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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

ECOLOGICAL ASSESSMENT AND PROTECTION OF SOILS OF THE GUSAR-GONAGKEND CADASTRAL DISTRICT

Specialty: 2426.01 – Ecology

Field of Science: Biology

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INTRODUCTION

Actuality of research. Over the past 20 years, the development of agriculture in the world has been taking place within the framework of the new biosphere paradigm of environmental management, adopted by the UN Conference in Rio de Janeiro in 1992. Its main essence is the greening of economic activities, that is, the adaptation of these activities to the laws and norms of environmental management based on ecology. The concrete expression of this position is manifested in the creation of environmentally and economically balanced, high-yielding and sustainable agricultural landscapes, maximally adapted to the local environmental situation.

According to the decree of the President of the Republic of Azerbaijan dated December 6, 2016, the "Strategic Road Map for the production and processing of agricultural products in the Republic of Azerbaijan" was adopted. According to the "Strategic Road Map", the implementation of the effective organization of territories where natural, economic and socio-demographic processes are harmoniously combined based on the greening of agricultural production should become one of the main priorities of state agricultural policy. The main goal of implementing the road map is to achieve the formation of competitive agribusiness based on strengthening the transition from traditional agriculture to market-oriented intensive agriculture by 2025. It should be noted that one of the main priorities of the Road Map is to conduct scientific research in the field of agriculture and expand the scope of application of the results obtained. From this point of view, scientific research of the land fund of the Gusar-Gonagkend cadastral district, which is one of the agricultural zones of Azerbaijan, carrying out an environmental assessment and developing ways to organize the effective use and protection of its lands are important.

Object and subject of research. The object of the study is the soils of the Gusar-Gonagkend cadastral district, located on the northeastern slope of the Greater Caucasus, with a total area of 453,932 hectares (5.24% of the total territory of the republic). The subject of the study was the environmental assessment of soils in the Gusar-Gonagkend

cadastral district.

Purpose and tasks of research. The main goal of the research work is to conduct an environmental assessment of the soils of the Gusar-Gonagkend cadastral district, located on the northeastern slope of the Greater Caucasus, and to develop protection measures. To achieve the goal, the following tasks were set: study of the current state of natural and environmental conditions of the Gusar-Gonagkend cadastral district; drawing up a soil map-scheme of the cadastral region based on a comprehensive survey of the territory's lands; assessing soil quality at the level of type and subtype; construction of open and final quality assessment scales by applying correction factors; carrying out forestry and agro-industrial grouping of soils in the Gusar-Gonagkend cadastral district, drawing up a cartogram of soil quality; compilation of special scales for assessing soils of territories according to the degree of expression of individual characteristics; conducting an environmental assessment of the soils of the Gusar-Gonagkend cadastral district and drawing up a map of the environmental assessment of soils; identification of factors influencing the land use in the cadastral region; organizing the effective use and protection of soils in the research area and developing ways to increase soil fertility.

Research methods. Physicochemical analyses taken from the soil samples are performed on the following methods: "*humus and total nitrogen by I.V.Turin; the amount of total phosphorus in percent - by X-ray spectral method; mechanical composition – by N.A. Kachinsky; total water extract – by D.I. Ivanov; absorbed* Ca^{+2} *and* Mg^{+2} *cations - by D.I.Ivanov; pH- water suspension – by pH-metre;* CO_2 *carbonate – by calcimeter "*[1].

When carrying out the appraisal and environmental assessment of soils in the Gusar-Gonagkend cadastral district, the following methods were used: *"Methodological recommendations for appraisal soils in Azerbaijan"*[2], *"Soil appraisal"*[3], *"Map of environmental*

[1] Аринушкина, Е.В. Руководство по химическому анализу почв. / Аринушкина Е.В. - Москва: Изд-во Московского университета, - 1970, - 488 с.

[2] Методические указания по проведению бонитировки почв в Азербайджане.

assessment of soils of Azerbaijan and its significance"[4], "*Methodological recommendations on conducting land valuation for the purpose of land cadastre in the Azerbaijan SSR*" [5], and the methods of *G.Sh.Mammadov*[6] *and S.Z.Mammadova*[7]. Statistical mathematical analysis of the obtained data was carried out *based on the methodology of B.A.Dospehov*[8].

Main provisions submitted for defense:

- ✓ Determination of the current state of soil fertility in the Gusar-Gonagkend cadastral district based on a qualitative assessment of soils;
- ✓ Forestry and agricultural production grouping of soils in the Gusar-Gonagkend cadastral district based on a detailed bonitet scale;
- ✓ Determination of ecological scores of soils and drawing up a map of ecological assessment of soils in the study area;
- ✓ Preparation of a system of measures aimed at the effective use and improvement of soil fertility in the Gusar-Gonagkend cadastral district.

Scientific novelty of research. For the first time, an assessment of the soils of the Gusar-Gonagkend cadastral district was carried out and a bonitet cartogram was compiled; forestry and agricultural production grouping of soils was carried out; special rating scales have been developed that reflect the level of expression of various soil properties; an environmental assessment of the soil cover of the Gusar-Gonagkend

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- Баку: Элм, - 1973, - 40 с.

[3] Məmmədov, Q.Ş. Torpaqların bonitirovkası. / Məmmədov Q.Ş., Cəfərov A.B. - Bakı: Elm, - 1997. -174 s.

[4] Мамедов, Г.Ш. Карта экологической оценки почв Азербайджана и ее значение. / Мамедов Г.Ш. - Баку: АзНИИНТИ. - 1992, - 25 с.

[5] Методические указания по проведению бонитировки почв в целях земельного кадастра Азерб.ССР.- Баку: Элм, - 1979, - 48 с.

[6] Məmmədov, Q.Ş. Azərbaycan torpaqlarının ekoloji qiymətləndirilməsi. / Məmmədov Q.Ş.- Bakı: Elm, - 1988. - 281 s.

[7] Məmmədova, S.Z. Azərbaycanın Lənkəran vilayəti torpaqlarının ekoloji qiymətləndirilməsi və monitorinqi. / Məmmədova S.Z. - Bakı: Elm, - 2006, - 370 s.

[8] Доспехов, Б.А. Планирования полевого опыта и статистическая обработка его данных./ Доспехов Б.А. - Москва: Колос, - 1972, - 208 с.

cadastral district was carried out and an environmental assessment map of a scale of 1:100,000 was compiled; a conceptual scheme for the effective use and protection of soils in the Gusar-Gonagkend cadastral district has been developed.

Theoretical and practical significance of the research. Materials such as a bonitet cartogram of the soils of the Gusar-Gonagkend cadastral district, an environmental assessment map, a conceptual scheme for the effective use and protection of territorial lands, have both theoretical and practical significance in solving the problems of restoring and protecting the balance of natural ecosystems, ensuring environmental safety and sustainability, protection of soil cover.

