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# Ecological assessment of pastures semi-deserts and dry steppes of Azerbaijan

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**ABSTRACT**

The absence in the scientific literature of criteria for assessing the ecological status of pasture lands, insufficient knowledge of the use of predictive methods and technology for carrying out special agrochemical measures, as well as issues of permissible loads, served as the basis for choosing the topic of research work. For the first time, in the conditions of pastures in Azerbaijan, an environmental and energy assessment of soil-landscape complexes was carried out. A detailed and final quality assessment was drawn up on soil scale, and the coefficient of their comparative merit was determined. A scientifically based system of agrochemical measures for the superficial and fundamental improvement of pastures has been developed. The final bonitet scale, reflecting the level of fertility of soil varieties, showed that the soils of the Jeyranchol massif turned out to be the most fertile at 62 points, compared with them, the pasture soils of Ajinohur on average across the massif received 53 points, Gobustan 51 points, and the Kura-Araz lowland 55 points. On average, pasture lands in Azerbaijan are valued at 55 points, which indicates the need for agro-reclamation measures. The types of forage plants are distributed as follows: i) Cereals 116, 12%; ii) Asteraceae 109, 11.2%; iii) Legumes 82, 8.4%; iv) Brassicas 59, 6.2%; 6%; v) Cloves 50, 5.3%; vi) Lamiaceae 42, 4.6%; vii) Linear 40, 4.2%; viii) Goosefoot 6, ix) Gimletaceae 32 species, 3.4%; x) Umbrellas 38, 4.4%; xi) Other 339 types, 35.5%.



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## 1. INTRODUCTION

In modern world practice, due to global climate change and the intensification of desertification processes, there is an acute problem of development and implementation of effective management of natural resource potential, which allows for to refusal of resource-intensive technologies and flexible manipulation of the level of anthropogenic load on ecosystems, preserving soil and plant resources of arid territories. One of the most important branches of the agro-industrial complex of the arid belt of the Azerbaijan Republic is pasture nature management. Negative transformation of pasture ecosystems in the region has reached unprecedented proportions, affecting almost 60% of pasture lands by desertification. This process was negatively affected not only by anthropogenic degradation but also by low agro-climatic potential as two

interrelated factors. Intensive pasture cattle breeding without taking into account the peculiarities of the natural complex caused a sharp deterioration of the ecological situation, reaching its peak in 2001-2018, when 14 settlements disappeared from the map of the Azerbaijan Republic. Degraded rangelands record a catastrophic decline in biodiversity, replacing highly nutritious species with low-eating and poisonous ones. The main cause of the degradation of pasture ecosystems is society's desire to obtain maximum high incomes (in any expression), which leads to unreasonably high volumes of natural resources withdrawal exceeding the potential capabilities of nature itself. Also, one of the reasons for the low sustainability of natural communities is the loss of biodiversity, which in changed ecological conditions is manifested in the phylogenetic incompleteness of ecosystems, where the optimal balance of bioecological groups is disturbed. The system of adaptive landscape nature management is gaining more and more demand in the world, especially in the countries of the arid zones [1], [2].

