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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

ANTHROPOGENIC DEGRADATION OF SOILS AND MEASURES TO FIGHT AGAINST IT IN NAKCHIVAN AUTONOMOUS REPUBLIC

Specialty: 5408.01 - Physical geography and biogeography, soil geography, geophysics and geochemistry of landscapes

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GENERAL CHARACTERISTICS OF THE WORK

The actuality of the topic and level of research on the topic. In modern times, people's daily increasing demand for food products necessitates efficient use of land resources. This situation causes the growth rate of the population in the country and the increase of anthropogenic impact on the environment, including the soil. For instance, in 1924, in the Nakhchivan region, the land area per person was 2.4 ha, but now this indicator consists of 0.4 ha of agricultural land and 0.13 ha of arable land. This is lower than the average not only for the world, but also for the Republic of Azerbaijan. Every year, as a result of the global desertification process and the increasing anthropogenic impact on individual regions and local areas, lands become unusable and fall out of the production cycle. One of the important reasons for the ineffective use of land is the incorrect assessment of the negative effects and the development of comprehensive measures to combat it. Accordingly, the soil of the area should be involved in a comprehensive study, taking into account natural-geographical and anthropogenic factors.

In developed countries, the protection of soil resources is carried out against the background of landscape planning and is constantly kept in the center of attention. The important role of soil as an irreplaceable and common wealth of society is noted in a number of international programs and documents, and the importance of their preservation for the sake of the welfare of future generations is indicated.

Long-term perspective plans have been drawn up to protect the ecological balance and develop the agricultural sector in the autonomous republic on the basis of the laws adopted in the Republic of Azerbaijan on land, in accordance with the state program. In the adopted prospective plans, measures for increasing, restoring, protecting soil fertility and developing the agricultural sector on the basis of the agro-industrial complex in the autonomous republic have been defined.

The unfavorable geographical conditions of the Nakhchivan

Autonomous Republic have led to a weak but intensive anthropogenic degradation of the soil cultivation process there. As a result, the structure of the soil fund of the autonomous republic has changed in a negative direction, fertile land areas have been taken out of the agricultural cycle and created conditions for the development of environmental problems. There is an urgent need to assess the current state of soil in the autonomous republic from the perspective of anthropogenic degradation against the background of the natural desertification process and to develop comprehensive measures to combat it.

Degradation of soil was discussed by foreign scientists T.G. Boychiyev, N.G. Kharin, R. Lahmar, Z.G. Zabilkov, G.U. Dobrovolski, A.M. Rusanov and others, and from domestic scientists K. A. Alekbarov, N. A. Asadov, H. A. Aliyev, S. H. Maharramov, A.G. Guliyev, E. Sh. Bayramov, A. I. Hajiyev, S. Y. Guliyeva, M. P. Babayev and others have widely studied it. These scientists have studied the causes of degradation, and the factors affecting its geographical distribution. The anthropogenic degradation of soils in the Nakhchivan Autonomous Republic, the factors affecting it, were studied by us in the GIS environment based on laboratory analyzes in cameral-preparation and field conditions, and aerospace images.

Research object and subject. The object of the research is the soil areas in the Nakhchivan Autonomous Republic that are subject to anthropogenic influences. In 2014-2021, more extensive studies were conducted in the areas of the autonomous republic that are subject to anthropogenic influences, including in Khok, Nehram and Boyukduz municipalities of the Arazboyu plains. The subject of the research is the anthropogenic degradation of soils in the autonomous republic and the factors affecting it.

Research aims and tasks. The main goal of the dissertation work is to study the anthropogenic factors that lead to the decrease in soil fertility in the Nakhchivan Autonomous Republic, and to develop complex control measures for its prevention. To achieve the goal, the following tasks have been defined:

1) Collecting, systematizing existing perennial materials according to the research direction, creating a monitoring database and taking them into account, determining the location of observation and pattern sites, the time and directions of the routes;

2) Conducting field research, laboratory analysis and analysis of its results;

3) Study and analysis of aerospace images, field and cameral works in GIS environment;

4) To characterize the current state of the soil of the Nakhchivan Autonomous Republic against the background of existing natural-geographical processes and to compare it based on the perennial soil database;

5) Assessment of anthropogenic loading by taking into account anthropogenic factors for individual administrative regions, including perennial socio-demographic indicators;

6) Making up a soil degradation map taking into account the influence of anthropogenic factors;

7) Preparation of recommendations and proposals in the direction of effective use of land and increase of soil fertility, taking into account the conditions of the autonomous republic regarding protection measures in lands subjected to anthropogenic degradation.

Research methods. In accordance with the scientific-theoretical issues and methodology of the problem posed in the dissertation, the research work was carried out on cameral-preparation, field-laboratory, summarizing-concluding stages.

Stationary, diagnostic, cartographic, mathematical-statistical, field-research, systematic analysis, observation, distance learning, laboratory-research works, Internet resources, satellite images, space images, Arc GIS programme were widely used in the research.

Statistical data reflecting modern socio-demographic, agricultural and other anthropogenic objects for the determined points of the research region, contours were drawn on tablets on a scale of 1:100000, taking into account actual images. The most characteristic soil and plant samples taken in field conditions were

analyzed by the general chemical method in the Laboratory of Soil and Plant Analysis of the Agricultural Research Institute of Ministry of Agriculture of the Republic of Azerbaijan.

The main provisions of the defense:

1) Assessment of the natural and geographical conditions of the Nakhchivan Autonomous Republic in terms of soil degradation against the background of the study of the scientific-theoretical problems of soil degradation in the world;

2) Determining and mapping the intensity of soil degradation of the Arazboyu plain based on the comparative analysis of perennial studies;

3) Assessment and mapping of the impact of anthropogenic activity on the soil in all directions;

Scientific novelty of the research. The scientific novelty of the dissertation can be summarized as follows:

-For the first time, the anthropogenic factors affecting the processes of desertification and degradation in the autonomous republic have been comprehensively studied, and the current situation has been evaluated.

- In the Arazboyu plain, which is the most appropriated and subjected to anthropogenic degradation, several observation sites were selected and soil samples were taken, and those samples were analyzed and compared with previous studies to determine the current situation;

-As a result of the application of modern technologies, a 1:100,000 scale map reflecting the state of land degradation in Nakhchivan AR was prepared for the first time based on the NDVI (Normalized Difference Vegetation Index) coefficient, mathematical-statistical calculations were made on it, and the areas of degraded areas were calculated;

- For the first time, the condition of summer and winter pastures, including the main forms of anthropogenic degradation, technogenically polluted land areas, areas subjected to salinization and water-irrigation erosion were determined and mapped;

Theoretical and practical significance of the research. The results of observations (monitoring) on the study of anthropogenic factors

affecting the reduction of soil fertility and degradation in the region are a valuable tool in solving the environmental problems of the autonomous republic. Besides that, articles and map materials published on the basis of the results of research conducted in the autonomous republic can be used as resources in appropriate specialties in organizations related to the agrarian field, higher education institutions. The most important theoretical significance of the research is to determine the geographic distribution patterns and forecast of the degradation based on the maps and tables, and the practical significance is to develop the measures of the research conclusions for combatting degradation and implementing them in similar districts.

