 214 p.

m above sea level on the left bank of the river to the north of Bash Diza. By comparing the samples of alluvial-meadow soils with the samples of 1988, an increase in all indicators was observed in the total composition of the soil compared to the current year. As we mentioned above, the reason for all these changes is the development of agrocenoses without following agrotechnical rules. If this continues, there will be problems in the sustainable development of agrocenoses.

The intensive anthropogenic transformation of our study area has had its negative impact not only on the soil cover, but also on the vegetation and caused ecological problems in the biotopes. In order to analyze this factor, the dynamics of vegetation in the study area was monitored, the Landsat 5 and Landsat 8 images of the area from June 1987 and June 2022 were processed[3]. It was determined that in 1987, the areas of places lightly covered with vegetation increased, while the areas of densely covered areas decreased. The continuation of such exploitation will have a negative effect on the decrease of soil quality parameters and the development of agrocenoses, which may lead to food shortages in the future.

Considering these factors in the study area, environmental dangers were also studied. The concept of "ecological dangers" is a new concept in the science of landscape science, and its research has been started in recent times in our republic. Although researches in this aspect have been carried out to some extent in different regions of our country, research works in this aspect have not been carried out sufficiently in the Autonomous Republic of Nakhchivan. "ecological dangers" is divided into 4 categories, which have their own sources of dangers, manifestation in natural landscapes and impact on socio-ecological systems[4].

In the area we studied, the constant exploitation of natural landscapes in various areas has led to an increase in ecological danger, which is very important to study. Soil erosion, salinization,

[3] Ibrahimova, L.P. The changes caused by the transformation of natural landscapes of Nakhchivan AR in SAV, NDV and NDM indices // – Baku: Geography and natural resources, – 2023. No. 2 (20), – pp. 39-45.

[4] Hasanov, A.M. Natural resources of Nakhchivan AR and ways of using them / A.M. Hasanov. − Baku: Elm, − 2001. − 246 p.

re-shoring, washing, various processes on the slopes, desertification, deforestation, floods, landslides, avalanches and other processes affect the disturbance of the ecological balance, the balanced development of the landscape takes a new direction, the physical and geographical conditions of our research area, and the development of agrocenoses.

The main reason for the occurrence of ecological danger in the study area and its wide coverage is that it has arid climatic conditions, arid-semiarid ecosystems make up 8.4%, which encourages the development of the desertification process, the creation of danger. In our research area, desertification manifests itself more acutely at altitudes between 650-1600 m above sea level, in plains and depressions along Araz river.

Landslides are another factor affecting the creation of ecological danger. The lack of clay sediments and climatic conditions in the territory of the Autonomous Republic led to the development of this exodynamic process. Landslides are unevenly distributed over the territory. They were mostly recorded in the silty sediments in the basins of Paragachay, Nakhchivanchay and other rivers, in the southeast of Bichenak pass, in the middle course of Kükuchay and in the Batabat massif, and the least in the Zangezur and Darelayaz ranges. It is possible to find all types of sliding here[5].

Another prominent process in the study of ecological danger is flood events. In the Nakhchivan Autonomous Republic, the abundance of soft-clay and granular lithological rocks during torrential rains in river basins with a slope of 15-20º and higher leads to more destructive flood processes. Processing and analysis of satellite images of the area from different periods show that floods here have very sharp regional and local differences. Thus, this process formed in the high and medium highlands causes serious damage to the low mountainous and foothill plains, where more settlements are densely located, where people live more compactly, as well as the cones of the rivers and the plains spread along Araz

[5] Geography of Nakhchivan Autonomous Republic. Physical geography / Head. ed. R.M. Mammadov, I.M. Hajiyev. − Baku: Science. issue. I. – 2016. – 613 p.

river[6].

While investigating the ecological danger in the study area, we have taken into account the widespread avalanche processes in the region. Avalanche processes are often observed here, especially in high mountainous areas. Batabat, Ganligol and other dam lakes are clear examples of the avalanche process. The height of the waterfall of the same name, which is located on the Pazmari river in the Ayichingili pass of the Zangazur range, passing through Ordubad region, was partially reduced during the avalanche that occurred in 2022.

