EVALUATION OF THE EFFICIENT USE OF AGRICULTURAL LANDS IN THE GANJA-DASHKASAN ECONOMIC DISTRICT BASED ON GEO-SPATIAL AND STATISTICAL DATA

R.I. Guliyev

Institute of Geography PLE, Ministry of Science and Education, Baku, Azerbaijan

quliyevramil915@gmail.com

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Abstract

A comprehensive analysis of the dynamics of the development of crop and livestock farming in the study area over the past 20 years, as well as the modern structure and transformation trends of agricultural lands. Against the backdrop of global climate change and food security challenges, assessing the potential of agricultural lands and determining ways to use them efficiently is of strategic importance. The study used modern computing platforms such as Google Earth Engine (GEE) and Geographic Information Systems (GIS) methods to process large-scale satellite data. These technologies allowed for a detailed study of the natural and geographical conditions of the area and to scientifically substantiate the results of agricultural production. Taking into account the impact of changes in geographical space on socio-economic relations, a mutual analysis of spatial indicators and official statistical data was carried out. This integrated approach allows for the quantitative and qualitative assessment of economic indicators in agriculture, as well as for predicting future development directions of the sector. The results of the study prove the necessity of applying innovative methods in land resource management and serve as a scientific basis for optimizing the agrarian potential of the region.

1. Introduction

The importance of efficient use of land resources in the agricultural sector, including in our Republic, is increasing day by day against the backdrop of global problems occurring in the world. Incorrect use of natural resources in the country [8] and global climate change not only limit agricultural productivity but also cause land degradation problems, which negatively affect rural areas and the living standards of vulnerable groups such as small farmers. Studies show that annual soil loss in the Dashkasan, Goygol and Goranboy regions located on the northeastern slopes of the Lesser Caucasus amounts to 11.7 t/ha/year [4].

The agro-climatic potential and topographical conditions of the Ganja-Dashkasan economic district open up wide opportunities for the development of agriculture. This region, which occupies 6% of the country's territory and population, covers almost all altitudinal zones from the highest northern-east slopes of the Lesser Caucasus Mountains to the Jeyranchol-Ajinokhur lowland. Thus, the relief conditions of the Lesser Caucasus have a favorable advantage, and the gradual decline, the presence of large plateaus above the mountains have created conditions for more population settlement here. Therefore, compared to the Greater Caucasus mountain system, the soil and landscape cover of the Lesser Caucasus mountain system has been subjected to more anthropogenic impact as a result of the economic activity of the population. The plain area of the region, up to 300 m above sea level, occupies 38% of it, the foothills and low mountainous zone 23%, the middle mountainous zone 25%, the high mountainous zone 9%, and the Mingachevir water reservoir 4%.

The main climate types here are a semi-desert climate with mild winters and hot, dry summers in the plains, a temperate-warm climate with dry winters in the low and middle mountains, and a cold climate with dry winters in the high mountains. A mountain tundra climate has developed in areas above 3000 m. The annual amount of precipitation varies from 200 mm to 800 mm. The fact that the maximum amount of precipitation falls in the spring months creates favorable conditions for the cultivation of winter grain crops. During this period of the year, the drought index

of 0.4-0.6 in april and 0.4-0.5 in may has an important role in meeting the water supply of plants. The intersection of transboundary rivers here and favorable topographic conditions have led to the creation of important water infrastructure.The formation of significant water resources is considered one of the main advantages of the area. Observations show that the application of efficient use of water resources is one of the main conditions for the implementation of secondary production here.

In addition, the economic and geographical position of the area, the richness of natural resources, and the proper use of great recrational opportunities can lead to sustainable economic development by attracting investment interests to the area.

By strengthening the activities of Agricultural Production Complexes in Ganja, the second largest city of Azerbaijan, or in other economic centers of the region, coordination and centralization between structures in the agricultural system can be achieved. Although land concentration remains a topic of political debate in several countries around the world [6], it cannot be allowed to occur only if there is a significant decline in family based farms. Unlike other regions, the concentration of more than 50% of the total population in cities seems attractive for the realization of the products of family-based farming, but the demographic processes taking place here are an indicator of the unsatisfactory economic situation. For example, The natural increase per 1000 people in Ganja city was 0.2 [2].

Land is a limited and scarce natural resource faced with competing and rising demands. Efficient use of land resources is considered one of the first conditions for achieving development in agriculture [11]. Agricultural land provides the largest share of food supplies and forms essential part of labour resourses in our country.

2.Materials and methods

The Ganja-Dashkasan economic region consists of the Goranboy, Samukh, Goygol, Dashkasan districts, Ganja and Naftalan cities, with a total area of 5.27 thousand km². The agricultural lands of the Ganja-Dashkasan economic region were taken as the object of the study (Fig. 1) .

The distribution of agricultural lands in the study area was determined based on Sentinel 2A satellite images according to natural and anthropogenic landscapes and a GIS-based map was compiled (Fig. 2). Water and forest reserves, national parks and reserves, and residential areas were taken as non-agricultural areas.