Approbation and application. The thesis was discussed and recommended for defense at the Department of Geography of Nakhchivan State University. The main results and provisions of the dissertation were presented at the following scientific conferences: International scientific conference on "Actual problems of modern natural sciences" (Ganja 2017), Republican scientific conference on "Human and environmental relations" (Baku 2017), "Modern natural and economic sciences" current problems" International scientific conference (Ganja 2019), Proceedings of International Scientific and Practical Conferences (Moscow 2019), I International Scientific Conference on Humanities and Social Sciences (Baku 2020), UGTU XXII International Youth Scientific Conference "Severgeoekotukh-2021" (Ukhta , 2021).

The results of the research studies conducted on the study of anthropogenic factors affecting soil fertility and pollution in the autonomous republic were applied in the Auxiliary Experiment Farm of the "Araz" Science and Production Union named after academician Hasan Aliyev under the Ministry of Agriculture of the Nakhchivan Autonomous Republic.

Name of the organization in which the dissertation was prepared. It was performed at the Department of Geography of Nakhchivan State University.

The total volume of dissertation with a sign, indicating the volume of the structural sections of the dissertation separately. Dissertation introduction - 7 pages, (12201 symbols) 4 chapters,

including chapter I - 33 pages (57299 symbols), chapter II - 14 pages, (25952 symbols) chapter III - 41 pages, (50986 symbols) chapter IV - 9 pages, (12323 symbols) conclusion and proposals - 2 pages (3150 symbols), it consists of a bibliography with 165 references to the publication, 12 maps, 15 diagrams, 1 graph, 12 photographs, and 24 tables. Dissertation is consist of 143 computer pages and contains 1619111 symbols.

MAIN CONTENT OF THE RESEARCH

In the **"Introduction"** part of the dissertation, the actuality of the topic, and the level of research on the topic are analyzed, theoretical and methodological issues are clarified, the object and subject of the research, aims and objectives are determined, the scientific novelty and practical importance of the work are indicated.

The first chapter of the dissertation work is called **"Physical-geographic conditions of the research area".** Under separate subsections of this chapter, geographical components have been analyzed according to the issues based on actual materials. An orographic map of the autonomous republic was prepared in the ArcGIS program using Landsat 8 satellite images, DEM (digital elevation model) files, taking into account the hypsometry, slope, slope and other morphometric indicators of the land and vegetation. A hypsometric curve where heights are given at intervals of 250 meters and diagrams showing the ratio of the areas with separate steps to the total area in sq. km and as a percentage were prepared based on the prepared map.

The landform of the Nakhchivan Autonomous Republic consists of mountainous and plain parts, the lowest point is the banks of the Araz River (600 m), and the highest point is Gapicig Mountain (3904 m). The Arazboyu zone is located at an altitude of 600-1200 meters and is the largest plain, and it is divided into Sadarak, Sharur, Boyukduz, Nakhchivan, Julfa, Ordubad and other plains. There are 2 orographic

units in the high mountains - Zangazur and Daralayaz ranges.[1]

The territory of Nakhchivan province covers a first-order 3-fold structure. These are Sharur-Julfa anticlinorium, Ordubad synclinorium and Zangezur anticlinor. These structures are Pan-Caucasus oriented. Quaternary rocks are widespread in the area, including Devonian, Carboniferous, Permian, Triassic, Jurassic, and Cretaceous sediments.

The autonomous republic has a severe continental climate, depending on the terrain, semi-desert and dry desert climate with hot summer and cold winter in the Arazboyu plains, cold climate with dry summer in the mountains, and mountain tundra climate type in the high mountainous part of the Zangezur range (3800-3900 m). formed. The number of sunny hours is 2600-2800 hours in the plains, and 2000-2400 hours in the highlands. Solar radiation is 140-160 kcal/cm^2, and the annual radiation balance fluctuates between 25.0-45.0 kcal/cm^2.[2]

Precipitation is unevenly distributed in the region. The amount of precipitation is 200-400 mm in the sloping plains and low mountainous zone, and 600-800 mm in the middle and high mountains.

The topography and climate of the area affect the density of the river network. The region is rich in small mountain rivers. There are about 400 rivers here. The total length of the main rivers of the area is 1752 km, and the density of the river network is 0.32 km^2.[3]

All the rivers of the region belong to the Araz basin and take their origin from the Zangezur and Daralayaz ridges.

Depending on the relief and the exposure of the slopes, different soil types are spread in the region. The soils of the foothills and plains are of alluvial, delluvial and proluvial origin.

Based on the classification of H. Aliyev and A. Zeynalov, there

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[1] Babayev, S.Y. Geography of Nakhchivan Autonomous Republic / S.Y. Babayev. - Baku: Elm, - 1999. - 298 p.

[2] Geography of Nakhchivan Autonomous Republic. [in 2 volumes] / - Nakhchivan: "Ajami" Publishing- Polygraphy Union, c.1. -2017. - 546 p.

[3] Hasanov, A.M. Natural resources of the Nakhchivan Autonomous Republic and ways of using them / A.M. Hasanov. - Baku: Elm, - 2001, - 247 p.

are 5 soil types and 14 subtypes in the mountainous part, and 5 types and 16 subtypes in the plain zone. They gave a broad description of the soil types in each part.[4]

The severe continentality of the climate affected the vegetation of the area and led to the development of poorly monotypic, i.e. xerophytic, plants. However, the territory of the autonomous republic has a complex relief structure, so it is rich in flora. More than 3,000 unique plant species have been identified here.

The second chapter of the dissertation talks about **"The current state of soil degradation".**

Global warming of the climate, the occurrence of droughts, deforestation and burning as a result of human economic activity, overloading of pastures, improper selection of norms and methods of irrigation, etc. factors cause the degradation process as a result of the violation of the law of balance of nature. 3.6 billion hectares of soil in 110 countries of the world have been subjected to desertification. Anthropogenic deserts cover 6.7% of our planet.[5]

The problem of soil degradation is an international problem that affects almost all countries. According to the information of the "Global Assessment of Soil Degradation" International Project supported by the UN, in which about 180 scientists from the countries of the world participated, physical degradation processes are spread over an area of 1.7 billion ha.[6]

As a result of observations and researches, according to the opinion of experts, 21 mln. ha area is subject to be completely degraded (UNEP Nairobi)[7].