The nature of Azerbaijan, its flora has long attracted the attention of travelers, explorers, and simply inquisitive people. Soil, as one of the main factors in the ecological environment, is extremely important in the development of the ecosystem [2], [3]. Currently, the world has clearly defined the environmental direction in the use of natural resources, giving preference to the preservation of the natural environment and the development on this basis of resource-saving projects for rational environmental management [4]–[6]. Rational use of pasture lands and their protection from depletion and degradation is given special attention in many government decisions and decrees of the President of the Republic of Azerbaijan, such: as "Regulations on State Control over the Use and Protection of soils, 2000." "Comprehensive Action Plan to Improve the Environmental Condition of the Republic of Azerbaijan, 2006, State Program for the rational use of summer and winter pastures of the Republic of Azerbaijan and the prevention of desertification" 2004, and others [7]–[9]. The main reasons for negative agroecological changes in natural resource potential are plowing pasture lands, large-scale reclamation works, overloading of pastures with sheep, and technogenic impacts [3], [10]. The problem lies in the following links in the chain: growth of livestock prohibitive loads and depletion of land. Degradation of pasture lands leads to a reduction in biological diversity and destruction of the biocenotic structure of natural ecosystems, which impedes the development of natural processes of self-regulation and self-healing [11]–[13]. The unique nature of pastures as a habitat for zonal plants and animals requires the development of measures for the conservation of genetic biological diversity, since in order to successfully solve the rational use of pasture resources, the development of appropriate measures is necessary. The main goal of this work was a scientifically based identification of the current ecological situation of soil-landscape complexes in the pastures of Azerbaijan, conducting an environmental assessment at a differentiated level of the needs of plants and animals for the purpose of their protection and rational use. One of the important climatic factors is the wind regime. Coastal breezes, as well as the Absheron north, are especially regular [14]–[17]. In the autumn, winter, and early spring, it has a detrimental effect on the growth of plants, especially ephemeral ones. The climate of winter pasture areas is dry subtropical with long hot summers and mild winters [18]–[20]. As the terrain rises above sea level, from east to west, towards the foothill slopes of the Greater and Lesser Caucasus, the climate gradually becomes moderately warm due to the reduction of the hot months to three and the temperature of the coldest month decreasing to 0-1°C. According to the annual precipitation in the pastures, three main zones are distinguished -coastal, transitional, and continental, which differ sharply in the time of onset of maximum and minimum precipitation. Characteristic features of the climate of winter pastures in Azerbaijan are insufficient precipitation throughout the year; their uneven distribution across the seasons (maximum in autumn, winter; minimum in spring); relatively warm winter, sometimes accompanied by cold winds; high average temperature in the summer months (from 25° to 35 °C). In the foothill areas, varieties of gray-brown soils are widespread. Of the zonal types of soils in the Kura-Araz lowland, widespread varieties of gray soils. Meadow soils occupy lower relief elements of the alluvial-accumulative region and are distributed under wormwood-ephemeral and wormwood-ephemeral-solyanka vegetation. These soils are formed under conditions of increased moisture, which is manifested in their higher humus content (1.8-3%).

Dominant vegetation cover of winter pastures in our study areas: *Aeluropus littoralis (Gouan)* Parl., *Aeluropus repens (Desf.)* Parl., *Agropyron repens* L., *P. Beauv., Alhagi pseudalhagi (Bieb.)* Fisch., *Artemisia lerchiana, Artemisia szowitziana, Bolboschoenus marittimus, Bothriochloa ischaemum, Camphorosma lessingii* Litw., *Capparis herbacea* Willd., *Cynodon dactylon (L.) Pers., Cyperus longus* L., *Echinochloa crus-galli, Fectuca rupicola Schur., Halocnemum strobilaceum, Halostachys belangeriana, Iris iberica* L., *Juncellus serotinus, Kalidium caspicum, Koeleria phleoide, Limonium meyer, Lycium ruthenicum* Murr., *Noaea mucronata, Petrosimonia hrachiata, Phragmites australis, Pinus eldarica* Medw., *Poa bulbosa* L., *Populus canescens, Puccinellia bulbosa, Salix exelsa, Salsola dendroides* Pall., *Salsola ericoides* Bieb., *Salsola nodulosa, Saueda dendroides, Stipa caspia, Tamarix hohenacker, Tamarix ramosissima* Ledeb., *Tragopogon graminifolius, Petrosimonia brachiata, Echinopsilon hyssopitolium, Chenopodium album, Echinochloa crus galli, Rozippa sylvestris, Aeluropus littoralis, Glycyrfhiza glabra, Kochia prostrata,*

*Potamogeton* L., *Poligonum* L., *Vicia faba, Aeluropus repens, Licium ruthenicum, Alhagi pseudalhagi, Persicarium lapathifolia,* and others. Pastures, meadows, forests are overloaded with herds of animals. The development of numerous farms and other livestock farms is mainly accompanied by uncontrolled and excessive exploitation of pastures, rural meadows, forest lands, and reserves belonging to the state land fund. Through more advanced development of livestock production in the country, productivity can be increased, protection of summer and winter pastures and hayfields can be strengthened, their utilization efficiency can be improved, and biodiversity can be preserved.