Aprobation and application of the dissertation. The materials of the dissertation and the obtained scientific results were discussed at various scientific symposiums, sessions, scientific and practical conferences of the republican and international level: BSU at the 7th Republican Scientific Conference "Current Problems of Ecology and Soil Science in the 21st Century" (May 2018); BSU at the VIII Republican Scientific Conference "Current Problems of Ecology and Soil Science in the 21st Century" (May 2019); "Reflection of bio-, geo- and anthropospheric connections in soil and soil cover" of the International Scientific Conference (Tomsk, September 2020), "Innovations in Soil Science and Plant Nutrition under Climate Change" Eurasian Soil Congress (Samsun, Turkiye, September 2025) and in scientific reports of the faculty.

Personal contribution of applicant.

Conducting field and laboratory research, analyzing and summarizing the results obtained in the dissertation work was carried out by the author personally.

Name of organization where dissertation work was carried out. The dissertation work was completed in the period from 2014 to 2020. The main part of the research work was carried out at the Faculty of Ecology and Soil Science of BSU, and part at the Institute of Soil Science and Agrochemistry of the Ministry of Science and Education of the Azerbaijan Republic.

The structure and volume of the dissertation. The dissertation consists of an introduction, 6 chapters, conclusion and a bibliography of 205 titles. There are 3 maps, 21 tables, 6 diagrams, 3 figures, and appendices. The total volume of the dissertation consists of 305 thousand characters, excluding tables, diagrams, appendices and references - 236 thousand characters.

CHAPTER I
ECOLOGICAL STATE OF GUSAR-GONAGKEND CADASTRAL DISTRICT

The Gusar-Gonagkend cadastral district, located on the northeastern slope of the Greater Caucasus, covers an area of 453,932 hectares (5.24% of the total territory of the republic). In the Gusar-Gonagkend cadastral district, the elevation varies from 115-250 m in the north to 950-1500 m in the south. It includes all low-mountain, mid-mountain and partially high-mountain parts of the Gusar, Guba, Shabran, Khizi and Siyazan administrative districts. The mountainous part of these administrative districts was allocated to a subdistrict and named the Khaltan-Khinalig cadastral subdistrict.

The soil-forming rocks of the territory are composed of Jurassic and Cretaceous rocks in the southwestern part and marine sediments in the northeastern part. The cadastral region includes 3 soil-climatic zones: 1. Mid- and high-mountain zones with dry winters and cold climates; 2. Low and mid-mountain zone with a moderately warm climate with dry winters; 3. Low-mountain and foothill zones with a moderate-warm climate. According to the weather stations of the Guba and Gusar administrative districts, the average monthly temperature at the study site was -1.1-2.0^{0}C in the winter months, and 17.1-21.7^{0}C in the summer months. The absolute minimum temperatures in the region's climate were observed in January, reaching -14^{0}C in Guba, -12^{0}C in Gusar and -8^{0}C in Khachmaz, which has lower altitudes. The amount of precipitation by month ranges from 23-82 mm (Gusar) to 29-80 mm (Guba). The river network of the cadastral region mainly consists of Gudyalchay,

Gusarchay, Valvalachay, Guruchay, Agchay, Jagadzhigchay, Garachay and other small rivers.

According to the "*classification of L.I. Prilipko"*[9], the following types of vegetation are common on the territory of the Gusar-Gonagkend cadastral district: 1) mountain xerophytic vegetation (500-1200 m); 2) forest vegetation (700-1800 m); 3) subalpine meadow vegetation (1800-2200 m). In the flora of low-mountain and mid-mountain zones there are cereal-legume and cereal-shrub formations. In addition to forests, the study area contains hornbeam, beech, oak forests, as well as willow pear (*Pyrus salicifolia*), blackberry, blackthorn, hawthorn and shrub-wormwood plant formations.

CHAPTER II
SCIENTIFIC, THEORETICAL AND METHODOLOGICAL FOUNDATIONS OF ECOLOGICAL ASSESSMENT AND SOIL PROTECTION

2.1. The degree of study of the problem

This sub-chapter provides a brief overview of studies highlighting important theoretical and methodological aspects of environmental assessment based on agroecological soil research.

2.2. Object and methodology of research

The soils of the Gusar-Gonagkend cadastral district as the object of research have a total area of 453,932 hectares. Research work consists of the following stages:

Stage I (desk-preparatory): an analysis of literary, fund and cartographic materials on soil-ecological indicators of the Guba, Gusar, Shabran, Siyazan, Khizi districts included in the Gusar-Gonagkend cadastral district was carried out, and a route for field

[9]Прилипко, Л.И. Растительный покров Азербайджана. / Прилипко Л.И. - Баку: Элм, - 1970, - 172 с.

research was drawn up.

Stage II (field): The field stage was carried out in 2014-2016, field soil research was carried out and 38 soil profiles were set at characteristic points of soil types and subtypes distributed in the study area. The vegetation of the territories on which these soil profiles were located was also studied.

Stage III (laboratory): Physico-chemical analyzes of the taken soil samples were carried out using generally accepted methods.

Stage IV (final and generalizing stage): Mathematical and statistical calculations were carried out to determine the reliability of soil fertility indicators and correlation dependencies were identified; soil appraisal was carried out on the basis of stable diagnostic characteristics. special rating scales have been developed for the degree of expression of individual soil features; based on the use of these scales, an environmental assessment of the soil cover of the study area was carried out.

CHAPTER III
CHARACTERISTICS OF SOIL FERTILITY OF THE GUSAR-GONAGKEND CADASTRAL DISTRICT

3.1. Soil cover of the Gusar-Gonagkend cadastral district

Based on the "Soil Map of Azerbaijan" on a scale of 1:100,000 of the Institute of Soil Science and Agrochemistry of MSERA, the "Soil Map of the north-eastern slope of the Greater Caucasus" and based on the results of our own field and laboratory research, a Soil Map of the research object on a scale of 1:100,000 was prepared (Fig. 1).

According to the schematic map, the following types and subtypes of soils are common in the territory:

I. High-mountain zone - mountain-meadow and mountain-forest-meadow soils (at an altitude of 1200-2000 m above sea level);

II. Middle-mountain zone - brown mountain-forest soils (800-1200 m above sea level);

III. Low-mountain zone - mountain-brown, mountain gray-brown (chestnut), mountain gray-brown (chestnut)-meadow soils (200-800

m above sea level);

IV. Intrazonal soils - mountain-forest soddy-carbonate soils, alluvial-meadow soils.

3.2. Morphogenetic and bioecological characteristics of soils in the high mountain zone

Primitive, soddy-peaty, soddy and chernozem-like subtypes of mountain-meadow soils are widespread at the study site.