Natural and anthropogenic factors play an important role in the degradation of the soil of the autonomous republic. Natural factors include erosion processes: water and wind erosion; climate change:

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[4] Aliyev, G.A. Soils of Nakhichevan ASSR / G.A. Aliyev, A.K. Zeynalov. - Baku: Azerneshr, - 1988. - 238 p.

[5] Mammadov, G.S. Ecology, environment and man / G.Sh. Mammadov, M.Y. Khalilov. - Baku: Elm, - 2006. - 608 p.

[6] Dobrovolskoi, G.V Degradation and protection of soil / pod ed. G.V. Dobrovolskoy. - M.: МГУ, 2002. - 654 p.

[7] Guliyeva, S.Y. Desertification in arid and semiarid mountain geosystems / S.Y. Guliyeva. - Baku: Victory publishing house, -2011, - 182 p.

warming, drought; salinization and solochak; swamp and swamp-meadow; rocky and bushy areas. Anthropogenic factors include the processes that occur after land reform: transfer of land to executive ownership, settlement of the population, grazing, cutting of trees and bushes, improper observance of agrotechnical rules, use of land under too many cultivated crops, irrigation erosion, unplanned transport roads, construction materials and refers to the production of the mining industry.

In arid climate, water erosion is intensive. As a result of water erosion, strong floods in the foothills of Sharur, Boyukduz, Nakhchivan, Julfa, Ordubad and other plains destroy soil fertility, create deep valleys and cover them with large stones. In the low mountainous areas, in the plain areas of Julfa, Sharur, Kangarli and other administrative regions, the activity of wind erosion is also observed in the loss of land suitable for agriculture. Climate change-warming is intensifying the process of desertification and land degradation by having a greater impact on the ecosystem of the southern slopes of Daralayaz mountains in the autonomous republic.

Swamped areas are formed as a result of the accumulation of surface and ground water flowing into depressions of the terrain under the influence of natural and anthropogenic factors. Salinity and salinization occurred in the Arazboyu plains in areas where the groundwater level rose and salty rocks came to the surface. As a result of the rise of the groundwater level, salinized and salinized land areas were formed in the areas near the Araz River in Sadarak, Sharur, Babek, Kangarli, and Julfa administrative regions, and as a result of the surfacing of salty rocks in the vicinity of Duzdag and in the area of Qabilli village. Land degradation areas increased from 32 percent to 41 percent between 1975 and 2005.[8]

As a result of improper irrigation, the irrigated areas of the autonomous republic, including the gray and gray-brown soils of the Boyukduz, Nehram plain and Julfa sloping plain, were more exposed to irrigation erosion.

The cause of repeated salinization in the plains along Araz is the

[8] Hajiyev, S.A. Ecological assessment of the lands of the Nakhchivan Autonomous Republic / S.A. Hajiyev. - Baku: MBM, - 2010, - 295 p.

lack of concrete lining in the irrigation canals, the effect of the reservoir created on the Araz river, and the fact that the collector-drainage network in some areas is in an unusable condition, as a result of which groundwater approaches the surface of the earth. Salt flats have formed around reservoirs and canals in the form of islands.

As a result of excessive grazing of animals in pastures, slopes become bare, soils lose their structure, and plants are trampled and destroyed. Such cases are more common in Arpachay, Nakhchivanchay, Lizbirtchay, Jahrichay, Alinchachay, Gilanchay and Duylunchay basins at altitudes of 1200-1800 m.

The area of terricone hills formed as a result of mining and industrial waste is more than 950 hectares. As a result of the mining industry and the production of construction materials, around the Dahne-Validag elevation (70 ha), in the downstream of Arpachay and nearby areas (15 ha), around the villages of Yayci and Dize of Julfa region (195 ha),Terricone hills were formed around the village of Karabaglar (157 ha), near the village of Shahtakht (280 ha), around Duzdag (65 ha), near the mouth of Nakhchivanchay (123 ha), near the village of Guznut (20 ha), and around the Paragachay and Gumushlu mines.

The table reflecting the current state of the general land fund of the Nakhchivan Autonomous Republic is shown below (table 1).

The third chapter of the dissertation work is dedicated to the problem of **"Development and assessment of soil degradation process in Arazboyu agrolandscapes of Nakhchivan AR".**
Since the Arazboyu plains are the area of the autonomous republic that is more subject to degradation and widespread in terms of the diversity of anthropogenic factors, it is planned to carry out more detailed studies mainly on the plain soil. Here, 3 typical test sites were selected for conducting research. The first experimental site is a 20-hectare plot of land located in the northeast of the Nakhchivan sloping plain, 6.4 km north of the coast of the "Araz water junction", in the Nehram municipality of Babek district, at 39°13' north latitude and 45°48' east altitude. The second experimental site is a 10-hectare plot of land located between 39°30' north latitude and 45°20' east altitude in the southeast of the Boyukduz sloping plain in Khok municipality

of Kangarli district. The third experimental site covers an area of 5 hectares located in the south of the Boyukduz sloping plain, 2.5 km north of the "Araz water junction", in the territory of the Boyukduz municipality of Kangarli district, at 39°24' north latitude and 45°21' east altitude. In all three experimental sites, stationary observations were made during 2014-2021, soil samples were taken from different depths, and geographic coordinates of the sampled areas were determined using GPS.

Soil analyzes were performed using the following methods: hummus and total nitrogen according to I.V. Tyurin; the reaction of the environment in water suspension-with a pH-meter; carbonation ($CaCO_3$) - using the Scheibler method using a calcimeter; total nitrogen – by the Keldal method; activated phosphorus (P_2O_5) – according to B.P. Machigin; exchangeable potassium (K_2O) – according to P.V. Protasov; dry residue and chlorine (Cl-) - with silver nitrate; results were obtained by precipitating sulfate ion (SO_4^{2-}) with barium sulfate reagent ($BaSO_4$). The results of the field experiments were checked by mathematical-statistical methods to calculate the productivity and the accuracy of the determination.

The results of the analysis reflect the parameters of the soil in eleven types. The conducted analyzes show that the use of these lands for agricultural purposes in arid conditions for many years has led to the weakening of the soil's bioenergetic potential. The grey soils that have been irrigated since ancient times are very poorly supplied with nutrients such as total hummus, total nitrogen, and available phosphorus.

According to the analysis of soil samples taken from the territory of Nehram municipality, the amount of hummus varies between 1.22-1.74%. This indicates that the area is poorly supplied with hummus. The area is moderately carbonated with the amount of $CaCO_3$ varying between 12.13-13.63%. The experimental site is moderately supplied with exchangeable potassium (K_2O), very poorly supplied with activated phosphorus (P_2O_5), and the pH value varies between 7.67-7.93 and is weakly alkaline.