The importance of studying erosion processes in the evaluation of ecological danger has led to extensive investigation of this area by us. Here, both natural and anthropogenic influences have led to wide area coverage and the spread of many types of erosion. As a result of our research, we have determined that wind erosion is most common in Sharur and Arazboyu plains. As the height increases towards the middle and high mountainous part, the intensity of the erosion process increases and linear, surface and gully erosion is observed. As a result of water and wind erosion, 4.7 thousand ha (13%) of arable land in our study area became unusable. It is important to carry out land restoration and improvement works for the development of agrocenoses. At this time, first of all, for the regulation of anthropogenic activity, the correct selection of pasture and planting area, issues of adaptation of plants to the area during planting, and the principle of rotation should be taken into account.

After studying the ecological danger threats by landscape types in the study area, we have drawn up the regionalization map of ecological dangers in the study area (Figure 2). When conducting zoning, processes of erosion, landslide, flood, avalanche, and desertification were taken into account in landscape types. When conducting zoning in the study area, 4 categories were defined: weak (554.79 km^2 - 10.1%), moderate (2133.85 km^2 -

[6] Hasanov, A.M. Natural resources of Nakhchivan MR and ways of using them / A.M. Hasanov. − Baku: Elm, − 2001. − 246 p.

38.8%), increased risk (1896.41 km^2 - 34.4%) and crisis areas (917.7 km^2 - 16, 7%).

If we pay attention to the characteristics of landscape-ecological danger categories in natural and social-ecological systems, soil erosion, avalanches, desertification, and other ecological dangers are either not observed or are observed to a weak degree in weak landscapes and are compensated by natural processes. The previous structure and natural boundaries of the landscapes have remained almost unchanged, and a balance has been preserved. As it mainly covers the highlands, it is little affected by anthropogenic influences, or relatively no anthropogenic influences are observed (table 1). Favorable climatic and relief conditions in these areas hinder the development of agrocenoses.

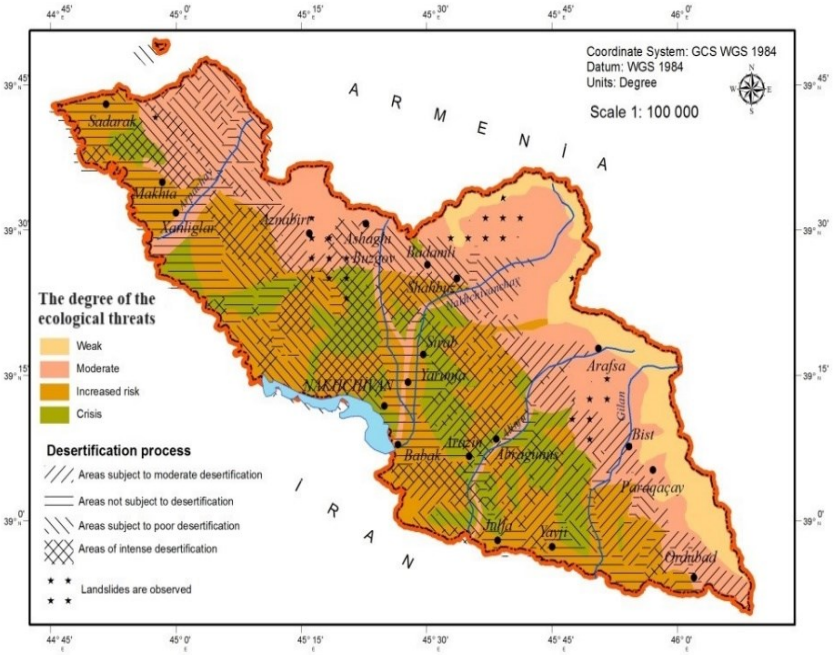

Figure 2. The map of ecological risks of the landscapes of the Nakhchivan AR

In temperate areas, soil erosion process, avalanche process, desertification and other ecological dangers are observed to a weak degree and are compensated by natural processes. Partial changes and disruptions occur in the structure and natural boundaries of landscapes. The landscape mainly preserves its functional mode. Environmental norms of land use are not strictly followed. The effect of measures against threats implemented periodically increases, partial threats remain. These studied areas are suitable for the development of agricultural livestock, such as the main summer pastures and hayfields.