The humus layer of primary mountain-meadow soils is 5-14 cm thick, its content is 2.62-3.75%, and the total nitrogen content is 0.22-0.25%; in soddy-peaty mountain-meadow soils, humus is 5.65-9.30%, and total nitrogen is 0.30-0.54%; in soddy mountain meadow soils, humus is 3.47-7.13%, total nitrogen is 0.25-0.39%, and total phosphorus is 0.17-0.22%; in chernozem-like mountain-meadow soils, humus is 5.81-9.65%, and the total nitrogen and phosphorus content is 0.31-0.49% and 0.22-0.29%. The amount of physical clay (0-100 cm) is 25.82-42.57% (primary), 31.16-50.76% (soddy), 33.08-56.83% (chernozem-like); the amount of silt particles is 13.46-27.38% (primary), 14.96-23.44% (soddy), 16.10-23.96% (chernozem-like). The profile of these soils is weakly acidic (pH 5.3-6.6) and the absorption capacity varies from 14.81-25.37 meq (primary), 34.42-47.39 meq (soddy-peaty), 25.81-35.41 meq (soddy) and 37.21-51.09 meq (chernozem-like).

3.3. Morphogenetic and bioecological characteristics of soils in the mid- and low-mountain zones

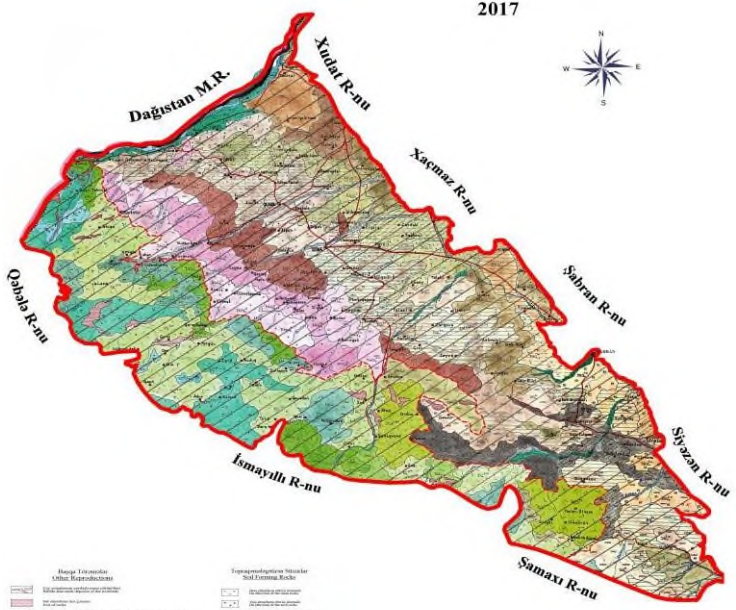
In the mid-mountain zone of the Gusar-Gonagkend cadastral district there are 4 subtypes of brown mountain-forest soils: typical - 20752 ha, unsaturated -12588 ha, residual carbonate -5500 ha and brown soddy mountain-forest soil -1530 ha.

In typical mountain-forest brown soils, the humus content in the upper layer was 2.91-5.82%, the total nitrogen content was 0.20-0.37%; in the residual carbonate subtype, humus was -4.56-8.84%,

LAND MAP-SCHEME OF THE GUSAR-GONAGKEND CADASTRAL DİSTRİCT

Scale 1:100000

2017



LEGENDA

Digər Təlimatlar
Other Reproductions

Torpaqəmələgətirən Süxurlar
Soil Forming Rocks

Torpağın Eroziyaya Uğarma Dərəcəsi
Degree of the Soil Erosion

Torpağın Quruluşculuğu Tədqiqi
Granulometric Structure of the Soil

Torpaq Kompleksləri
Complex of Soils

Xəritə-sxem M.E. Salayevin rəhbərliyi altında "Azərbaycanın Torpaq Xəritəsi" (M 1:100000, 1994-cü il) əsasında tərtib edilmişdir.

nitrogen -0.28-0.51%. Total absorbed bases - 23.10-37.69 meq (typical), 27.44-43.50 meq (residual carbonate); clay particles -39.51-55.19% (typical), 45.04-60.18% (residual carbonate); silt particles - 13.77-25.63% (typical), 15.31-27.70% (residual carbonate); the amount of carbonates -0.43-3.84% (typical), 11-13% (residual carbonate); The pH indicator was 6.1-7.2 (typical), 7.0-7.8 (residual carbonate).

In the low-mountain zone of the Gusar-Gonagkend cadastral district, the distribution of 13 subtypes and species diversity of mountain-brown soils has been established.

The amount of humus in typical mountain-brown soils in the upper layer is 3.01-4.87%, total nitrogen -0.17-0.30%, total phosphorus -0.15-0.23%, in carbonate mountain-brown soils humus - 2.31-4.22%, nitrogen - 0.18-0.25%, phosphorus - 0.15-0.23%; the amount of carbonates in the 0-100 cm layer is 0.76-5.43% (typical), 8.40-15.31% (carbonate); pH - 6.5-6.9 (typical), 6.8-7.5 (carbonate). These soils have a high absorption capacity. The amount of particles <0.001 mm - 12.72-26.65% (typical), 15.06-27.82% (carbonate). The amount of particles <0.01 mm was 37.46-58.61% (typical), 30.18-58.23% (carbonate).

In the Gusar-Gonagkend cadastral district mountain gray-brown (chestnut) soils are located on an area of 40,566 hectares: 6,000 hectares of them are dark, 15,240 hectares are ordinary, 9,762 hectares are light soils.

In dark mountain gray-brown (chestnut) soils, the amount of organic matter in the 0-20 cm layer is 2.32-4.47%, nitrogen-0.18-0.25%, phosphorus-0.16-0.21%; in ordinary mountain gray-brown (chestnut) soils, humus is -2.18-4.01%, nitrogen-0.20-0.28%, phosphorus-0.18-0.25%; in light mountain gray-brown (chestnut) soils, humus is -2.06-3.21%, nitrogen -0.15-0.21%, phosphorus - 0.15-0.20%. The absorption capacity of these soils varies between - 19.70-37.10 meq in a half-meter layer by subtype. The amount of $CaCO_3$ is -7.85-21.19% by subtype. The pH value varies from neutral to alkaline - 7.1-8.3; the granulometric composition is light clay and loamy - 30.88-65.10%. Light mountain gray-brown (chestnut) soils

are weakly saline in terms of dry matter content - 0.15-0.25%.

3.4. Intrazonal soils

In soddy-carbonate mountain-forest soils, the humus content in the upper layer is 5.90-10.21%, the nitrogen content - 0.36-0.55%, the absorption capacity in the upper layer is 23-37 meq, pH-8.0. The granulometric composition of these soils is heavy loamy and clayey.

In alluvial-meadow soils, the humus content in the upper layer is 2.11-3.76%, the total nitrogen content - 0.16-0.25%, the absorption capacity - 18.20-24.50 meq (in the upper layer); 17.62-25.20 meq (in a half-meter layer), the carbonate content - 6.8-7.5%. pH-7.2-8.0. The granulometric composition varied from weakly clayey to heavily clayey, amounting to 24.10-48.72% in the 0-100 cm layer.