Table 1.

Soil resources, types of ownership and state of use of Nakhchivan Autonomous Republic (in hectares) (based on January 1, 2021 data)

District	Total fund of soil	By types of property			Total usable soil for agriculture	Unusable parts of pastures	Forest and bushes	Swamps, area of reeds	Flooded lands	Transport routes	Balka, ravine, valley, sandbar	Cemeteries	Land under construction
		State	Municipality	Special									
Sadarak	16374	10838	2278	3258	7483	6962	101	-	23	96	1545	11	153
Sharur	87226	42507	30499	14220	28950	33008	334	19	3021	1436	19662	133	663
Kangarli	70489	20681	42967	6841	26542	4455	92	-	3133	119	35026	38	1084
Babek	82842	26557	43215	13070	30911	9954	508	-	3394	1685	35077	84	1229
Shahbuz	83658	23944	54843	4871	30364	7389	2208	28	1510	355	41330	41	433
Julfa	92630	20909	63969	7752	25757	4845	712	-	1734	987	57999	45	551
Ordubad	97899	30987	62194	4718	22160	6592	389	-	1172	753	66289	37	507
Nakhchivan	19157	13600	3761	1796	5215	3957	406	-	4654	436	3491	8	990
Total on AR	550275	190023	303726	56526	177382	77162	4750	47	18641	5867	260419	397	5610

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In the amount of harmful salts, sulfate ion (SO_4^{2-}) dominates, and it is considered to be weakly saline in the 0-25 cm layer, and strongly saline in the 50-75 cm layer.

From the results of the soil analysis taken from the territory of Khok municipality, it can be seen that the area is poorly supplied with hummus and has high carbonate content (4.43-20.20%). Based on the amount of pH (7.59-7.88), the research area is weakly alkaline. It is high in exchangeable potassium, very poorly supplied with active phosphorus. The amount of harmful salts consists of chlorinated-sulfated compounds, and the sulfate ion has increased to 1.023%, which indicates severe salinization of the area. The amount of chlorine ion varies between 0.009-0.623% in a layer of 50-75 cm, and the area is considered moderately saline.

From the results of soil analysis in the territory of Boyukduz municipality, it is known that the amount of hummus in the area is between 0.65-0.75% and it is of very poor quality. The amount of carbonate is 16.64-20.57% and it is considered highly carbonated and weakly alkaline. The field is very high in potassium and very low in phosphorus. The upper layer of the soil is considered to be non-saline, and the lower layers are considered to be moderately saline, with sulfate ions predominating in the amount of harmful salts.

In the autonomous republic, the process of swamping and repeated salinization under irrigation conditions is widespread in the Sadarak Plain, the eastern part of Boyukduz, and the southeastern parts of the Nakhchivan Plain, developing on grey, grey-meadow, grey-brown, chestnut coloured soil, and partially alluvial-grass soils. Swamped and salinized soils are mainly formed around reservoirs and irrigation canals as a result of water seepage from them raising the groundwater table. The information about grassy, swampy and saline land areas in the autonomous republic using the field research materials and fund data collected by us is shown in the following table (table 2).

As a result of natural processes in the territory of the autonomous republic, 6,699 ha of land are marshes, and 4,879 ha of land are salt marshes. As a result of anthropogenic influence, 1196 ha of irrigated land became swampy, 3858 ha of land became saline, and 3689 ha of land became grassy and degraded.

Table 2

Administrative districts subjected to soil degradation due to anthropogenic effects

Administrative districts	Swampy lands, ha	Turfing lands, ha	Salinated lands, ha	Total degraded lands, ha	Percentage of irrigated land
Ordubad	9	4	54	67	1,3
Nakhchivan	61	435	336	832	31,5
Babek	54	478	257	789	5,5
Julfa	294	97	573	964	18,1
Sadarak	404	2075	781	3260	82,2
Kangarli	-	137	1126	1263	10,2
Sharur	374	463	731	1568	9,6
Total on AR	1196	3689	3858	8743	13,7

There are 63,785 ha of irrigated land in the autonomous republic, of which 6,153 hectares (10%) have been degraded as a result of anthropogenic effects and removed from the production cycle. 1327 ha of Sharur district, 1234 ha of Kangarli district, 1134 ha of Sadarak district, 958 ha of Julfa district, 795 ha of Babek district, 638 ha of Nakhchivan city and 67 ha of Ordubad district are covered by irrigated lands (Diagram 1). Compared to the total irrigated lands, the most water-degraded lands are in Sadarak district, and the least in Ordubad district. Slope inclination is one of the most important features that determine the potential hazard of erosion. Using Geographic Information Systems (GIS) technologies, field research materials, Landsat satellite images, Google Earth Pro and ArcGIS 10.3 software, a map depicting the slope distribution were prepared for the first time (Diagram 2).

Based on these data, the degree of soil degradation was determined, taking into account the area of the territory according to the inclination, and current situation of anthropogenic load on the areas.