## 2. RESEARCH METHOD

Carried out an environmental assessment of pasture lands based on generally accepted methods. Determine environmental assessments using special scales compiled according to the degree of manifestation of individual soil characteristics in accordance with the requirements of plants and animals. The ecological assessment of soil is carried out on the basis of an assessment of its attribute quality, and fertility, taking into account stable, intra-diagnostic characteristics [2], [21]. The object of research during 2020-2023 were selected pasture areas with a total area of Shirvan steppe 127.720 ha; Gobustan 120647 ha; Mugan Salyan lowland 416310 ha; Jeyranchol and Ajinohur steppe 209.665 ha, Miles of the Karabakh steppe 125.600 ha. As a result, 998.720 hectares were the subject of research (Figure 1). For this purpose, research was carried out on selected ungrazed pasture areas across all pasture tracts, covering 50 key areas measuring 10×10 m and 20×10 m (156 sections) on mountain-dark chestnut, gray-brown gray-meadow, meadow-bog soils. During the period of the stationary study, the biological yield of each phytocenosis was taken into account using the mowing method [8], [22]. Taking into account the biological productivity of each phytocenosis. When taking into account the yield of phytocenosis herbs, ephemerals, and other herbaceous vegetation were mowed manually at a height of 3 cm from the soil surface. For wormwood and tree-like saltwort, annual shoots were taken into account. The yield of ephemerals was determined in the second ten days of April in the first ten days of May and for wormwood and tree solyanka in the second ten days of October and the first ten days of November. Sites were selected based on the main, most common type of soil, taking into account the degree of erosion, salinity, granulometric composition, and thickness. hygroscopic humidity by weight method, total nitrogen, and humus according to I.V. Tyurin, granulometric composition using the method of N.A. Kachinsky; pH of the aqueous suspension potentiometric, exchange-absorbed by Na method of K.K. Hedroyts, exchange-absorbed by $Ca^{2+}$ and $Mg^{2+}$ by the method of D.I. Ivanov; $CO_2$ carbonates-calcimeter. During the period of the stationary study, the biological yield of each phytocenosis was taken into account using the mowing method counting the mass and recording of plants of the wormwood formation at the end of April, and the bearded-dry-steppe formation in mid-May [23], [24]. Productivity was determined from an area of 1×2.5 $m^2$, in fivefold repetition. The cut mass was weighed in a wet and dry state, followed by a transfer of the yield per hectare. In feed samples the following was determined: raw ash by combustion method; crude protein - according to Keldahl; crude fat using Soxhlet apparatus; fiber according to Ginzburg and Shtoman, hygroscopic moisture and nitrogen-free extractives by the calculation method. The results of chemical analyses were used to convert natural feed into feed and energy units. Microelements were determined by the atomic absorption method on a Japanese-made device "Shimadzu-6800". The main criterion for assessing the quality of soils in forage lands is their genetic and agro-production properties, as the most objective indicators that, in local conditions, affect soil fertility and the yield of grassland forage [21], [25], [26]. These indicators are the gross reserves of humus, nitrogen, phosphorus, potassium, and absorption capacity in 0-20; 0-50; and 0-100 cm layers of the main types and subtypes of soils, as properties that determine their fertility.

Figure 1. Winter pastures of Azerbaijan selected study sites (2020-2023 years)

## 3. RESULTS AND DISCUSSION

To solve the problems, during the entire period of research, experimental work was carried out to identify the agroecological characteristics of the properties and quality of soils, as well as the productivity of forage lands [17]. The flora of winter pastures contains about 72 species (8.2%) of endemic plants growing only in Gobustan, Jeyranchel, and the Sheki Highlands; among them, the following are especially valuable: *Artemisia Hanseniana, Onobrychis Cyri, On. Komarovii, Astragalus Stevenianus, Vicia cinerla, Vicia faba, Puccinella bulbosa, Trifolum Sachokianum* and other. Along with the unique plants that make up biodiversity, there is a lot growing on winter pastures 30% of weed-inedible plants, 7.1% of which are poisonous.

When carrying out ecological zoning in the pasture territory, landscapes of subtropical semi-deserts of lowland and foothill dry steppes Pale-meadow vegetation is local in nature and occupies about 3.1% of the total forage area of pastures. In pastures, it is mainly allocated 20 main plant groups (6 semi-desert, 8 dry-steppe plains, 6 dry-steppe foothills, and 3 primary-meadow-like). A basic bonitet scale has been compiled taking into account the basic diagnostic characteristics of the soils of the Kura-Araz, Gobustan, Ajinohur, Jeyranchol, and Kura-Araz winter pastures. In this case, gray-brown, dark, thick soils were taken as the standard. In comparison, the score of gray-brown soils varied between 64-69, and that of gray-brown soils-48-96, depending on the area. The gray-brown soils of Jeyranchol have a higher score (69) compared to the gray-brown soils of Ajinohur and Gobustan (61 points).