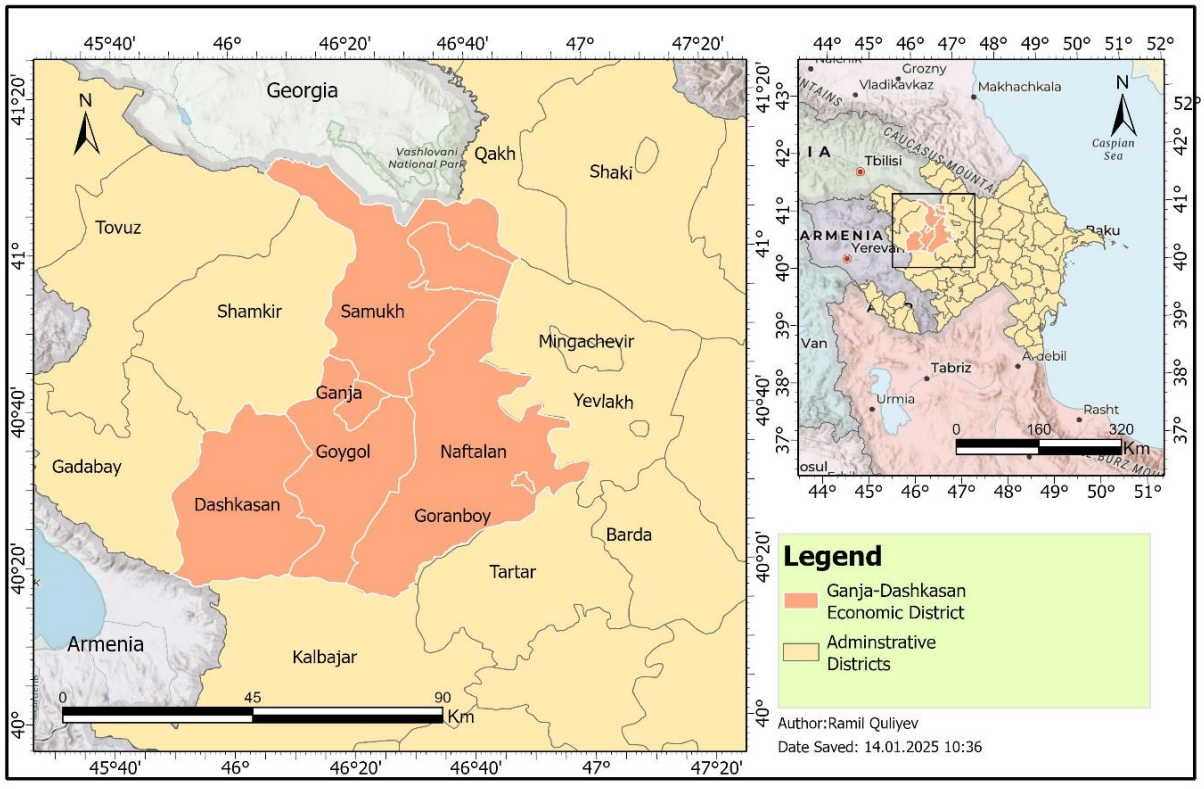


Figure 1. Study area

Satellite images of the area were taken in May, the most active period of the vegetation cycle and agro-climatic resources of the region which allows us to accurately classify agricultural areas according to their natural landscape. İn the map elaborated the data reflects the potential agri-cultural oppor-tunities of the area and how it has been trans-formed compared to statistic data from 2000. The boundaries of cultivated areas can be clearly observed from satellite images.The desig-nation of pasture and hayfield areas depends on the degree of plant cover and is determined based on satellite images. Shrubby semi-desert and dry steppe vegetation, which is not suitable for ag-riculture, is widely used as winter pastures in many regions, including our country. The high mountain belts contain alpine meadows and partly subalpine me-adows used as summer pastures.All this informa-tion allows us to compare the dynamics of changes based on the potential op-portunities in the use of agricultural lands and to create an idea about the region over the years.

Based on long-term statistical data, it is pos-sible to clearly distinguish in the correlation quad-rangle graph how the productivity of agri-cultural crops has changed compared to one another, and which crops have consistently incre-ased or de-creased their productivity indicators. Determining the coefficient of variation in overall productivity indicates the extent to which the product depends on the natural and climatic conditions of the area.

The drought graph with a spatial resolution of 0.5 degrees for the area obtained from the GEE (Google Earth Engine) platform clearly shows the increase in drought after 2012 (Fig. 8). The Global SPEI database, SPEIbase, offers long-time, robust information about drought conditions at the global scale, with a 0.5 degrees spatial re-solution and a monthly time resolution. It has a multi-scale character, providing SPEI time-scales between 1 and 48 months. It is based on monthly precipi-tation and potential evapotranspiration data from the Climatic Research Unit of the University of East Anglia, starting in January 1901, and it is updated as soon as new data becomes available. Multi-year temperature and precipitation graphs based on the CRU TS data-base confirm this once again. (Fig. 9) [5]. Deter-mining the moisture con-tent coefficient based on potential evapotrans-piration and prec-ipitation helps us to understand the changes in crop productivity over the years.