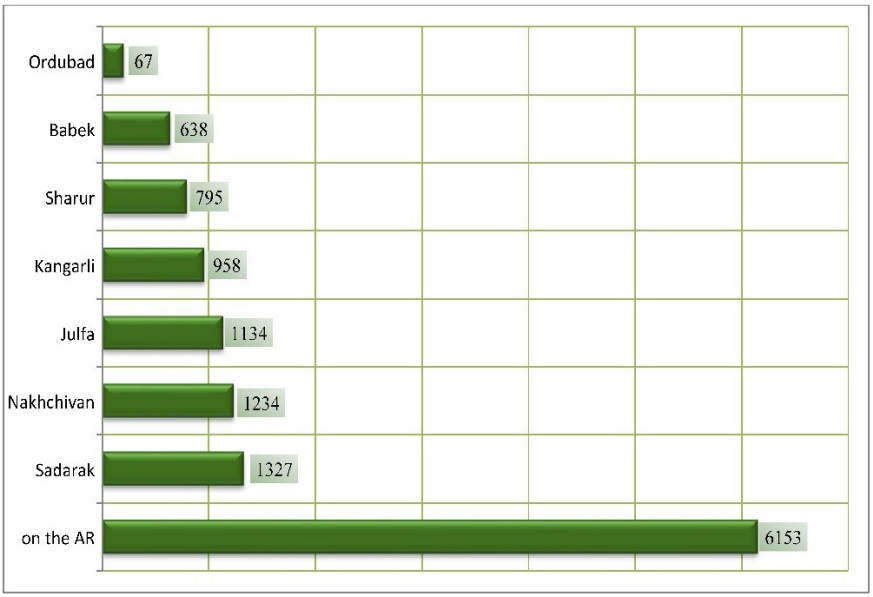

Diagram 1. Land areas subj ect to water-degradation

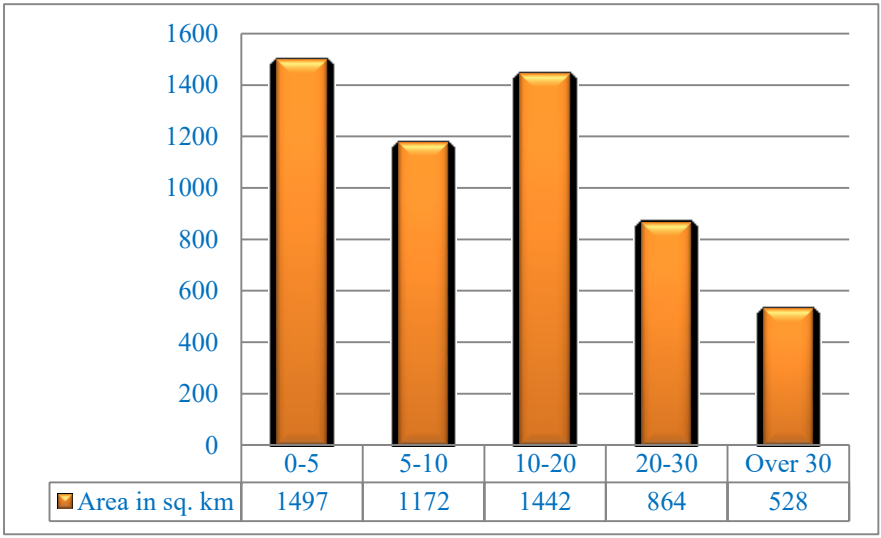

Diagram 2. Distribution of inclination by area

Based on the mathematical and statistical calculations, it was determined that the area of 2669 km^2 or 266884 hectares with an inclination of up to 10 degrees, which is intensively used in agriculture, includes plains and foothills with a height of up to 1200 meters. 2,756 ha of perennial crops, 8,605 ha of meadow-swamped lands, 40,974 ha of crops, 403 ha of forest, 66,265 ha of pasture, 5,712 ha of salinities, and 14,192 ha of residential areas of this area, which is equal to 1,389 km^2 in total.

A part of the area of approximately 1000 km^2 with an inclination of up to 10 degrees is a rural grazing area, and the rest is under transport roads, water basins, etc. are areas subject to natural-anthropogenic influences or degraded.

Correct assessment of the distribution of anthropogenic loading on the territory has a great role in soil degradation. The densest settlement covers the area between 600-1000 m absolute altitude. 96.7% of the urban population and 67.6% of the rural population are concentrated here. The cities of Nakhchivan, Sharur, Julfa, Babek, Ordubad, Haydarabad, Givrag, Nehram, Aliabad, Shahriyar and 111 rural settlements of the autonomous republic are located within these heights. The Nakhchivan plain covers a large part of the Arazboyu plain. 91,076 people live in Nakhchivan city, Aliabad settlement, Karakhanbeyli, Karachug, Bulgan, Hajiniyat, Tumbul villages located in the Nakhchivan plain. 85.7% of it (78037 people) belongs to the city of Nakhchivan. Nakhchivan plain is the most densely populated area after Sharur plain. One of the important reasons for the greater degradation of soils in this zone in the territory of the autonomous republic is the greater anthropogenic influence to the area. The decrease of the population, density and settlements towards the middle and high highlands has led to the weakening of anthropogenic influence and the strengthening of natural degradation. This trend is repeated in separate administrative districts. A population settlement (density) map was drawn up of the area based on modern research methods and statistical data.

Prof. R.H. Mammadov (1956-1967) and prof. Since the research conducted by A.G. Guliyev (1974-2002) is closer to our research work, the nature of the work carried out there directly

played an important role in solving the issues we faced. Therefore, the experimental sites were selected according to the areas of their research, these areas are shown on the land map at a scale of 1:100000 (Figure 1). The results obtained from the experimental sites were compared with previous studies (table 3).

In the results of the analysis of the soil samples taken from the Nehram experimental area, a 0.50% decrease in the amount of hummus and an increase in the amount of harmful salts were observed during the last period (table 3).

The results of the research conducted in the experimental area of the village of Boyukduz show that over the last 50-60 years, the amount of hummus in the top 25 cm layer of the soil has decreased from 1.24% to 0.75%, the amount of $CaCO_3$ has decreased from 18.64% to 15.3%, and according to the analysis results of 2021, it increased to 16.64%. Although the amount of harmful salts was less in the 0-50 cm depth than in the 1980s, it increased from 0.548% to 1.025% in the 50-75 cm depth in 2021 (table 3).

The results of observation and analysis in the Boyukduz experimental area show that as a result of the failure of the collector-drainage network, the level of groundwater has risen and the amount of harmful salts has increased at a depth of 50-75 cm.

From the analysis of soil samples conducted in Khok experimental area, it can be seen that in the period between 1957 and 2021, the amount of hummus decreased to approximately 75%, while the amount of $CaCO_3$ and harmful salts increased (table 3).

The fourth chapter of the dissertation is called **"Evaluation of soil degradation, mapping and ways of efficient use of soil resources".**

To the methodological ideas of studying and mapping soil degradation processes were found in A. G. Guliyev (1977), S. A. Hajiyev (1980), E. Sh. Bayramov (2002), A. I. Hajiyev (2002), M. P. Babayev (2003), V.H. Hasanov (2003), T.G. Boychiyev (1982), N.G. Kharin (1985) and others works. When preparing the degradation map of the autonomous republic, referring to the methodology and