Table 1.
Characterization of landscape-ecological threats categories in natural and social-ecological systems

Threat categories	Threats	Manifestation in natural landscapes	Manifestation in socio-ecological systems
Weak	soil erosion process, avalanche process, desertification and other ecological threats are either not observed or are observed to a weak degree and are compensated by natural processes	The previous structure and natural boundaries of the landscapes remained almost unchanged. Balance is maintained	As it mainly covers high mountainous areas, it has been little exposed to anthropogenic influences, or relatively no anthropogenic influences are observed.
Moderate	soil erosion process, avalanche process, desertification and other ecological threats are poorly observed and compensated by natural processes	Partial changes and disruptions occur in the structure and natural boundaries of landscapes. The landscape mainly preserves its functional mode. Environmental norms of land use are not strictly followed.	The effect of measures against threats implemented periodically increases, partial threats remain.

Continuation of Table 1

Increased risk	Anthropogenic effects are strong, soil erosion is strongly observed, landslides are mainly observed in the eastern part of the zone, while the central part can be observed at certain intervals, there are hot spots of desertification.	Strong changes are observed in the structure and natural boundaries of landscapes, the ecological balance is disturbed	Measures taken against threats are not effective, productivity in agrosenosis is below the norm
Crisis	Intensive anthropogenic effects are observed, erosion almost completely flattens the slopes in the relief, intensive desertification is observed, there are strong landslide processes.	Intensive changes are observed in the structural and natural boundaries of landscapes	Defense measures against threats are implemented, but they are less effective

Anthropogenic effects are strong on landscapes, soil erosion is intensifying, landslides are mainly observed in the eastern and intermittently central part of the zone, there are hot spots of desertification. Strong changes are observed in the structure and natural boundaries of landscapes, the ecological balance is disturbed. Measures taken against threats are not effective, productivity in agrosenosis is below the norm. Here, it is important to follow agrotechnical rules for sustainable development of agrocenoses. Mainly fruit orchards, partly cereals are cultivated.

Intensive anthropogenic impacts are observed in landscapes in a state of crisis. Erosion makes the slopes almost completely bare, intense desertification is observed, there are strong landslide processes. Intensive changes are observed in the structural and

natural boundaries of landscapes. Defense measures against threats are implemented, but they are less effective. Currently, the area of agrocenoses in these areas covers a wide area.

The fourth chapter of the dissertation work is called "**Geographical basis of ensuring sustainable development of agrocenoses of Nakhchivan Autonomous Republic**". In this chapter, we have studied the principles put forward by many local and foreign scientists to ensure the sustainable development of agrocenoses, and we have determined the important conditions for increasing the sustainability and stability of the agrocenoses of the research area and the methodology of mapping.

Ensuring sustainable development of agrocenoses is one of the most urgent problems of the Nakhchivan Autonomous Republic. In modern times, the daily increase in the demand for food has made this problem even more urgent. During the mapping of sustainable development of agrocenoses, we studied geomorphological, lithological, hydrogeological, soil, vegetation. Also, by using GIS technologies, we calculated the Soil Adjusted Vegetation (SAV), Normalized Difference Humidity (NDM) and Normalized Difference Water (NDW) indices of different years and compiled the marked maps of the studied area and analyzed the results (Figure 3, Table 2).

Based on our research, we have divided the Autonomous Republic into 5 regions based on the degree of development of agrocenoses. It was determined that 8% of the research area does not have favorable conditions for the development of agrocenoses. However, 1/3 of the territory is defined as stable for the development of agrocenoses.

In the fourth chapter, a plan of measures ensuring the balanced development of agrocenoses has been prepared. Agrocenoses are a component of agriculture, in which high productivity is observed due to the interaction of animals, plants and microorganisms. They are the key to increasing the productivity and quality of agricultural products. Agrocenoses also help maintain soil fertility and reduce the risk of ecosystem destruction. In such systems, the balance of interaction between

plants, animals, soil and atmosphere is maintained. One of the main points in the creation of agrocenosis is the selection of plants. It is necessary to take into account their characteristics - strength, resistance to diseases and pests, productivity and others. Consideration should be given to how these plants will interact with each other and with the environment. Special attention should be paid to the organization of the irrigation and fertilization system. Depending on the climate and soil, it is necessary to choose the optimal method and means for fertilization. It is also important not to forget water management measures in order not to harm the nature in the process of land cultivation. In addition, the creation of agrocenosis requires attention to the maintenance of biological balance. It is necessary to develop a strategy for plant protection, disease prevention and pest control. In order not to disturb the ecosystem, it is necessary to consider other animal and plant species located in the territory of cultivated lands.

