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ARID ZONE LAND MANAGEMENT IN THE SOUTHERN AND SOUTHEASTERN PARTS OF THE GREATER CAUCASUS

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SUMMARY

The dry climate of the southern and southeastern slopes of the Greater Caucasus has developed various problems for their land management. In this zone, the formation of soils resulted in a zone of intense neotectonic movements, particularly contrasting climatic conditions, on arid-denudation folded lowlands composed of Upper Pliocene and Quaternary pebbles, conglomerates, and loams. The soils in the forest-steppe arid zone belong to the brown earth type, with its various taxonomic units characterized by the widespread siallitic type of weathering. Using landscape zoning optimized the agricultural landscape. For zoning, generally the zonal, subzonal, district, and subdistrict taxonomic units were categories used. In each subdistrict, planning comprised the moisture content of the territory, the directives for the development of agriculture, the soil, and vegetation cover. In fact, the proposed measures sought to combat the erosion and drought by developing an appropriate territorial base. A gap has developed between progressive ways of using land and the traditional organization of the territory. Agriculture suffers the most, since within the framework of the old land management, the soil conservation may not be highly effective.

Keywords: Arid zone, landform, landscape type, agricultural landscape, zoning, taxonomic units, erosion, drought

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Key findings: Geomorphological and climatic factors play a key role in the formation of the landscape in arid regions of the Greater Caucasus, and zoning based on these factors is highly important for the efficient organization of agriculture. Microclimate differences on the northern and southern slopes affect soil fertility and vegetation cover. Therefore, a differentiated approach is essential in arid zone agriculture, considering irrigation opportunities and erosion risks as key conditions for expanding arable land and increasing crop productivity.

INTRODUCTION

The problems of combating drought and soil erosion and preventing soil degradation are becoming increasingly acute as agriculture intensifies. As a result of these processes, the natural soil fertility declines. Overall, the production's growth rate lags the expenditures spent on crop production. Improving the natural environment and mitigating negative phenomena require ways from nature itself. Having learned environmental laws, one must act by using its methods. A method of environmental optimization of agricultural landscapes, based on the teachings of V.V. Dokuchaev, provides the construction of sustainable agricultural landscapes that imitate the actions of nature itself (Gurbanov, 2024). However, at the same time, the production activities must remain adequate to the natural laws of the environment.

For environmental optimization of agricultural landscapes, the newly developed scientific foundations need linkage with the traditional farming systems (Tselovalnikov, 2010; Kravchenko *et al.*, 2017). After all, agricultural landscapes and traditional agriculture are phenomena of the same order and interrelated with each other. Agrolandscape is the territorial basis, which also provides a crucial basis for sustainable agriculture. All these processes represent a single adaptive system, forming a favorable environment for agrobiocenoses (Akhmedenov, 2009; Bairakov, 2018).

For sustainable farming, the considerations are multifaceted. However, along with improving crop production technologies and other measures, it is necessary to enhance the agricultural environment, and their management leading role belongs to the optimization of agricultural

landscapes (Stultseva, 2009). Arid open forest is a widespread biocenosis of the arid zone foothills and low mountains of the Greater Caucasus, located at an altitude of 300–700 m above sea level (Figure 1).

Although locations are in dry, highly dissected, and hard-to-reach places, they have valuable soil and water protective and water-regulating significance. A sharp reduction in their area and a decrease in quality increased the loss of soil cover. Consequently, this developed soil erosion, destruction of slopes, and the appearance of badlands and the formation of numerous ravines, which led to a sharp reduction in arable areas. The widespread nature of the desertification process is notable, especially in the lower boundaries and gradual areas of arid woodlands.

The extreme diversity and dissected relief of the foothills and low mountains of the Greater Caucasus determine an exceptionally variegated situation in the distribution of all climatic elements. This, together with the mosaic of the lithological composition of soil-forming rocks, favors the development of diverse and complex vegetation cover. The combination of natural soil formation factors, as well as centuries-old and diverse human production activities, exclusively complicates the general patterns of spatial distribution of soils.