One of the big problems in the study of pasture ecosystems is the limited information on the content of trace elements in natural objects and the patterns of their distribution in pasture lands of the arid zone. The content of trace elements in different types of soils varies greatly and is related to soil formation factors and the origin of soil-forming rocks. Considering the needs of animals to plants and the environment environment, an environmental and energy assessment of landscape complexes for pastures based on estimated scales for the content of microelements of metabolic energy in forage plants of landscape pasture complexes. During the environmental assessment of pasture lands, the content of the main microelements in pasture feed was taken into account: Cu, Zn, Mn, Co, Se. It has been established that, in many respects, pasture plants are not sufficiently supplied with nutrients: in digestible protein, phosphorus, carotene, and the indicated microelements, the deficiency is 22-26%. From Table 1, it is clear that for such elements as the first protein, carotene, and all the listed microelements in cattle rations, they are significantly inferior to optimal ones, or on average by 27.8%, and for sheep-by 24.0%, which is completely unacceptable for ensuring high animal productivity.

Table 1. Availability of animal (dairy cow) rations

| Nutrients diet | Total contained in the diet | Optimal maintenance standards | 1 g dry matter | Security in % of normal |
|---|---|---|---|---|
| Digestible protein (g) | 1092 | 107 | 87.5 | 81.8 |
| Ca | 73 | 6.1 | 5.7 | 94.9 |
| P | 39 | 4.1 | 3.1 | 71.3 |
| Cu | 69.4 | 9.1 | 5.6 | 61.2 |
| Zn | 387.8 | 40.1 | 30.8 | 77.1 |
| Mg | 532.3 | 50.0 | 42.3 | 84.3 |
| Co | 6.02 | 0.70 | 0.49 | 68.4 |
| Se | 0.88 | 0.11 | 0.07 | 70.0 |
| Carotene | 256 | 40.4 | 20.2 | 50.1 |

Results of field data processing, April 2020 to November 2023

Considering the needs of plants for the soil and environment an environmental assessment of soils under pastures was carried out based on special rating scales, which revealed the limiting factors in the development of phytocenoses: lack of moisture, which ultimately leads to the processes of salinization, desertification, and degradation. In general, the environmental assessment for pasture areas (73-81 points) indicates a good ecological potential of soils for plant development, as evidenced by the results on the biological productivity of dry steppe and grassland-meadow landscapes, which have a biological productivity coefficient close to and above 1.0. The limiting factor was the lack of moisture and the pastures of the semi-desert ecological region had low indicators, which indicates the need for measures to improve them. The highest ecological soil score was observed in Jeyranchol pastures 81 points.

Pastures of the Kur-Araks lowland, which occupy most of the territory, are rated at only 53 points, which needs to be taken into account when carrying out work to improve pastures. Under the influence of natural and anthropogenic factors, negative changes occurred in the soil and vegetation cover of dry subtropical pastures. The fertility of the most typical gray-brown soils for pastures has deteriorated; the humus content decreased by 0.15-0.78%; nitrogen by 0.02-0.08%; the amount of absorbed bases by 2.0-9.0

mg-equiv.; the pH of the soil solution increased by 0.8 and the amount of salts by 0.06-0.08%. As a result, the weighted average score decreased from 62 to 52. The area under steppes decreased from 23.7 to 14%. Thus, the unsystematic, intensive use of winter pastures in the extremely arid climate of the dry subtropics of Azerbaijan leads to the loss of fertile lands and increased desertification processes. The quantity of nitrogen and ash elements fractions in phyto-mass (kg/ha) is shown in Table 2. Due to their location and subject to anthropogenic impact, the pastures of the selected areas received different assessments. Final bonitet scale of pasture soil groups in selected areas (ha) of Azerbaijan is shown in Table 3.