Table 2.
Statistical indicators of regionalization of agrocenoses in Nakhchivan AR

№	Regionalization of agrocenoses	Area	
		ha	%
1	Areas where the landscape is more stable for the development of agrocenoses	183212	33
2	Areas where the landscape is moderately stable for the development of agrocenoses	112673	20
3	Areas where the landscape is poorly stable for the development of agrocenoses	141385	26
4	Areas where the landscape is unstable for the development of agrocenoses	68854	13
5	Areas where natural conditions are not favorable for the development of agrocenoses	44075	8
	Total	550200	100

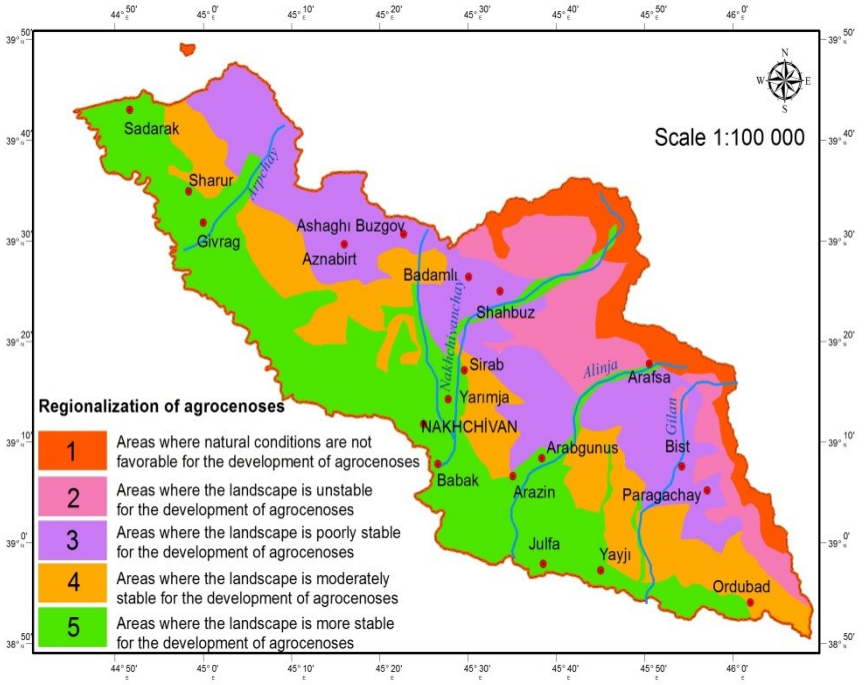

Figure 3. Regionalization map of agrocenoses in Nakhchivan AR

Thus, based on the conducted analyses, the following measures must be implemented in the balanced development of agrocenoses in the Nakhchivan Autonomous Republic.

1. Increasing productivity. Agrocenosis is a complex association of plants, animals, and microorganisms that interact with each other and the environment. Unlike monocultures, which grow only one type of plant, agrocenoses increase soil productivity by providing more efficient use of nutrients in the soil. This should be applied mainly to the ancient lands of areas along Araz river.

2. Protection from pests and diseases. The creation of agrocenoses with different types of plants and animals also helps to fight against the spread of pests and diseases. Insects, birds, and insects Biological controls can kill harmful insects, and cultural diversity helps reduce pests and diseases associated with

certain crops. This type of control measures are needed more or less everywhere in the region.

3. Reducing the impact on the environment. Monocultures, frequent use of pesticides and agriculture lead to the deterioration of the soil and the environment in general. Agrocenoses can help reduce environmental impact by reducing pesticide use, improving soil quality, and preventing soil erosion. Although there is less pollution with pesticides in the study area compared to other regions of our republic, it is necessary to implement such control measures.

4. Improving biodiversity. The creation of agrocenoses helps to increase biodiversity, including the restoration and protection of local ecosystems. In addition, agrocenoses can help preserve rare animal and plant species that are part of the ecosystem and cannot exist in monocultures. The mentioned measures should be implemented especially in the middle and high mountain regions.