The studied territory of Azerbaijan exhibits a characteristic of the earliest settlement as a result of diverse human activities, which led to a significant change in the primary appearance of the landscape and drying of the climate. In this regard, the arena of action of such processes degrading the natural environment as erosion, gravity, arid denudation in mountain zones, and processes of soil salinization in low-plain areas has

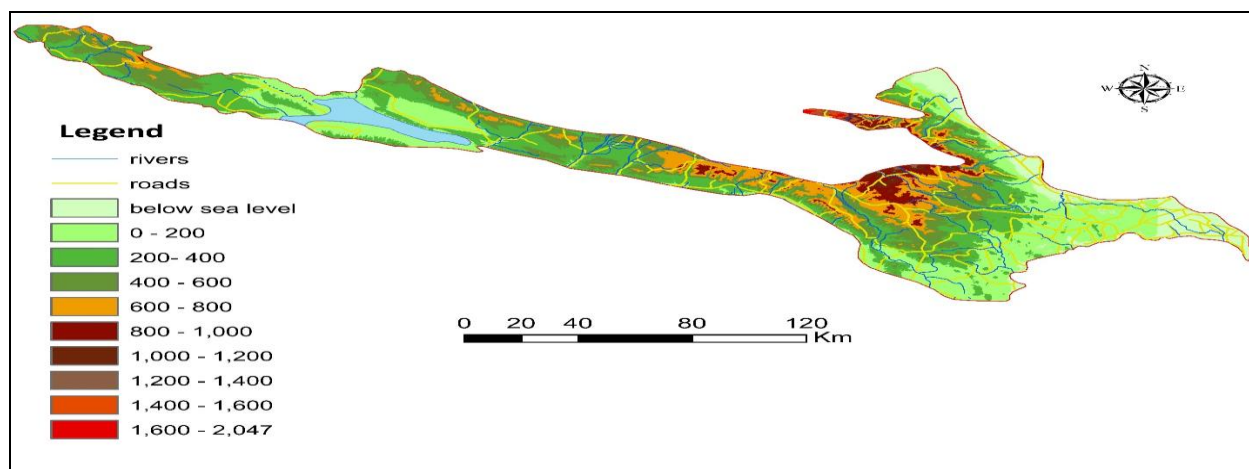


Figure 1. Hypsometric map of the studied region.

expanded and intensified. The geographical location, geological structure, and the influence of the Kura-Araz lowland and the Greater Caucasus mountain system have a relevant impact on the differentiation of biogeocenoses in the foothill zones. Variations in soil properties and the nature of soil cover occur with the influence of anthropogenic and natural processes. Anthropogenic processes like physical degradation, dehumification, and erosion in arable areas; grazing failure of steppe and forest lands; and gully formation when plowing slopes are destructive.

Landscape zoning of the arid zone is of exceptionally great scientific and practical importance. Large resources of heat and light and soils rich in mineral composition provide the arid zone numerous prospects for the development of diversified agriculture. However, the accelerated pace of the improvement in agricultural production entails hindrances from several limiting factors, and insufficient water is the primary one. Other crucial circumstances that hamper the development of agriculture are the highly dissected terrain and the creation of erosion processes, complicating the mechanization of production and the use of agrotechnical measures. The main difference between the arid zones of Azerbaijan and Central Asia is the less aridity and associated natural complexes. Almost all types of aridity are evident in

Central Asia, including severe droughts. Within the arid zone of Azerbaijan, droughts of predominantly weak and medium intensity prevail (Feldman, 1957).

MATERIALS AND METHODS

In the arid zones of the Greater Caucasus, the widespread soil degradation covers about one million hectares of territory, caused by improper cultivation of the rainfed arable areas, resulting in the severe thinning of forest and grass cover (Figure 2). Cultivation of fields with various slopes and slopes of the terrain, without using agrotechnical techniques, promotes wash-off and dispersion and loss of organic matter. The use of heavy agricultural machinery leads to significant compaction of soils, a decrease in their water and gas permeability, and a sharp decline in soil fertility.

Anthropogenic influence on soils, widespread in dry, highly rugged climatic zones with complex geomorphological and geological conditions, contributes to the intensification of desertification and erosion processes, leading to maximum losses of soil resources (Aliiev *et al.*, 2001; Khalilov and Abduev, 2004; Gurbanov *et al.*, 2024). The territory under consideration represents a set of foothills, foothill plains, shallow valleys, and plateaus