CHAPTER IV
APPRAISAL OF SOILS OF THE GUSAR-GONAGKEND CADASTRAL DISTRICT

4.1. Evaluation criteria used in assessing soil in our republic

The most important issue in the qualitative assessment of soils is the selection of the correct assessment criteria, that is, the selection of the most important and stable soil properties among the main diagnostic soil indicators. When carrying out appraisal work, the properties and composition of the soil are taken such that they are both the main indicators of fertility and have a direct correlation with plant productivity and are easily expressed using points. According to soil scientists, soils may vary in origin, but all soils have common leading genetic characteristics when it comes to their contents. Based on this, the quantity (%) and reserves (t/ha) of humus and minerals (nitrogen, phosphorus, potassium), as well as the absorption capacity of the soil, were taken as the main price criteria when assessing soil. The reliability of the collected soil data must be checked during a qualitative assessment of the soil; for this purpose, mathematical and statistical analysis is carried out: the average value, standard

deviation, coefficient of variation, average mathematical error and the degree of data reliability are calculated.

4.2. Compilation of the main bonitet scale of soils and bonitet cartogram of soils of the Gusar-Gonagkend cadastral district

The research methods we used when conducting the land assessment of the Gusar-Gonagkend cadastral district are given in the introduction. Based on the collected materials, we divided the territory of the Gusar-Gonagkend cadastral district into 2 agro-ecological regions: 1) soils of the high-mountain zone and 2) soils of the middle and low-mountain zones.

For each zone in the study area, a "standard" soil subtype with the highest fertility was selected, all indicators of which were conditionally taken as 100 scores. For the high-mountain zone, chernozem-like mountain-meadow soils were chosen, and for the middle and low-mountain zones, residual carbonate brown mountain-forest soils were chosen as standard soils.

After calculating the quality indicators of each soil type and subtype distributed in the study area, the main bonitet scale of soils of the Gusar-Gonagkend cadastral district was compiled (Table 1).

According to the results of soil bonitet work, the soils of the high-mountain zone are classified as highly fertile, and quality scores generally range from 62-100 scores; in this area, only primitive mountain-meadow soils have low fertility (52 scores). The soils of the middle and low mountain zones are also very fertile, and quality scores vary between 58-100 scores.

According to the bonitet scale, the mountain-forest soils of the region have higher fertility (87-100 scores) than the soils of the steppe zone. Mountain-forest soddy-carbonate soils, which are intrazonal, received 91 scores as having high fertility. Mountain-brown soils (66-84 scores) have higher fertility than mountain gray-brown soils (58-82 scores). It was found that alluvial meadow soils, which are other intrazonal soils common in the territory, received 73 scores.

Table 1

The main bonitet scale of soils of the Gusar-Gonagkend cadastral district

Name of soils	Humus, t/h score			Nitrogen, t/h score		Phosphorus, t/h score		Sum of absorb. bases meq.100g score		Bonitet score
	0-20	0-50	0-100	0-20	0-50	0-20	0-50	0-20	0-50	
Chernozem-like mountain-meadow	124,93 100	281,84 100	313,95 100	7,13 100	16,64 100	4,35 100	9,38 100	42,85 100	37,75 100	100
Soddy-peaty mountain-meadow	122,50 98	266,76 95	-	6,96 98	16,64 100	3,83 88	8,84 81	39,37 92	33,25 88	93
Soddy mountain-meadow	96,22 77	222,56 79	-	5,57 78	13,0 78	3,31 76	7,28 67	34,13 80	30,71 81	77
Primitive mountain meadow	53,42 43	135,2 48	-	3,83 54	9,88 59	2,44 56	5,72 53	20,29 47	19,01 50	52
Mountain meadow steppe	87,62 70	165,88 59	128,80 41	5,39 76	13,0 78	3,65 84	7,28 67	31,17 73	27,10 72	62
Mountain-forest-meadow	93,61 75	192,92 68	204,70 65	6,44 90	14,04 84	4,35 100	9,88 90	34,87 81	33,59 89	79
Mountain-forest soddy-carbonate	120,06 96	245,44 87	277,15 88	7,13 100	16,12 97	4,35 100	10.00 107	32,45 76	29,15 77	91
Residual carbonate mountain-forest brown	138,92 100	180,32 100	259,86 100	8,36 100	15,12 100	5,92 100	11,76 100	37,14 100	29,17 100	100

Typical mountain-forest brown	94,45 68	179,38 99	245,11 94	6,12 73	11,76 78	4,90 83	11,20 95	31,07 84	24,67 85	87
Typical mountain-brown	92,75 67	174,38 97	229,87 88	5,19 62	11,25 74	4,48 76	10,63 90	34,01 92	30,62 104	84
Carbonate mountain- brown	84,02 60	136,88 76	162,56 63	4,96 59	10,0 66	4,25 72	9,38 80	31,03 84	25,67 88	70
Mountain-brown meadow	89,92 56	161,88 90	217,17 84	4,87 58	11,34 75	4,64 78	11,34 96	33,65 91	28,05 96	81
Mountain-brown steppe	73,04 53	121,61 67	166,40 64	4,44 53	9,07 60	3,77 64	9,07 77	27,45 74	24,26 83	66
Dark mountain gray-brown (chestnut)	88,30 64	180,6 100	183,48 71	5,95 71	13,55 90	5,24 89	12,26 104	31,04 84	29,74 102	82
Ordinary mountain gray-brown (chestnut)	72,83 52	123,84 69	134,64 52	5,47 65	12,26 81	4,76 80	10,32 88	29,32 79	27,51 94	68
Light mountain gray-brown (chestnut)	61,40 44	93,53 52	126,72 49	4,28 51	10,32 68	4,05 68	9,03 77	23,85 64	23,46 80	58
Mountain gray-brown meadow	72,62 52	128,96 72	135,20 52	5,8 69	12,4 82	4,08 71	9,3 79	29,97 81	29,30 100	68
Alluvial-meadow	69,83 50	156,83 87	205,74 79	4,92 59	11,43 76	4,43 75	10,16 86	20,78 56	18,82 65	73

"In practical soil science, the calculation of bonitet scores of subtypes and species diversity of soils is carried out by applying correction factors that reflect the individual properties of the soil" [10]. According to the methodology, the main soil quality score is multiplied by correction factors to calculate the diversity score of specific soil types.

On the territory of the Gusar-Gonagkend cadastral district there are soils with varying degrees of erosion and leaching, thickness and level of cultivation. "*Bonitet scores of soil species diversity were determined using the main bonitet scale and correction factors (based on the degree of leaching, thickness of the soft layer, clay content, alkalization, cultivation)"*[11] and a detailed scale of soil bonitet in the study area was created.

The final bonitet scale of soils of the Gusar-Gonagkend cadastral district was compiled on the basis of an expanded soil bonitet scale (Table 2)

Based on calculations, it was established that the average bonitet score of the soils of the Gusar-Gonagkend cadastral district is 77. As can be seen from Table 2, the natural factors we adopted as correction factors, including degree of leaching, thickness of the soft layer, clay content, alkalization, cultivation had a positive or negative impact on soil fertility. Thus, due to the negative influence of natural factors, the fertility of mountain-forest brown and alluvial-meadow soils has decreased, and due to cultivation, the quality scores of chernozem-like mountain-meadow, mountain-brown and steppe mountain-brown soils have increased.