The preservation of the ecological stability of agrocenoses is determined by the stabilization and increase of soil fertility, as well as the cessation of all types of degradation. At present, during the period of high development of agriculture, the processes of degradation of agricultural land and loss of fertility of arable land have been activated. The problem of soil incompatibility with climate conditions, increase in frequency and destructiveness of adverse weather conditions, especially droughts, becomes even more acute. Therefore, it is very important to develop a diagnosis of the ecological sustainability of the future development of agrocenoses in the study area.

RESULT

1. In 67% of the research area, the hypsometric height is higher than 1000 m, in 34% of the topography the slope is higher than 16º, and in 65% of the topography the aspect is south and south-west, the continental climate is the main reason that hinders the development of agrocenoses in the area. However, in addition to these indicators, the low inclination of the slopes plays an important role in the assimilation of the territory by agrocenoses.

2. In the study area, the indicator of agricultural crops was 3.6% in 2000, and in 2021, this indicator increased to 3.9%. These cultivated areas reached 64,259 ha from 37,117 ha with an average annual increase of 3.5% during the respective years. In addition to agriculture, there was also an increase in the number of cattle, so the number of cattle increased by an average of 1.6% annually and reached 121 thousand during the period 2015-2021. The number of cows and buffaloes in this period reached 68 thousand with an average annual increase of 10.3%. The average annual increase in the total number of sheep and goats in the relevant period was 1.8% and amounted to 747 thousand heads. The expansion of livestock and agricultural fields has increased the level of erosion in the area, so that now more than 70% of the areas are eroded.

3. 16.7% of the study area is in crisis, 38.8% in moderate, 34.4% in increased risk, and 10.1% in weak zone. Landscapes in a critical state are the low highlands and the lower part of the middle highlands, as well as most of the Arazboyu sloping plains, landscapes in a state of increased risk are mainly areas spread along flooded river banks, moderate areas are the upper part of the middle highlands, and landscapes located in the weak zone are mainly highland landscapes.

4. The natural geosystems of Nakhchivan Autonomous Republic have undergone a complete change in the structure of all geocomplexes with the development of agrocenoses. Here, the area of agro-irrigation geosystems has increased significantly and, accordingly, the area of irregularly used agrocomplexes has

significantly decreased. In 1981, the area of agro-irrigation complexes was 23.28 thousand ha, while the area of cotton cultivation complexes was 4.92 thousand ha. Today, the areas of these complexes are equal to 31.97 and 5.56 thousand ha, respectively.

5. Regionalization of agrocenoses was carried out for the first time in Nakhchivan AR, and it was found that the areas where the landscape is more stable for the development of agrocenoses are 33%, medium stable 20%, weakly stable 26%, unstable 13%, only 8% of the areas where natural conditions are not favorable.

RECOMMENDATIONS

1. Regular monitoring of quality and quantity of agrocenoses. It is a component of agrocenosis management measures.

2. Currently, there are three forms of land ownership in the Nakhchivan Autonomous Republic - state, municipal and private (farmers and private farms). Each of these economic forms has its own agrocenosis. Farmers create agrocenoses that are more economically viable. Regardless of the form of ownership, sustainable development of agrocenoses and preservation of ecological balance is important.

3. It is important to classify agrocenoses according to their ecological condition, sustainability (balanced development) throughout the Nakhchivan Autonomous Republic and their altitude levels (low, medium and high mountains). Thus, the morphometric indicators of the relief (inclination, slope, horizontal and vertical division) have a great influence on the geographical distribution of agrocenoses, quantitative and qualitative indicators.

4. Using the newest achievements of science and technology, it is important to keep accurate records of all agrocenoses, to prepare an action plan depending on their condition.

5. Special attention should be paid to the agrocenoses located along the Araz River coast (in the arid zone) and subjected to more intensive economic effects.

6. Achieving cartographic assurance of sustainable development of agrocenoses - that is, large-scale maps of all types of agrocenoses (geographical distribution, forecast, dynamics, sustainable, development, agroecological, etc.) should be drawn up based on modern cartographic sources and technology.