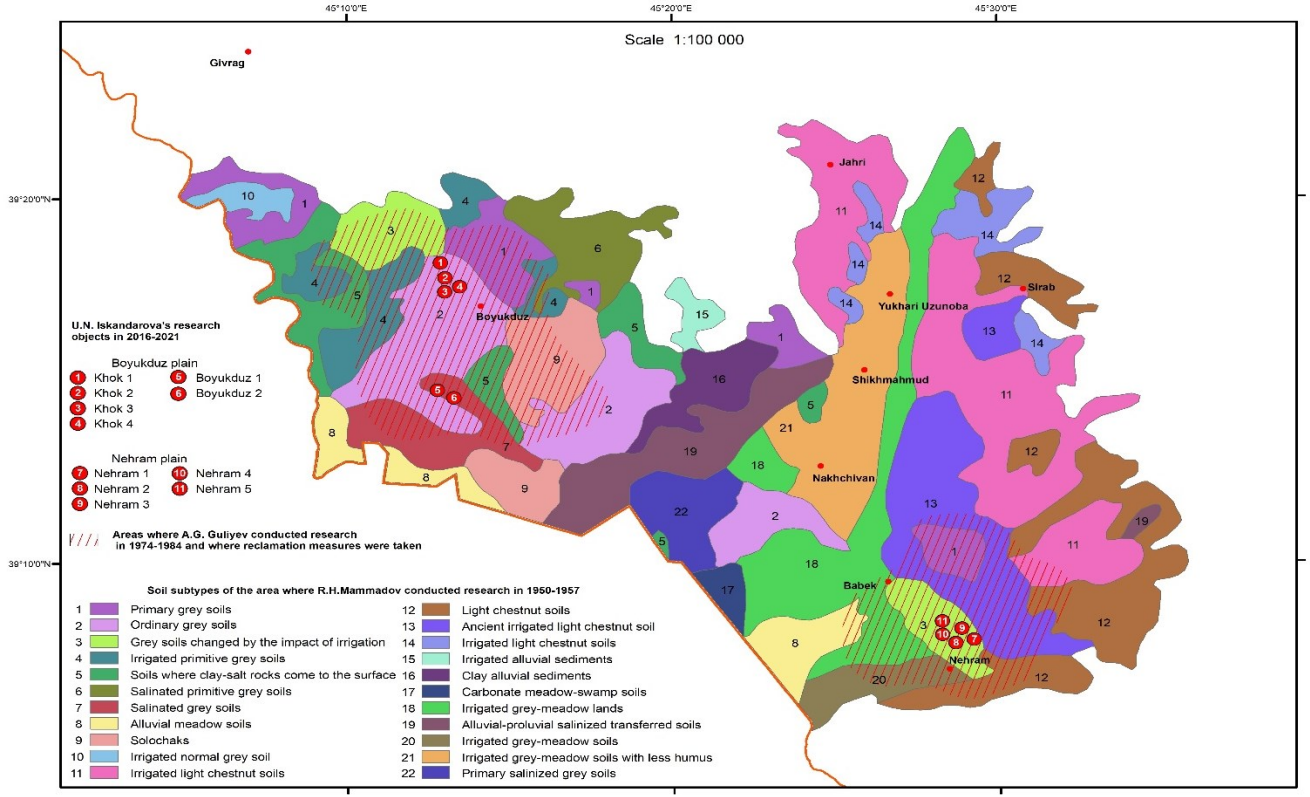

Figure 1. Map scheme of soil surveys conducted in the plain areas of Nakhchivan Autonomous Republic of Azerbaijan

Table 3.

Comparative table of experimental field soils

Researchers	Depth	**Nehram research area**	Indicators (in %)			**Boyukduz experimental field**	Indicators (in %)			**Khok experimental field**	Indicators (in %)		
			Total hummus	$CaCO_3$	The amount of harmful salts		Total hummus	$CaCO_3$	The amount of harmful salts		Total hummus	$CaCO_3$	The amount of harmful salts
R.Mammadov (1950-1957)	0-25		1,73	11,34	0,120		1,24	18,64	0,070		4,16	12,73	0,070
	25-50		1,35	10,23	0,195		0,98	25,70	0,288		1,36	15,35	0,288
	50-75		1,40	10,68	0,240		1,01	26,83	-		0,78	18,64	-
A.Guliyev (1974-1984)	0-25		1,37	14,46	0,385		1,21	15,3	0,368		1,99	19,87	0,325
	25-50		1,25	8,025	1,495		1,07	13,55	0,526		1,73	16,91	0,837
	50-75		0,71	8,890	1,650		1,32	16,66	0,548		1,63	19,73	1,000
U.Iskandarova (2014-2021)	0-25		1,23	13,63	0,642		0,75	16,64	0,157		1,19	16,43	0,339
	25-50		0,90	12,74	1,210		0,63	18,71	0,125		0,65	18,78	1,441
	50-75		0,66	12,92	1,048		0,31	19,84	1,025		0,65	16,97	1,482

experience of the mentioned authors, the following criteria were taken as a basis: 1) degree of surface covering by plants; 2) irrigation erosion; 3) salinization; 4) turfing; 5) swamping; 6) overloading of pastures; 7) industrial and technogenic pollution.

As a result of the research carried out in 2014-2021, a 1:100,000 scale map reflecting the state of soil degradation in Nakhchivan AR was drawn up for the first time using Landsat satellite images based on the NDVI coefficient (Figure 2). Preparation of NDVI maps is one of the most modern methods established for the quantitative indicators of vegetation cover. According to the methodology used by M.P.Babayev and E.A.Gurbanov (2008) to determine soil degradation in the study area, the area is divided into four categories reflecting the density of vegetation: non-degraded areas; mildly degraded areas; moderately degraded and severely degraded areas.

According to our calculations on the map, 111862 ha or 20.3% of the total territory of the autonomous republic are non-degraded areas with well-grown vegetation. Weakly degraded areas are sparsely vegetated land areas, accounting for 244,906 ha or 44.5% of the total area. Moderately degraded areas are land areas with poor vegetation covering 174,894 ha or 31.8% of the total area. Covering 13,667 ha or 2.5% of the total area, severely degraded areas include artificial cover areas, landslide and avalanche areas, swamps, and soil under water surfaces. Seasonal glacier and snow covered areas cover 4944 ha or 0.9% of the area.

An anthropogenic degradation map of the soils of the Nakhchivan Autonomous Republic on a scale of 1:100,000 was drawn up with the experts of the State Service for Real Estate and Land Issues, the Ministry of Ecology and Natural Resources, and the "Araz" Science and Production Union based on perennial field research and fund materials (Figure 3). The anthropogenic factors causing land degradation are classified in 3 groups (water degradation, grazing-pasture and industrial-technogenic factors) on the map. According to the research, water-irrigation degradation is spread over 8743 ha, pasture-pasture degradation is 185102 ha, and industrial-technogenic degradation is spread over 950 ha. In general, 194,795 ha of soil in the autonomous