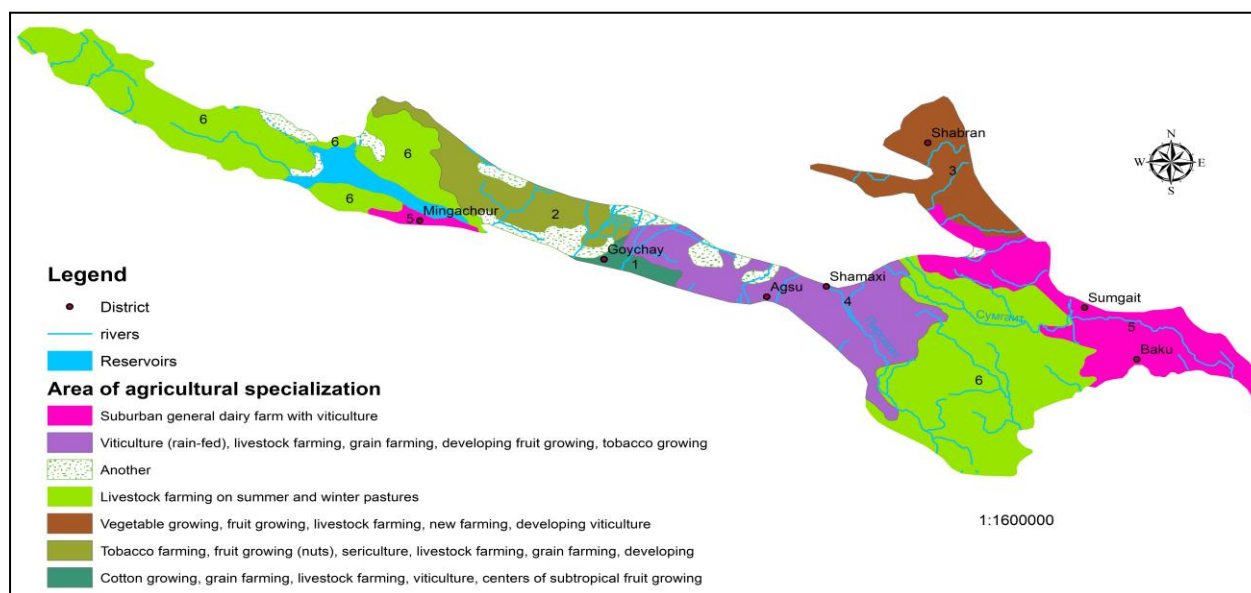


Figure 2. Agricultural map of the studied region.

that formed in the Upper Pliocene-Quaternary period. Mountain ranges and basins consisted of clays, conglomerates, pebbles, and sand. The plateaus have exclusive armors of Akchagyl and Absheron limestones. The southern macroexposures of the slopes of ridges and river valleys reveal features of intensive development of badlands and clayey karsts. A significant territory showcases dissection of river valleys, ravines, and gullies (Shirinov and Sulejmanov, 1964).

Given the extreme dryness of the southern slopes, the vegetation cover has a weak root system, resulting in the development of erosion-denudation processes that contribute to the intensive dismemberment of the relief. Such forms of relief are especially characteristic of the Adzhinour foothills. Numerous small drainless depressions reached development in places covered with solonetzic soils. The most extensive, drainless depression, Adzhinour, has a widespread distribution of salt marshes and meadow-takyr formations in the west (Sulejmanov, 1965). The eastern part of the arid zone is quite different from the western. The Gobustan, with high air humidity, is one of the main features that distinguishes it from Jeyranchol. Therefore, in the eastern regions of Gobustan, the relief shows an obvious lack of

expression compared with its western part and the tertiary plateau (Gurbanov, 2024).

Climatically, the entire territory under consideration is part of the subtropical zone with varying degrees of aridity. With large heat reserves (sum of temperatures above 10 °C within the range of 1800 °C–4400 °C), the humidification value ranges from 0.10 to 0.25, while in some places, it is up to 0.35. The western part is distinct with significant dryness of air and soil (Ejjubov, 1964). General features of aridity persist in winter months. Although water appearing in many dry lands, increasing flow in some rivers in autumn, and causing increased precipitation contribute to a slight rise in moisture reserves in the soil, especially in river valleys (Shashko, 1952). The hydrographic network puts Gobustan in a special position. If there are enough sources of irrigation around Jeyranchel (Mingachevir reservoir; Kura and Iori rivers) compared with Gobustan, however, this is not the case (Ejjubov, 1965).

Natural vegetation characteristics display an abundance of ephemerals, ephemeroïds, and dry-steppe formations—wormwood, bearded grass, feather grass, and fescue—developed on mountain chestnut, mountain gray-brown, and gray-brown solonetzic soils. These plants mostly grow in the autumn-winter-spring period, which makes

it possible to use almost the entire territory as winter pastures. Along river valleys and on developed lands, hygrophytes—poplar, alder, willow, and tamarix—are mostly prevalent in wild and cultivated forms. The characteristic landscapes are semi-desert and dry-steppe, sometimes forest-shrub natural landscapes, largely modified by humans. However, vast areas contain cotton fields, vineyards, grain crops, and orchards.