Published scientific articles on the dissertation work:

1. Ibrahimova, L.P. Natural land-cadastre districts and sub-districts in Sharur administrative district // − Nakhchivan: Nakhchivan State University, Scientific works, − 2017. No.7 (88), − p. 94-100 (together with S.H.Hajiyev)
2. Ibrahimova, L.P. Restoration of the fertility of arable land in the plain along Araz river and its use under cultivation // 2nd international conference of science, − Baku: − April 1, − 2018, − p.158-159
3. Ibrahimova, L.P. Eco-geographical factors affecting the soil formation under the cultivated plants in the Republic of Azerbaijan // − Poland: Scientific Light, − 2018. 1(19), − p. 8-11 (together with S.A. Hajiyev, S.H. Kahramanov)
4. Ibrahimova, L.P. Study of the degradation processes of arable land spreading in the Nakhchivan Autonomous Republic // − Baku: Works of the Azerbaijan Geographical Society, − 2018. No. 1 (7), − p. 55-59
5. Ibrahimova, L.P. Directions of using Shahbuz district lands in agriculture // I International scientific conference, − Ganja: − May, − 03-04, − 2019, − p.111-114
6. Ibrahimova, L.P. Differentiating features of modern natural landscapes of Nakhchivan AR // Development of environmentally friendly agriculture of Azerbaijan, − Ganja: − October 29, − 2019, − p.178-180
7. Ibrahimova, L.P. Problems and solutions caused by the impact of flood processes on agrocenoses in the Autonomous Republic of Nakhchivan // − Nakhchivan: Journal of Scientific Works of Nakhchivan State University, Nature and medical sciences series, − 2020. No. 3(104), − p. 154-158 (together with H. Asadov)
8. Ibrahimova, L.P. Environmental assessment of factors causing degradation of natural landscapes of Nakhchivan AR // Information, science, technology and university perspectives, − Lankaran: − December 18, − 2020, − p.66-67 (together with Y.A. Garibov)

9. Ibrahimova, L.P. The ways of increasing fertility of the plain lands used for planting soil (Nakhchivan Autonomous Republic in the example of zone lands along the Araz river) // IX International Scientific and Practical Conference scientific research in XXI century, − Ottawa: − 18-19 June, − 2021, − p. 316-320.
10. Ibrahimova, L.P. Algorithms for pastures in Nakhichevan (Azerbaijan) and their economic and geographical assessment based on landscape planning // − Nizhnevartovsk: Bulletin of science and practice Scientific Journal, − 2021. No. 7 (6), − pp. 105-112 (together with A.M.Hasanov, N.Z.Aliyeva)
11. Ibrahimova, L.P. The results of the transformation of the natural landscapes of the Nakhchivan Autonomous Republic in the Pleistocene and Holocene stages // − Nakhchivan: Journal of Scientific Works of the State University, Series of Natural and Medical Sciences, − 2022. №7(120), − p. 103-107.
12. Ibrahimova, L.P. Changes caused by the development of agrocenoses in the landscapes of the Nakhchivan Autonomous Republic // − Baku: Geography and natural resources., − 2022. No. 3 (18), − p. 36-43.
13. İbrahimova, L.P. The role of geosystems in the development of agrocenoses (in the case of the Nakhchivan Autonomous Republic) // Modern problems of geography: Integration of science and education II International scientific-practical conference Volume I, − Baku. − November 29-30, − 2022, − p. 279-285.
14. Ibrahimova, L.P. The role of morphometric indicators of relief in the development of agrocenoses in Nakhchivan Autonomous Republic // − Grozny: Grozny Natural Science Bulletin, − 2023. №2 (32), − p.18-23
15. Ibrahimova, L.P. Exogenous processes of relief formation and patterns of their spatial distribution (within the Nakhchivan Autonomous Republic) // Natural resource potential and environmental rehabilitation of degraded landscapes, − Grozny: − March 17–18, − 2023, − p. 153-156.

16. Ibrahimova, L.P. The influence of the climatic factor on the development of mountain geosystems and emerging environmental problems // – Tula: News of the Tula State University, Earth Sciences, – 2023. No. 3, – p.68-80
17. Ibrahimova, L.P. The influence of magmatic processes on the development of agrocenoses // – Almaty: Proceedings of KazNU. Ecological series, – 2023. No. 3(76), – p. 20-28.
18. Ibrahimova, L.P, Geographical basics of ensuring sustainable development of agrocenoses of Nakhchivan Autonomous Republic // – Nakhchivan: Scientific Works of Nakhchivan University, – 2023. No. 3, – p. 201-209.
19. Ibrahimova, L.P. Application of NDV index in monitoring the development dynamics of agrocenoses // Modern problems of geography: Integration of science and education II International scientific-practical conference Volume II, – Baku. – November 22-23, – 2023. – p. 39-46.
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