As a result of soil assessment work in the Gusar-Gonagkend cadastral district, a Map of soil quality assessment (Bonitet cartogram) (scale 1:100,000) of the study area was compiled (Fig. 2).

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[10]Методические указания по составлению почвенных, бонитировочных и др. необходимых картографических документов для целей земельного кадастра. - Баку: АзНИИНТИ, - 1993, - 22 с.

[11]Məmmədov, Q.Ş. Azərbaycan respublikasının dövlət torpaq kadastrı: hüquqi, elmi və praktiki məsələləri. / Məmmədov Q.Ş. - Bakı: Elm, - 2003, - 445 s.

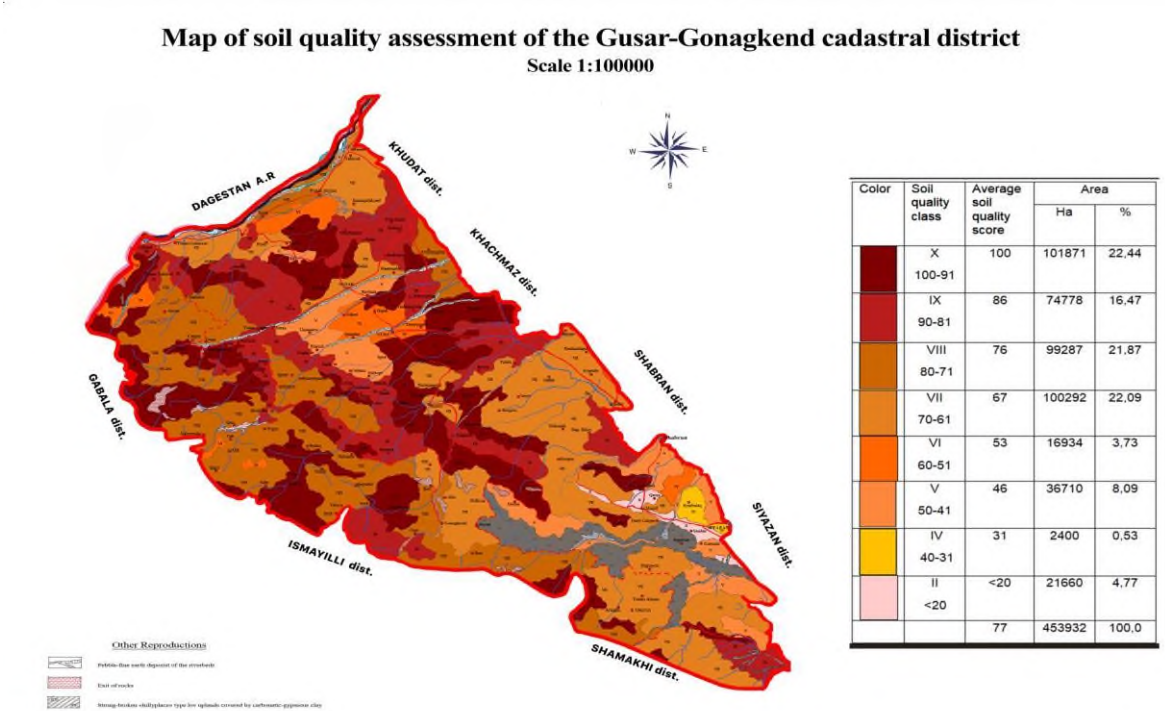
Table 2. The final bonitet scale of soils of the Gusar-Gonagkend cadastral district

No	Name of soils	Final bonitet scale	Coefficient of comparative merit of soils	Area	
				Ha	%
1	Mountain- meadow	83	1,08	142582	31,41
2	Mountain-forest-meadow	83	1,08	20650	4,55
3	Mountain-forest soddy-carbonate	91	1,18	8741	1,92
4	Mountain-forest brown	85	1,10	40370	8,89
5	Forest-brown	82	1,06	146 824	32,34
6	Mountain gray-brown (chestnut)	62	0,81	40566	8,94
7	Mountain gray-brown (chestnut) - meadow	69	0,90	17920	3,95
8	Alluvial- meadow	52	0,67	9860	2,18
9	Technogenic soils	20	0,26	21660	4,77
10	Soil complexes	69	0,90	4759	1,05
	Total	**77**	**100**	**453932**	**100,00**

4.3. Forestry and agro-industrial grouping of soils of the Gusar-Gonagkend cadastral district

The forestry and agro-industrial grouping of soils of the Gusar-Gonagkend cadastral district was carried out "*according to the methodology of G.Sh. Mammadov"*[12] based on soil quality scores according to the general type of agro-industrial grouping. For this purpose, a detailed bonitet scale of soil was taken as a basis; on its basis, forest and agricultural production groups were carried out, as a

[12]Məmmədov, Q.Ş. Azərbaycanın torpaq ehtiyatlarından səmərəli istifadənin sosial-iqtisadi və ekoloji əsasları. / Məmmədov Q.Ş. - Bakı: Elm, - 2007, - 854 s.



Color	Soil quality class	Average soil quality score	Area	
			Ha	%
	X 100-91	100	101871	22,44
	IX 90-81	86	74778	16,47
	VIII 80-71	76	99287	21,87
	VII 70-61	67	100292	22,09
	VI 60-51	53	16934	3,73
	V 50-41	46	36710	8,09
	IV 40-31	31	2400	0,53
	II <20	<20	21660	4,77
		77	453932	100,0

Figure 2. Map of soil quality assessment (Bonitet cartogram) of the Gusar-Gonagkend cadastral district

result, the soils of the study area were combined into 5 forest and agricultural production groups.

Below is a brief description of the groups identified as a result of the forestry and agricultural production grouping of soils carried out on the territory of the Gusar-Gonagkend cadastral district:

Group I – high quality soils. High-quality soils are located in the northwestern and central parts of the cadastral district and occupy 176,649 ha (38.92%). This group includes cultivated, deep, meadow, irrigated, poorly washed varieties of chernozem-like mountain-meadow, mountain-forest and mountain-brown soils. In high-quality soils, the supply of humus in a meter layer 204-260 t/ha, the supply of nitrogen and phosphorus in a layer of 0-50 cm is 11-17 t/ha, respectively, and 9 - 12 t/ha. The absorption capacity of these soils is 28-34 meq. The granulometric composition varies from clayey to medium and heavy loamy composition. The average soil bonitet score of group I was 94.

Group II – soils of good quality. The soils included in this group are located in the northern, northwestern and southwestern parts of the Gusar-Gonagkend cadastral district and amount to 199,579 hectares (43.96%) of area. This group includes irrigated varieties of mountain-brown, steppe mountain-brown, mountain gray-brown (chestnut) and alluvial-meadow soils. In good quality soils, the humus reserves in the meter layer - 183-245 t/ha, and in the 0-50 cm layer - nitrogen reserves are 11-16 t/ha, the phosphorus reserves are 10-11 t/ha, the absorption capacity is about 25-27 meq. The average score of group is 71.