Several studies reported the presence of anomalies in the distribution of individual elements of physical geography in the southern arid zone slopes in the latitudinal direction. Studying the vegetation of the southern slope of the Greater Caucasus, L.I. Prilipko points to the relative dryness of the Sheki subdistrict, located between the most humid Belakan-Kahekim and Gebelin-Ismaili subdistricts (Prilipko, 1954). The Sheki Region has a drier climate than the neighboring regions to the west and east (Eyyubov, 1965). The aridity presence, as explained by B.A. Budagov, is the reason for the strengthening of the structure of mudflows in the area between the Kurmukhchay and Dashgylchay rivers (Budagov, 1961). Shirinov and Suleymanov (1964) established a pronounced anomaly in the landscape, which is obviously visible on the southern ridges and in the central depression.

RESULTS AND DISCUSSION

The geomorphological and climatic factors play a vital role in landscape formation of the arid regions of the Greater Caucasus (Table 1). Therefore, the study area with landscape zoning relied on a geomorphological and climatic feature that determines the distribution of dryness, surface and groundwater, and intensity of the dissection. The climatic conditions in the surface air layer are amenable to reclamation, and the degree of dissection can entail reduction by taking measures to level out the roughness and stabilize the slopes.

Thus, during zoning, aside from accounting for the existing natural complexes,

considerations for their more natural boundaries and the possibility of artificial influence on them could expand agricultural production. Previous researchers have taken landscape indicators as the main feature in organizing and managing arable areas with complex relief in the arid zone (Budagov, 1961; Ejjubov, 1965). However, occurring climate changes over the last 30–40 years, mainly the decline in precipitation and its heavier nature, require diverse approaches. In landscape zoning of the proposed land structure, these indicators require much consideration, i.e., surface slope, soil cover fertility indicators, direction of planting and irrigation, erosion, potential risk of erosion, and plant density and botanical composition.

In the landscape zoning of the territory, covering the climatic section in relation to agricultural purposes mainly took the form of agroclimatic analysis. Therefore, for the analytical characteristics of the natural environment, the use of moisture maps, the sum of temperatures above 10 °C, the sum of the remaining temperatures above 10 °C after harvesting winter wheat, the availability of precipitation, and the frequency of weather succeeded. Utilizing the said data was in combination with typological maps of vegetation and soil cover. Several maps had direct relevance to landscape zoning and are crucial for characterizing the natural landscape, while others are important for characterizing the cultural landscape and its natural potential.

Thus, geomorphological and climatic factors play a considerable role in forming the landscape in arid regions of the Greater Caucasus. Therefore, the landscape zoning of the study area was dependent upon the geomorphological and climatic features that determine the distribution of dryness, surface and groundwater, and intensity of dissection. This choice refers to the fact that in the surface air layer, the climatic conditions are amenable to reclamation. Moreover, the degree of dissection can also cause a decrease by taking measures to level out the roughness and stabilize the slopes. Thus, during zoning, researchers considered the existing natural

Table 1. Landscape planning for land management of the arid zone in the Greater Caucasus.