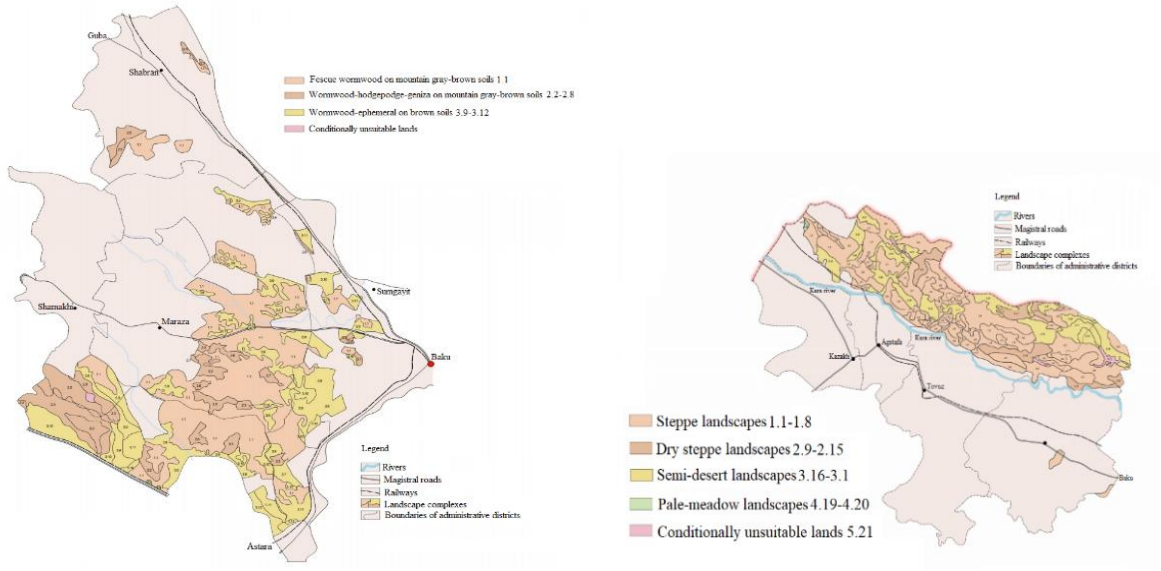
Table 2. Quantity of nitrogen and ash elements in phytomass (kg/ha)

| Plant groups | Fractions | Phyto-mass | N | Si | Ca | Mg | K | P | Al | Fe | Cl |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Xerophyte, Halophyte | Above ground | 1520 | 110.0 | 24.4 | 17.1 | 9.1 | 3.6 | 4.4 | 1.8 | 2.2 | 1.3 |
| vegetation | Roots | 2019 | 180.4 | 400.7 | 240.1 | 77.4 | 100.5 | 30.5 | 168.9 | 167.5 | 3.1 |

Table 3. Final bonitet scale of pasture soils

| Soil groups | Weighted average final score | CCA* | Area | |
|---|---|---|---|---|
| | | | % | ha |
| Jeyranchol | | | | |
| Mountain gray-brown, medium-moist | 68 | 1.17 | 0.36 | 525.9 |
| Dark grayish-brown, strong | 72 | 1.43 | 3.46 | 4994.6 |
| Mountain dark gray-brown, medium-thick | 87 | 1.10 | 4.99 | 7112.7 |
| Mountain light gray-brown | 48 | 0.78 | 13.75 | 19819.4 |
| Gray-brown, thick | 82 | 1.34 | 19.09 | 27531.9 |
| Light gray-brown | 58 | 0.93 | 51.93 | 74878.9 |
| Gray-brown | 45 | 0.72 | 6.39 | 9258.6 |
| Swamp-meadow | 53 | 0.85 | 0.09 | 88.99 |
| by array: | 62 | 1.0 | 100 | 144219 |
| Ajinohur | | | | |
| Mountain gray-brown | 44 | 0.80 | 27.55 | 18005 |
| Mountain light gray-brown | 35 | 0.64 | 10.13 | 6631 |
| Dark gray-brown | 78 | 1.44 | 26.82 | 17550 |
| Gray-brown | 58 | 1.08 | 15.19 | 9946 |
| Light gray-brown primitive | 34 | 0.62 | 6.49 | 4250 |
| Dark meadow-gray | 55 | 1.03 | 2.54 | 1660 |
| Grey-meadow-meadow | 45 | 0.82 | 4.20 | 2759 |
| Serozem | 43 | 0.78 | 3.13 | 2049 |
| Gray-brown | 53 | 0.97 | 2.30 | 1500 |
| Alluvial dark-meadow | 73 | 1.37 | 1.71 | 1120 |
| by array: | 55 | 1.1 | 100 | 65459 |
| Kura-Araz lowland | | | | |
| Light gray-brown | 65 | 1.15 | 17.79 | 104220 |
| Gray-brown, thick | 74 | 1.29 | 14.92 | 87422 |
| Serozem-meadow | 50 | 0.88 | 31.94 | 187131 |
| Light meadow-gray | 49 | 0.85 | 21.90 | 128200 |
| Swamp-meadow | 51 | 0.93 | 3.88 | 22770 |
| Unsuitable lands (primitive solonchaks) | 9 | 0.17 | 9.53 | 55892 |
| by array: | 55 | 1.0 | 100 | 585732 |
| The coefficient of comparative advantage of land (CCA) | | | | |