Group III – soils of medium quality. These soils are located in the east, south and southeast of the territory. The area of the group of medium quality soils is 53,644 hectares (11.82%). The core of group consists of degraded, saline and thin varieties of alluvial-meadow, mountain-brown, mountain-gray-brown (chestnut) soils. Soil fertility of group III is relatively low, humus reserves are 53-93 t/ha in a meter layer, nitrogen and phosphorus reserves in a 0-50 cm layer are respectively 10-12 t/ha and 9-11 t/ha. The absorption capacity of soils in this group is 22-27 meq. The average score of group is 48.

Group IV - the group of low quality soils includes only one soil - thin light mountain gray-brown soil. These soils cover an area of 2,400 hectares (0.53%) and are located near Siyazan in the southeast of the territory. The average score calculated for low quality soils is 31.

Group V – conditionally unsuitable soils. This group includes technogenic soils, occupying an area of 21,660 hectares (4.77%) and distributed locally in various parts of the south of the territory in Siyazan-Gonakkend. Average score below 20.

Thus, as a result of forest and agricultural grouping of soils in the soil cover of the Gusar-Gonagkend cadastral district, the average quality score of the soils was determined, the coefficient of the comparative dignity of the soils was calculated, and the areas were determined by qualitative groups of soils (Table 3).

Table 3

Average bonitet score of soils of the Gusar-Gonagkend cadastral district by forest and agricultural production groups

Soil quality groups	**Average bonitet score of soils**	**Coefficient of the comparative dignity of the soils**	**Area**	
			Ha	**%**
I – high quality soils	94	1,22	176649	38,92
II – good quality soils	71	0,92	199579	43,96
III – medium quality soils	48	0,62	53644	11,82
IV – low quality soils	31	0,40	2400	0,53
V – conditionally unsuitable soils	20	0,26	21660	4,77
Average	**77**	**1,00**	**453932**	**100,00**

CHAPTER V
ECOLOGICAL ASSESSMENT OF SOILS OF THE GUSAR-GONAGKEND CADASTRAL DISTRICT

5.1. History of studying of environmental assessment of soils

The half-chapter provides information about the peculiarities of the emergence and development of research in the direction of environmental assessment of soils in our republic.

5.2. Drawing up scales for environmental assessment of soils

Based on the methodology of S.Z.Mammadova, we for the first time compiled scales for assessing the degree of expression of various characteristics of the soil cover of the Gusar-Gonagkend cadastral district in relation to the environmental requirements of forests, perennial plantings, vegetables, grains and forage plants. Indicators collected in special rating scales include altitude, precipitation, temperature, slope steepness, Md index, pH, particle size distribution, and degree of salinity. Using these scales, an environmental assessment of the territory's soils was carried out.

5.3. Environmental assessment of soils of the Gusar-Gonagkend cadastral district

The ecological scores of the soils of the Gusar-Gonagkend cadastral district were calculated based on the methodology of S.Z. Mammadova. At this time, an environmental assessment of soils was carried out by applying special scales for assessing the degree of expression of soils to the collected indicators of relief, climate and soil of the study area, and an environmental assessment map of the soils of the Gusar-Gonagkend cadastral district was compiled on a scale of 1:100,000 (Fig. 3.).

According to the map legend, 17 subtypes of soils belonging to different zonal zones are common in the Gusar-Gonagkend cadastral district. Of these, 6 belong to mountain-meadow soils of the highlands,

and 11 - to forest, mountain-steppe and intrazonal soils of the middle and low mountains.

As a result of the research, it was determined that the main limiting factors for summer pastures of mountain meadow soils in the high mountain zone of the Gusar-Gonagkend cadastral district were environmental factors - high slope steepness (33-45 scores) and soil factors – bonitet scores calculated on the basis of internal diagnostic soil indicators (humus, nitrogen, phosphorus, sum of absorbed bases) (52-86 scores).

For mesophytic forests developing on soils of the middle mountain zone, it has been established that the limiting factors are environmental indicators - slope steepness (58 scores) and the sum of active temperatures (80-90 scores), soil indicators - pH (80 scores) and granulometric composition (80-90 scores).

The amount of precipitation (80-90 scores) and soil fertility indicators (bonitet points 58-82 scores) are the main limiting factors for grain and vegetable crops grown on the soils of the low-mountain zone. The main limiting factors for growing vegetables on intrazonal alluvial-meadow soils are the amount of precipitation (70 scores), the Md indicator (90 scores) and fertility indicators.

In the territory of the Gusar-Gonagkend cadastral district, the highest environmental scores were given to chernozem-like mountain-meadow, dark and ordinary mountain-gray-brown (chestnut) soils (93 scores).

CHAPTER VI
LAND PROTECTION BASED ON ECOLOGICAL SOIL ASSESSMENT

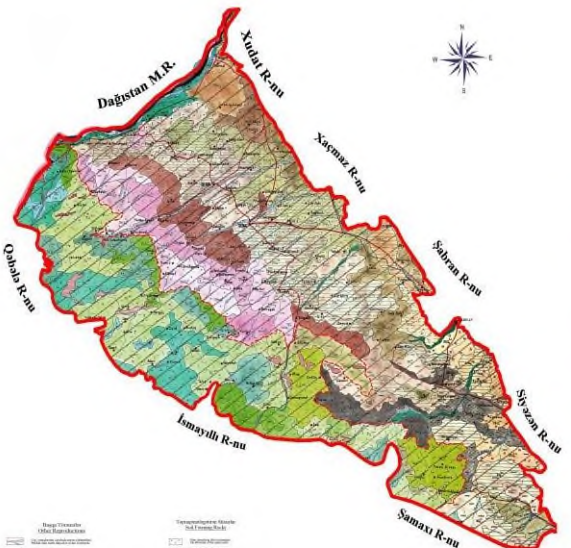
6.1. Theoretical foundations of soil protection from anthropogenic impact

The causes of soil degradation in the world, the basic principles of soil protection, the main directions and principles of the use of natural resources, including soil conservation, the scientific basis of soil protection and other issues were discussed.