Subzones	Districts	Sub-districts	Characteristics of the landscape and ecological types of cultivated crops
1	2	3	4
1.Arid lowland	1. Shabran-Sumgayit 2. Absheron 3. Puta-Alat	- - -	Semi-desert with saltwort-sandy vegetation on gray-brown solonetzic soils. Cereals, vegetables, horticultural crops, winter pastures. Semi-deserts with ephemeral forb-grass and seaside-sandy vegetation on gray-brown solonetzic and gray-brown soils. Vegetables, grains, grapes, figs, olives, saffron, etc. Deserts and semi-deserts with seaside-sandy and annual saltwort vegetation and gray-brown saline soils.
2.Arid mountain	4. Jeyranchol	a) Garayazi b) Chobandag-Eldar c) Palantekyan	Steppes with wormwood and wormwood-bearded grass vegetation on mountain chestnut soils. Tugai forests. Cereals, melons, and winter pastures. Steppes (feather grass, feather grass and beardgrass upland xerophytes, Eldar pine on mountain brown and chestnut soils. Winter pastures). Semi-deserts with wormwood, wormwood-hodgepodge vegetation on gray-brown solonetzic and mountain-gray-brown soils. Winter pastures include melons and partly grains.
	5. Acinohur	a) Dashuz b) Aresh c) Gojashen d) Gurjivan	Steppes, low-growing forests with bearded fescue and bearded-feather grass vegetation and oak-hornbeam bushes on mountain-chestnut, mountain-forest brown posts. Cereals, grapes, vegetables, melons, and tobacco. Steppes and semi-deserts with bearded grass, fescue, wormwood-hodgepodge vegetation on chestnut-chernozem-like and gray-brown soils. Cereals, grapes, sunflowers, and winter pastures. Steppes, semi-deserts and open forests with wormwood-hodgepodge, bearded fescue, and juniper-pistachio vegetation on mountain gray-brown alkaline and chestnut soils. Cereals, cotton, melons, pomegranate, persimmon, figs, grapes, etc. Steppes and low-growing forests with feather-fescue, feather-grass-bearded grass, and sometimes phryganoid vegetation and oak-hornbeam shrubs on chestnut mountain-gray-brown and mountain-forest brown soils. Rainfed grains, tobacco, sunflower, grapes, etc.
	6. Gobustan	a) North Gobustan b) South Gobustan c) Navai	Dry steppes, steppes with beardgrass, wormwood-beardaceous and wormwood-wheatgrass vegetation on gray-brown soils. Rainfed grains, sunflowers, vegetables, grapes, partly winter pastures. Semi-deserts with wormwood, wormwood-hodgepodge, and hodgepodge-shrub vegetation on gray-brown, saline, light gray-brown soils. Winter pastures, partly grain. Semi-desert with wormwood and wormwood-hodgepodge vegetation on gray-brown saline soils. Cereals, melons, grapes, figs, pomegranate.
	7. Siyazan	-	Semi-deserts with wormwood, wormwood-hodgepodge vegetation on mountain chestnut and chestnut soils. Cereals, orchards.

complexes, their more or less natural boundaries, and the possibility of artificial influence on them to expand crop production.

Identified taxonomic units resulted in the following order: zone, subzone, district, and subdistricts. The subzone refers to the entire arid zone, the territory within the Eastern Transcaucasus, the continuation of which passes into the Transcaspiian deserts and semi-deserts. The zone determination was simply according to the general system of latitudinal zoning. With a dissected relief, the additional factors of landscape formation appear, and the arid zone within the Eastern Transcaucasia underwent division into subzones, i.e., flat and mountainous.

The presented article examines the arid plain subzone, covering narrow strips of coastal regions, and the arid mountain subzone, which occupies most of the foothill belt of the Azerbaijani part of the Greater Caucasus. Within the plain subzone emerged three distinctions, and in the mountain subzone were five isolated regions, differing in the degree of relief dissection, resulting in the influence of several physical and geographical factors. The detection of subdistricts was mainly based on moisture, the nature of the soil, vegetation cover, and the agricultural orientation. Within the regions of the mountain subzone, based on their length from west to east, 10 subdistricts were distinguishable (Figure 3). Without going into details of the individual territories' characteristics, the

smaller units can be evident within subdistricts. Noticeable differences within subdistricts existed, as well as between slopes of northern and southern exposures. The latter can serve as a basis for identifying areas within the subdistrict. Placing objective signs, like low-growing forests and shrubs occupying a significant area on the northern slope, will identify areas within subdistricts.

Microclimatic observations can provide comparisons of the hydrothermal conditions of the surface layer of air and soil on the northern and southern slope exposures. Thus, the air temperature at an altitude of 2 m at 13:00 is 1 °C to 3 °C lower than in the south. Closer to the active surface, this difference increases and reaches 5 °C–8 °C at the soil surface. Up to a certain extent, this determines the disparity in the intensity of evaporation from the soil cover. Therefore, on the slopes of the northern exposure, at the depth of maximum development of the root system of herbaceous vegetation, the humidity was 3%–8%. Meanwhile, in some places, it is even higher, up to 12%, than on the slopes of the southern exposure. This develops the conditions for the production of low-growing forests and shrubs on the northern slopes. In lack of irrigation water, the northern slopes are of greater agricultural interest than the southern. The higher elevations on the northern slopes were once successful for growing potatoes (Khalilov *et al.*, 2004; Ismayilov, 2006).