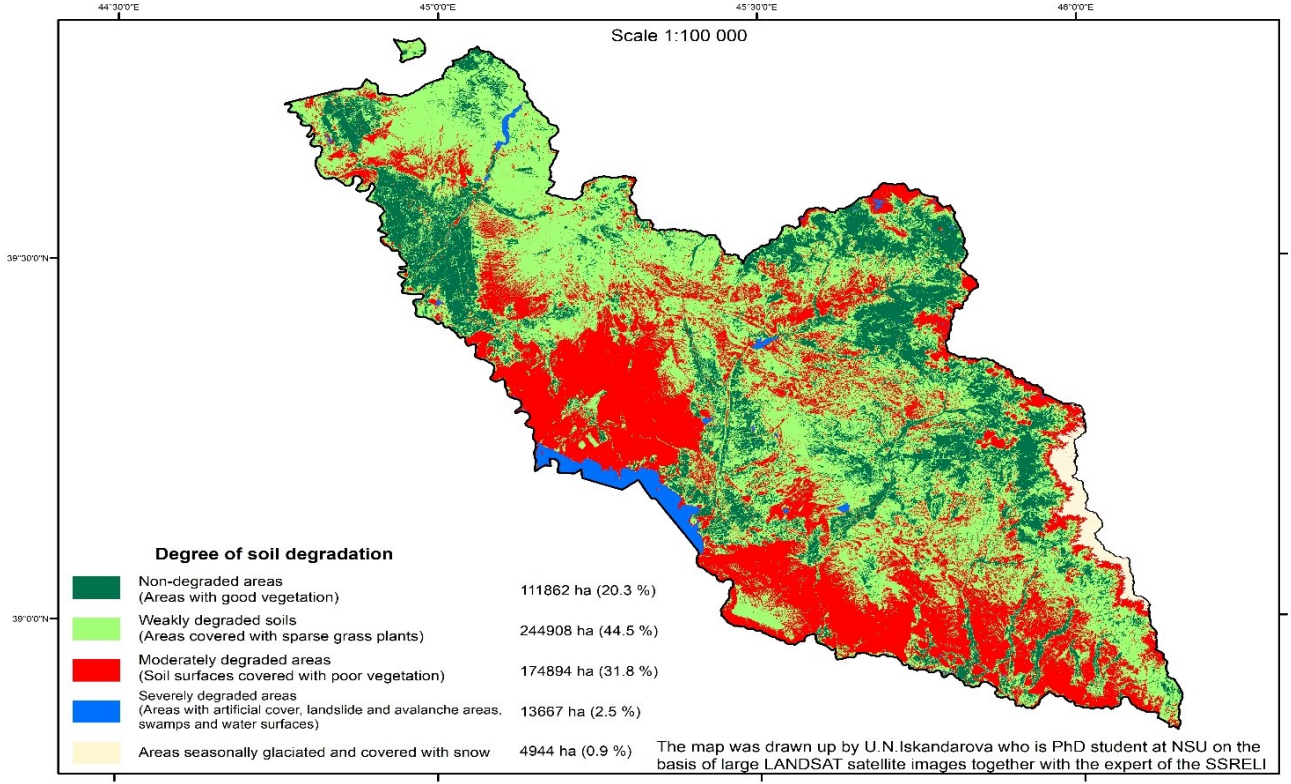

Figure 2. State of land degradation of Nakhchivan Autonomous Republic

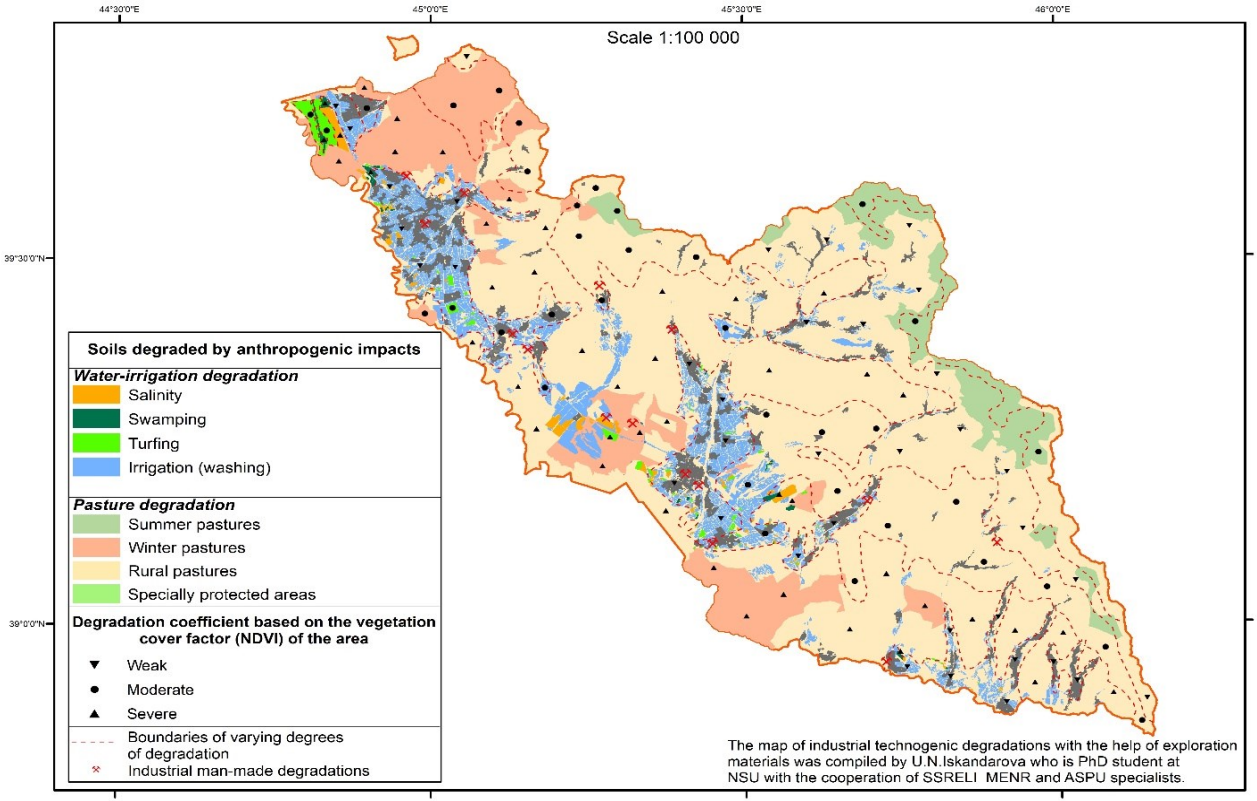

Figure 3. Anthropogenic soil degradation map in Nakhchivan Autonomous Republic.

republic have been subjected to anthropogenic degradation, which is 35.4% of the total area.