Map of environmental assessment of soils of the Gusar-Gonagkend cadastral district

Scale 1:100000

2021



LEGENDA

Rəngi	Torpaqların adı	Hündürlük m	Meyllik, °	T>10° S	Yağıntılar,mm	Md	Torpağın bonitet balı	pH	<0,01 mm,%	Quru qalıq,%	Ekoloji bal
	Yüksək dağlıq zona torpaqları										
	Qaramtıl dağ-çəmən*	2100	25	1500	1200	0,40	100	6,9	44,81	-	93
		100	45	100	100	100		100	100		
	Çimli-turflu dağ-çəmən*	2500	25	1200	1400	0,45	93	6,0	40,55	-	92
		100	45	100	100	100		100	100		
	Çimli dağ-çəmən*	2200	25	1400	1300	0,45	77	6,2	42,09	-	90
		100	45	100	100	100		100	100		
	İbtidai dağ-çəmən*	2600	30	1100	1500	0,45	52	6,1	36,14	-	82
		100	33	100	80	100		100	90		
	Dağ-çəmən-bozqır*	2100	25	1600	1100	0,40	67	7,4	48,69	-	85
		100	45	90	100	100		80	100		
	Dağ meşə-çəmən*	1900	25	1800	1000	0,35	86	7,2	45,48	-	87
		100	45	90	100	100		80	100		
	Orta və alçaq dağlıq zona torpaqları										
	Qalıq-karbonatlı qonur dağ-meşə**	1500	20	2200	1000	0,40	100	7,4	51,83	-	89
		100	58	90	100	100		80	80		
	Tipik qonur dağ-meşə**	1500	20	2500	1000	0,40	87	6,9	47,18	-	89
		100	58	80	100	100		100	90		
	Tipik dağ-qəhvəyi***	900	15	3500	800	0,35	84	6,7	42,04	-	87
		100	70	90	90	80		80	100		
	Karbonatlı dağ-qəhvəyi***	800	12	3800	700	0,35	70	7,2	49,77	-	89
		100	83	90	90	80		100	100		
	Çəmənləşmiş dağ-qəhvəyi***	800	10	3500	700	0,35	81	7,4	47,82	-	91
		100	83	90	90	80		100	100		
	Bozqırlaşmış dağ-qəhvəyi***	700	10	3800	700	0,30	66	7,4	52,61	-	89
		90	83	100	90	100		100	80		
	Tünd dağ boz-qəhvəyi (şabalıdı)****	600	10	4000	600	0,30	82	7,5	42,80	0,15	93
		90	83	100	90	100		100	100	90	
	Adi dağ boz- qəhvəyi (şabalıdı)****	500	5	4000	600	0,30	68	7,9	46,58	0,18	93
		90	100	100	90	100		100	100	90	
	Açıq dağ boz- qəhvəyi (şabalıdı)****	400	5	4200	500	0,25	58	8,1	55,36	0,21	89
		100	100	100	80	100		90	80	90	
	Dağ boz- qəhvəyi (şabalıdı)-çəmən*****	300	3	4200	500	0,25	68	7,9	43,64	0,18	90
		90	100	100	80	100		90	90	90	
	Allüvial-çəmən******	150	2	4200	500	0,25	73	7,2	38,51	0,20	92
		100	100	100	80	100		90	100	90	

Xəritə 2017-ci ildə TAİ Xəritə fonduna aid materiallar əsasında hazırlanmış
Qusar-Qonaqkənd Kadastr rayonunun torpaq xəritə-sxemi əsasında tərtib olunmuşdur.

6.2. Evaluation of the results of application methods for soil protection

Brief information is provided on the main areas of research conducted by foreign and local scientists in the field of protection and efficient use of soil.

6.3. Organization of protection and effective use of soils of the Gusar-Gonagkend cadastral district

The system we have developed for the effective use and protection of soil cover in the Gusar-Gonagkend cadastral district includes:

1. Anti-erosion measures.

It is recommended to prevent erosion processes on summer and winter pastures and agricultural soils of the Gusar-Gonagkend cadastral district "*by carrying out the following agrotechnical and reclamation measures"*[13 ,14, 15 ,16]:

It is necessary to reduce the number of livestock and grazing time in slightly eroded areas of pastures, and apply grazing rotation. It is recommended to reduce (by at least 25%) the number of large and small ruminants grazing in moderately eroded areas, introduce rotational grazing, and apply a mowing and grazing system. It is recommended that in heavily washed-out areas, stop grazing livestock for at least 2-3 years, clear pastures of weeds, bushes and stones, use a

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[13]Abdullayev, R.A. Böyük Qafqazın cənub-şərq yamacı torpaq örtüyünün deqradasiyası və qarşısının alınması yolları: - /aqrar üzrə fəlsəfə doktoru dis. avtoreferatı./ - Bakı, 2014.- 20 s.

[14]Aşırov, M.M. Böyük Qafqazın şimal-şərq hissəsində eroziya prosesinə məruz qalmış torpaqların münbitliyinin bərpası yolları : - /aqrar üzrə fəlsəfə doktoru dis. avtoreferatı./ - Bakı, 2015.- 20 s.

[15]Məmmədova, M.N. Eroziya prosesinin torpağın münbitlik parametrlərinə təsiri / Məmmədova, M.N., Abasova, E.M., Nəsirova, T.A. // Torpaqşünaslıq və Aqrokimya, - Bakı: 2019, Cild 24. №1, - s. 133-137

[16]Nəbiyev, Z.C. Yay otlaqlarında məhsuldarlığın artırılması üçün aparılan kompleks tədbirlər sistemi // Torpaqşünaslıq və Aqrokimya, - Bakı: 2013, Cild 21. №1, - s. 73-78.

pasture-haymaking system, perform transverse plowing of slopes, destroy poisonous and harmful plant species and replace them with perennial grasses, lay protective forest strips to protect pastures and hayfields from the wind, apply mineral and organic fertilizers. Providing pastures with water, creating cultivated pastures are measures that lead to increased productivity of pastures.

2. Restoration and expansion of forests.

Only 49,111 hectares (10.81% of the total area) of the soils of the Gusar-Gonagkend cadastral district, once covered with forests, have forests, the main reason for decreasing of forest areas was the massive deforestation in the region in order to expand areas for agricultural use.

According to the research of many scientists working in this area, "*to restore the forest cover of the area in the low-mountain zone, on rocky slopes at an altitude of 500-600 m, it is recommended to plant trees such as hackberries, almond, pistachio, Eldar pine, pear, Pistacia lentiscus are used, on eroded rocky slopes in the lower forest zone - hook pine, Crimean pine, Scots pine; in the upper forest zone - Scots pine, mountain-ash and birch" [17]* .

3. Improving the use of agricultural land. In highly developed areas of the Gusar-Gonagkend cadastral district, field protection work should be carried out and forests should be planted in the ravines, and the inclined slopes of the ravines should be used for perennial plantings by constructing terraces. On agricultural fields of farms with eroded and uneven terrain, it is recommended to use contour strip cultivation. At this time, areas for crop rotation are divided into contour strips, at a depth of 0-20 cm the width of the strips is 100-300 m, depending on the steepness of the slopes; on slopes with a steepness of $3\text{-}5^0$ or more, a strip width of 50-100 m is recommended. In areas with strong wind erosion, it is recommended that the width of arable strips be 50 m on soils of light mechanical composition, 100 m on soils of medium and heavy clay composition and 150 m on clay soils.

[17]Dolxanov, A. Azərbayan meşələrinin davamlı idarəedilməsinin əsasları.

4. Increasing the area of perennial crops. The expansion of perennial plantings, primarily gardens and vineyards, can be carried out through the use of unproductive slopes, which in turn creates the opportunity to use agricultural land more efficiently and reduce erosion processes. "*When planting perennial plantings on mountain slopes, it is recommended to place them transversely to the slope, and in very difficult terrain conditions - along the horizons, contourally; the area of the block is recommended to be up to 15 hectares. Terracing is carried out on slopes with a slope of 8-20^0. In areas with a slope slope of 6-15^0, it is recommended to take block sizes of 250-400 m in length and 80-250 m in width*" [18].