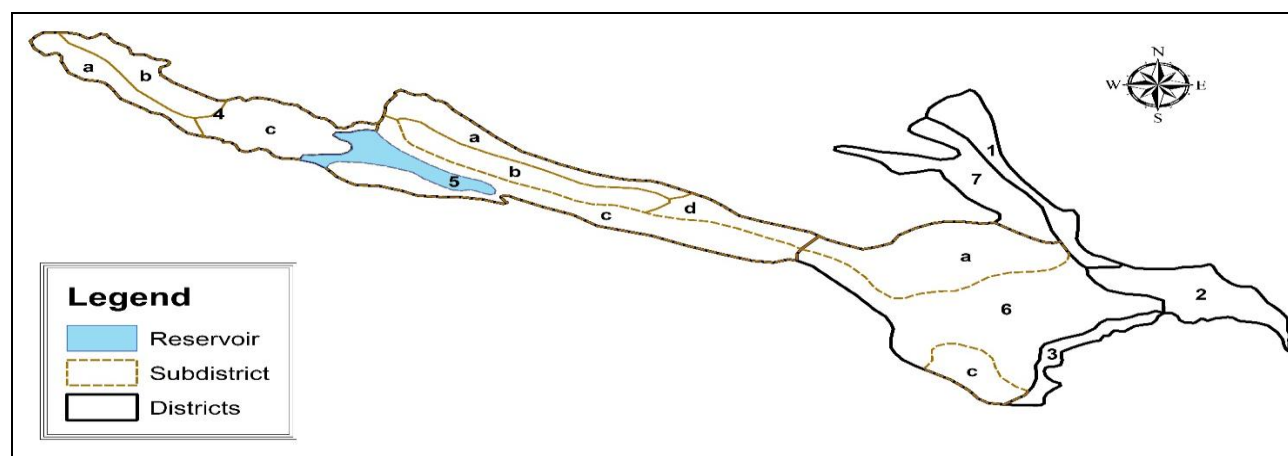


Figure 3. Landscape and land management zoning of the studied region.

Agriculture in the developed areas of the arid zone specializes mainly in the production of grain, cotton, grapes, and fruit crops. Vast unplowed tracts in Jeyranchel and Gobustan served as winter pastures. In terms of thermal resources, a significant low-lying part of the mountain subzone and the entire flat subzone belong to the subtropical zone with a long growing season for crops. However, in irrigated areas, excess heat after harvesting crops with a relatively short growing season makes it possible to grow a second and even a third crop with a short growing season. As a second crop, the study can recommend stubble, corn for silage, and forage legumes, which could provide a strong feed base for livestock. Several studies have prioritized the use of winter pastures in the planning of the arid zones, mainly based on several components of the landscape (Suleymanov, 1965). However, in this research, based on soil and bioclimatic potential data, in addition to pasture areas, irrigation-based perennial crops and companion crops should also proceed planting, considering the indicators of various geographical factors. Soil degradation factors must also be notable in the implementation of these processes.

In the arid zone under consideration, an indispensable condition for further development of agriculture is a unique approach to the allocated territories based on landscape zoning. As already mentioned, in the surroundings of Jeyranchol appear powerful sources of irrigation, with Gobustan deprived of such sources. Therefore, by developing the arid zone, priority should focus on the steppe subdistricts of Jeyranchol—Karayazin and Eldar. The Jeyranchol and Ajinour districts require immediate reclamation of erosion-hazardous areas. In the southern exposure, the areas of slopes are especially susceptible to gully erosion (Ejjubov, 1965). However, in Absheron Gobustan, especially in the South Gobustan subdistrict, the main fight should center on the wind erosion. Additionally, according to agricultural workers' experiences, the badlands seemed unsuitable for agricultural use, where growing grapes can be possible if irrigation water is available.

CONCLUSIONS

Landscape zoning for agricultural purposes is of particular importance for expanding the arable areas of existing crops and zoning new crops. Given the foothill location of a significant part of the territory, the arid zone tended to act as a 'warm zone' in winter due to frequently repeated weather inversions. Here, the absolute minimum air temperatures are significantly higher than in the central regions of the Kura-Araks lowlands. By studying the requirements of the subtropical crops' climatic conditions, as well as practices, it showed a considerable area has favorable conditions for cultivating olives, figs, pomegranates, and persimmons on a large scale. For olives and figs, the best soil and climatic conditions are available in all three regions of the lowland subzones, and for pomegranates and persimmons, the Gojashen and Apsheron subdistricts of the arid mountain subzone can be desirable.

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