Jeyranchol winter pastures are located in the northern part of the natural area of the Lesser Caucasus, are located at an altitude of 100-500 m above sea level, and occupy an area of about 144,208 ha. According to the degree of moistening the district is included in the arid zone (Md=0.10-0.25). The annual amount of precipitation is 300-600 mm. The sum of temperatures above 10 °C ranges from 3.800-4.600 °C. It should be noted that when assessed as a whole by massifs, the highest score was given to the soils of Jeyranchol at 62 points, compared to Ajinohur pastures at 55 points; and the soils of pastures of Kura-Araz lowlands were assessed at 55 weighted average points respectively; the weighted average score of pastures of Azerbaijan on the final scale was estimated at 56 points, which indicates that the soils of pastures are subject to degradation and need to be protected and improved on the basis of science-based recommendations. In total, lands of average quality are the most common in pastures of Azerbaijan, with a weighted average score of 52, they occupy 325,171.19 ha or 37% of the total pasture area. In comparison with them, good lands occupy the second place at 25%, or 232,652.6 ha, with bonitet score of 68; the third place in terms of prevalence is occupied by lands of low quality 195,594 hectares. The third place by prevalence is occupied by lands of low quality 195,594 ha, or 20% with an appraisal score of 33 pastures of Azerbaijan is only 11% of the total area. Landscape complexes of winter pastures are shown in Figure 2. Figure 2(a) shows the environmental assessment of winter pastures in Gobustan (Azerbaijan) and Figure 2(b) shows the pastures of Jeyranchol (Azerbaijan).




(a) (b)

Figure 2. Landscape complexes of winter pastures on (a) Gobustan and (b) Jeyranchel

## 4. CONCLUSION

Moving on to the description of the floristic composition of the vegetation cover of winter pastures, it should be noted that the total number of species is 974; which according to biological characteristics are distributed as follows: shrubs 33 species (4%); subshrubs 15 species (2.0%); annual grasses 516 species (54%) subshrubs 13 species (1%); perennial grasses 397 species (39%). The edificators and dominant species we have identified, depending on habitat conditions according to ecological types: i) Mesophytes: *Aegilops ovate L., Avena pilosa, Poa pulbosa, Medicago minima*, and others. ii) Mesohalophytes: *Salsola nodulosa, Tamarix ramosissima, Artemisia Srowitsiana* and others. iii) Halophytes: *Aeluropus repens, Eremopyrum orientale, Hordeum geniculatium, Halostahys caspica, Petrosimonia brachata, Sasola crassa, Salsola ericoides, Salsola dendroides* and others. iv) Hygrophytes: *Balloschoenus maritimus, Jancus maritimus* and others. v) Psammophytes: *Astragalus hyrcanus, Plantago indica, Artemisa scoparioides*, and others. One of the main reasons for the low productivity of individual pastures is the participation of weeds and harmful plants in natural grass stands. It has been established that the main prerequisites for the development of desertification in the winter pastures of Azerbaijan with an area of -1.2 million hectares is their high susceptibility to anthropogenic pressures such as unsystematic grazing, excessive overloads, plowing of pasture lands and natural fragility since they are located in an extremely arid zone with saline (>16%) and wetland (>3.1%) lands. On pastures, steppe, dry-steppe, and semi-desert soil types are formed: varieties of gray-brown, gray-brown, and gray-brown soils >74.1%, which are not distinguished by high fertility. A valuation of pasture lands was carried out on an agro-ecological basis. The final bonitet scale, reflecting the level of fertility of soil varieties, showed that the soils of the Jeyranchol massif turned out to be the most fertile at 62 points, compared with them, the pasture soils of Ajinohur on average across the massif received 53 points, Gobustan 51 points, and the Kura-Araz lowland 55 points. On average, pasture lands in Azerbaijan are valued at 55 points, which indicates the need for agro-reclamation measures.

## RECOMMENDATIONS

It is recommended to carry out surface improvement on dry steppes and semi-desert pastures with sparse grass (<30%) by introducing valuable forage grasses, macro, and micro fertilizers in combination with harrowing, which guarantees an increase of 108% metabolizable energy and getting 239 USD/ha of conditionally net income. It is recommended to carry out a radical improvement i.e. creation of rain-fed or irrigated cultivated pastures on semi-desert lands with sparse, ballast grass stand >50% using a grass mixture from seeds of local drought and salt-tolerant pasture plants: hedgehog grass, alfalfa, ryegrass, sainfoin against a background of $N_{90}P_{60}K_{60}$ and irrigation, which guarantees the receipt of 710-760 c/ha of dry mass with 4-6 cuttings.

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