5. Construction of forest shelter belts. In areas unsuitable for use, such as eroded meadows, pastures and arable lands, it is recommended to create forest belts. As researchers have shown, the economic and reclamation efficiency of creating oak forests is higher. "*In areas with hilly terrain and susceptible to water erosion, it is recommended to place forest strips across the slope*" [19].

Forest strips can be expanded to 21 m in order to reduce surface runoff on slopes with a slope of more than 20^0 and use them for plowing. It is recommended to install forest strips 15 m wide on slightly eroded areas, 20-25 m wide on moderately eroded areas and 30 m wide on heavily eroded areas. If forest strips are laid longitudinally, then for mountain-chernozem and mountain-brown soils it is recommended to take a distance of 600 m, for mountain gray-brown soils - 500 m.

6. Prevention of soil alkalization.

It has been established that 10 thousand hectares (2.2%) of lands in the Gusar-Gonagkend cadastral district are subject to alkalization. In this regard, it is effective to use the agrobiological method to increase the fertility of alkaline soils in the region. With the agrobiological

[18]Məmmədov, Q.Ş. Aqroekologiya. / Məmmədov Q.Ş., Xəlilov M.Y., Məmmədova S.Z. - Bakı, II hissə, - 2011, - 448 s.

[19]Abdullayev, R.A. Torpaq deqradasiyasına qarşı meşəmeliorasiya tədbirləri // "Müstəqillik illərində Coğrafiya elminin inkişafı" konfransının materialları, -Bakı, - 2013, - s. 406-410.

method, a combined application of biological and agrotechnical measures is carried out: in layers containing $CaCO_3$ and gypsum, planting and deep plowing are carried out to dissolve these compounds.

Improving the water-physical properties of alkaline soils, enriching them with mineral nutrients, and increasing microbiological activity occurs due to organic fertilizers. In this case, *nitrogen and phosphorus fertilizers are recommended, since alkaline soils have a greater need for nitrogen and phosphorus elements"*[20]. In areas of the study area where small and medium alkaline contours are widespread, it is recommended to apply the operation of adding a soil layer; for this, it is recommended to bring a layer of fertile soil 2-3 cm thick and sprinkle it on the alkaline spots.

7. Proper placement of farm boundaries. The placement of the boundaries of farms on the territory should be done in such a way as to create favorable conditions for the subsequent on-farm organization of the territory, for the correct and efficient use of the land. In particular, situations such as shredding the contours of plantings, creating irregular shapes, and inconveniently located areas should be excluded. In agricultural farms, it is recommended to use crop rotation. Since farms, as a rule, are small plots, the use of this crop rotation leads to a limitation in plant diversity, however, experts recommend the use of crop rotation and compliance with erosion protection rules, no matter how small the crop rotation is carried out.

Based on the *"Strategic road map for the production and processing of agricultural products in the Republic of Azerbaijan*" [21] in the Gusar-Gonagkend cadastral district, in order to strengthen access to the market for small farms, consolidate, reform family farms into a system cooperative and contract farming, its completion will allow the application of advanced agrotechnical rules and will lead to an increase in income from farms.

[20]Məmmədov, Q.Ş. Aqroekologiya. / Məmmədov Q.Ş., Xəlilov M.Y., Məmmədova S.Z. - Bakı, II hissə, - 2011, - 448 s.

[21]https://static.president.az/pdf/38542.pdf

RESULTS

1. The composition of the soil cover of the Gusar-Gonagkend cadastral district was studied, modern soil-ecological characteristics of the main zonal soils were given, and on the basis of field-laboratory, desk-preparatory, literary and fund materials, the soil map of the cadastral region on a scale of 1:100,000 was prepared [1,3,4].
2. Soil appraisal of the Gusar-Gonagkend cadastral district was carried out and the main bonitet scale of soils was compiled. For the high-mountain zone, chernozem-like mountain-meadow soils were selected as standard soils, for the middle and low-mountain zones - residual carbonate mountain-forest brown soils, and the bonitet scores of the remaining soils were also calculated relative to them. It was found that on the territory of the cadastral region, soddy-peaty mountain-meadow (93 points) and soddy-carbonate mountain-forest (91 points) soils have high fertility, and primitive mountain-meadow (52 points) and light mountain gray-brown (chestnut) (58 points) soils have low fertility [7,10,12].
3. Detailed and final bonitet scales were compiled by applying correction factors to determine the bonitet scores of soil varieties distributed in the Gusar-Gonagkend cadastral district, and weighted average scores were determined. The average bonitet score of the territory of the Gusar-Gonagkend cadastral district was determined - 77 points, and a “Bonitet cartogram of soils of the Gusar-Gonagkend cadastral district” was compiled (1: 100000 M).
4. Based on the expanded scale of soil quality of the territory, forestry and agricultural production grouping of soils of the Gusar-Gonagkend cadastral district was carried out and average soil quality scores and areas were determined by groups: Group I - 94 scores, area - 176,649 hectares (38.92%); Group II – 71 scores, 199,579 hectares (43.96%); Group III – 48 scores, 53644 hectares (11.82%); Group IV – 31 scores, 2400 ha (0.53%); Group V – 20 scores, 21660 hectares (4.77%) [6,8,10,12].

5. Special rating scales have been prepared for the severity of individual characteristics of the soils of the Gusar-Gonagkend cadastral district with the environmental requirements of summer pastures, mesophytic forests, perennial plantings, grain and vegetable crops [9,10].
6. An environmental assessment of the soils of the Gusar-Gonagkend cadastral district was carried out using special scales for assessing the ecological state, the main limiting factors influencing the soil fertility of the territory were determined, and the environmental scores of soil subtypes were calculated. On the territory of the cadastral region, the highest environmental scores in the high-mountain zone were given to chernozem-like mountain-meadow soils, and in the low-mountain and mid-mountain zones - dark and ordinary mountain gray-brown (chestnut) soils (93 points). As a result of the research, an environmental assessment map (scale 1:100,000) of the land cover of the Gusar-Gonagkend cadastral district was compiled [2,5,14].
7. The types of anthropogenic impact (development of erosion processes, reduction of forest resources, decrease in soil fertility, deforestation, etc.) that have a significant impact on environmental conditions when using the lands of the Gusar-Gonagkend cadastral district have been studied. It has been established that 56.1% of the lands of the cadastral region are eroded to one degree or another, and 24.6% of the mountain gray-brown (chestnut) lands are subject to alkalinity [6,14, 15].
8. In order to ensure environmental safety and sustainability of the ecosystem of the Gusar-Gonagkend cadastral district, the main directions for the effective use and protection of land resources have been determined and a system of relevant measures has been developed (anti-erosion measures, restoration and expansion of forests, improving the use of agricultural land, construction of forest shelter belts, prevention of soil alkalization and etc.) [6,13,15].

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