As a result of the degradation processes, the usable land areas, which decrease year by year, will lead to a shortage of fertile land and food in the future. Therefore, comprehensive measures to combat soil degradation in the autonomous republic should be prepared and implemented at the same time. At this time, specifically, all the characteristics of the territories should be taken into account. Phytomelioration and recultivation measures should be taken as a basis when developing control measures and the following measures should be taken:

- To keep the collector-drainage network in working condition in order to lower the level of groundwater in Sadarak, Sharur, Kangarli, Nakhchivan, Julfa plains, and to increase their density in crisis areas;
- It is necessary to use organic and mineral fertilizers and apply the rotation system of cropping in order to increase the productivity of the soil in the Nehram experimental area.
- In order to prevent repeated salinization in the study area, the collector-drainage network should be reconstructed, the overflowed irrigation canals should be cleaned and the irrigation regime should be strictly followed.
- It is possible to use organic and mineral fertilizers to increase the fertility of the soil in the Khok experimental area, and to direct the harmful salts to the lower layers, by giving an excess irrigation rate (25-30%), it is possible to prevent repeated salinization. At the same time, it spraying methods.
- In order to prevent repeated salinization that may occur in the Boyukduz experimental area, it is necessary to restore the collector-drainage networks that have been filled or failed as a result of neglect, to strictly follow the irrigation norms, and to apply the spraying method.
- It is necessary to adapt the load of summer pastures of Shahbuz, Ordubad and Julfa, Sharur administrative districts and winter pastures of Sadarak, Kangarli, Julfa administrative districts to the number of animals.
- It is necessary to entrust the task of implementing a rotational grazing system and preventing overgrazing to local municipalities and

executive bodies.

- It is important to control the annual cleaning of irrigation canals, collectors, and open drains in all administrative districts located in the Arazboyu plain, and the transportation of earthen canals with concrete-lined canals.

- In areas affected by Technogenic pollution such as Gumushlu, Paragachay, Shahtakhti, recultivation measures should be carried out, natural landscapes should be restored taking into account the relief and climate characteristics, or cultivated landscapes should be created in areas where this is not possible.

- In order to prevent irrigation erosion, it is advisable to improve is more appropriate to carry out irrigation here by drip-irrigation and irrigation technology, apply drip irrigation and spraying method, taking into account the local conditions of the irrigated area.

- In order to prevent erosion around the Duzdag Plateau, where wind erosion spreads, it is necessary to determine the direction of the winds and build protective forest strips, and on the Julfa plain, plow the land in the opposite direction of the wind and plant trees and bushes according to the direction of the wind.

CONCLUSIONS

1. For the first time, perennial observations and soil analysis results of chosen experimental areas were compared with previous research results. From the comparison of the results, it is known that in the Nehram experimental area (39°8'3,712" N.E., 45°28'48,432" N.N.) the amount of hummus decreased by 0.50% during the last 60-70 years, harmful salts increase of its amount by 5 times, in Khok experiment area (39°18'23,030" N.E., 45°12'22 N.W.) the amount of hummus decreased to approximately 75%, the amount of harmful salts increased by 2 times, Boyukduz in the experimental area (39°14'39,595" N.E., 45°12'4.330" N.N.) the amount of hummus decreased to approximately 35%, the amount of harmful salts in the lower layers (50-75 cm deep) It has increased by 2 times. If this process continues, desertification centers in the area may cover a

wider area [13].

2. From the research, we conclude that it is possible to implement complex agromelioration measures properly in the Arazboyu sloping plains of Nakhchivan and to reduce the anthropogenic load in the area, to weaken the degradation process and restore the biopotential.

3. For the first time, a 1:100,000 scale map was prepared based on the NDVI (Normalized Difference Vegetation Index) coefficient with LANDSAT satellite images, reflecting the state of soil degradation of Nakhchivan AR. According to our calculation on the map, 79.7% of the research area has been subjected to various degrees of degradation. Among them, 44.5% of them were weakly degraded, 31.8% moderately degraded, and 3.4% severely degraded [12].

4. There is a dependence between the compiled degradation map and the map reflecting the density of settlements and population, that is, it was determined that the low mountainous areas of 600-1000 meters, where settlements and population are densely located, have suffered from more anthropogenic degradation [9].

5. Degradation processes (re-salinization, irrigation erosion, swamping) due to improper assessment of ecogeographical conditions and inefficient use of soil are most often observed in the soils of Julfa, Sadarak, Kangarli and Sharur districts, and least often in the soils of Babek, Ordubad and Shahbuz districts [11].

RECOMMENDATIONS AND PROPOSALS

1. Based on field researches and fund materials, we consider it appropriate to use the map showing the state of summer and winter pastures, technogenically polluted soil areas, areas that subject to salinization and irrigation erosion in the Auxiliary Experimental Farm of the "Araz" Science and Production Union named after Academician Hasan Aliyev of the Ministry of Agriculture.

2. In order to prevent soil erosion in the foothills and mountainous areas, it is recommended to apply transverse plowing and drip irrigation system on mountain slopes, and use large-scale morphometric maps in the duration of terracing.

3. It is advisable to observe the grazing norms and to sow perennial plant seeds suitable for local conditions in order to restore the degraded landscape areas in the summer pastures, to prevent plant and soil degradation.

4. It is recommended to study the international experience in the organization of agricultural activity, develop measures to fight against degradation and implement it relevant to local conditions.

5. Using the most modern achievements of science and technology in the management of agriculture, the study of the degradation process and the fight against it, for instance, remote monitoring, the installation of surveillance cameras, etc. are appropriate.

6. We recommend monitoring the rise of the groundwater level and salinization in the Arazboyu Plain and the development of measures to combat it.

The maın content of the dıssertatıon ıs published ın the followıng works:

1. Iskandarova U.N Forms of anthropogenic impact on soils in the territory of Sharur region // - Nakhchivan: Scientific Works of Nakhchivan State University, Natural Sciences and Medicine Series, - 2013 No. 2 (55), - p. 69-71.
2. Iskandarova U.N. Landscapes created by anthropogenic effects in the low mountains of Nakhchivan MR / - Ganja: Current problems of modern natural sciences. International scientific conference, May 4-5, 2017, p. 327-330.
3. Iskandarova U.N Forms of anthropogenic impact on the middle mountainous zone in the territory of Nakhchivan MR / - Baku: Works of the Azerbaijan Geographical Society, Human and

environmental relations, volume XX, - 2017, - p.188-190.
4. Iskandarova U.N. Relief as the main soil-forming algorithm and its main features // - Nakhchivan: Nakhchivan State University Scientific Works Series of Natural Sciences and Medicine, Gayret publishing house -2018. No. 7(96), - pp. 167-170 (jointly with A.M. Hasanov).
5. Iskandarova U.N. Disruption of land by technical works in Nakhchivan MR as a factor causing land degradation / - Ganja: Actual problems of modern natural sciences, International scientific conference, - May 3-4, 2019, -p. 317-319 (together with A.M. Hasanov).
6. Iskandarova U.N Irrigation erosion as a factor causing soil degradation / - Baku: Proceedings of the 1st International Scientific Conference on Humanities and Social Sciences. - July 24, 2020, – p. 330-333.
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13. Iskandarova U.N. The study of geographical distribution characteristics and ecological problems of gray soils in Nakhchivan MR // - Baku: Works of the Azerbaijan Geographical Society, Geography and natural resources, - 2022. No. 2 (17), - p.53-59

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