The area covered by vegetation greater than 0.2 was calculated on the GEE computing plat-form based on Landsat satellite images com-po-sited over 35 years (Fig. 4). Google Earth Engine is a computing platform that allows users to run geospatial analysis on Google's infra-structure.

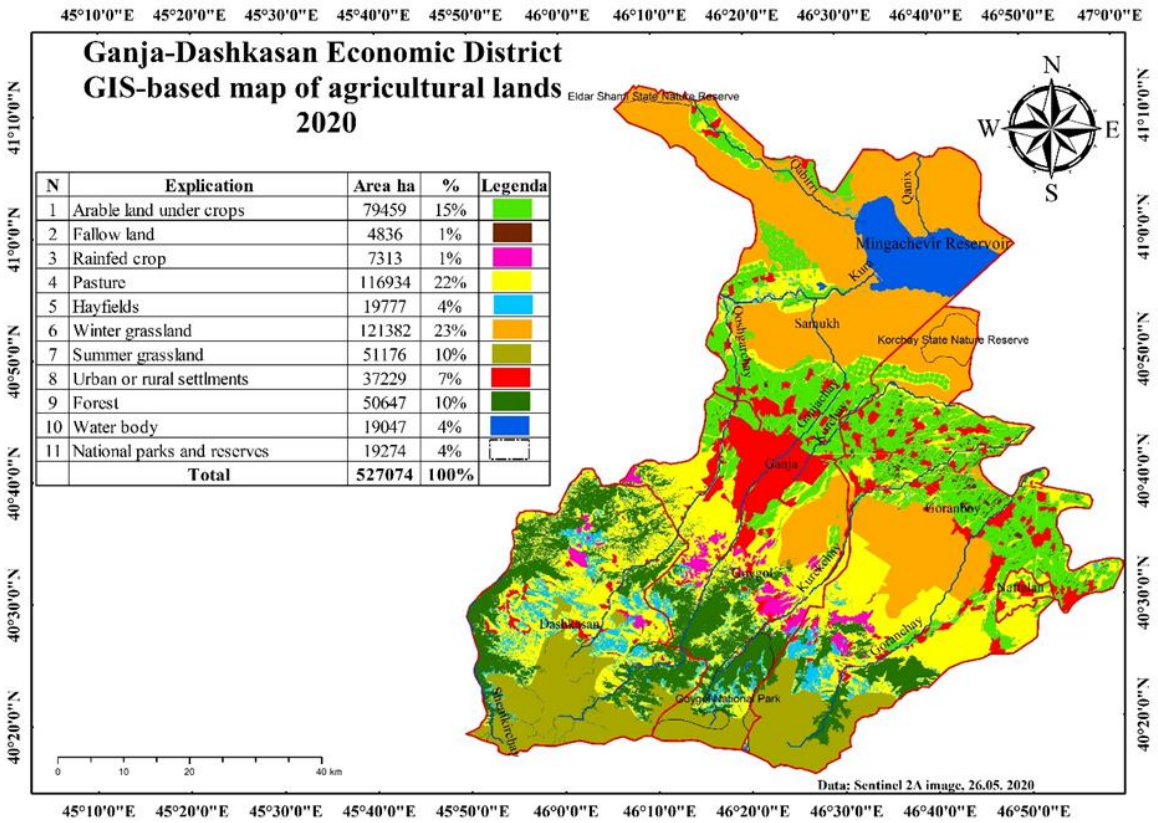
3.Results and discussion

The economic valuation of agricultural lands is a very complex issue. The main direction here is to conduct an economic valuation based on physical and geographical conditions [3]. The prerequisite for assessing the potential of land resources is the acquisition of land use and land cover data in the area. Studies show that the designation of agricultural lands should be deter-mined according to the characteristic features of the vegetation cover of the area and topo-graphic conditions.

Measuring the extent and geographical distri-bution of cropland and the current performance of crop production in the study area is crucial to as-sess the potential for further increases in food production and to monitor the sustainability of agriculture. As a result of processing satellite ima-ge data of agricultural areas in the GIS da-tabase, Although arable land has expanded by 12649 ha (17.7%) since 2000, its share in total agricultural land decreased. (Fig. 2, 3). Modern agroparks built on an area of nearly 7,700 hectares in the Goranboy and Samukh regions form a major part of this trend. However, in statistical data, the total area under agricultural crops in-creased by 44% for the corresponding period [1]. The increase in arable land has occurred mainly due to the encroachment of pastures around vil-lages and winter pastures. The area of rainfed crops is decreasing, unlike irrigated crops. This may be one of the main consequences of the re-cent in-crease in drought in the area.

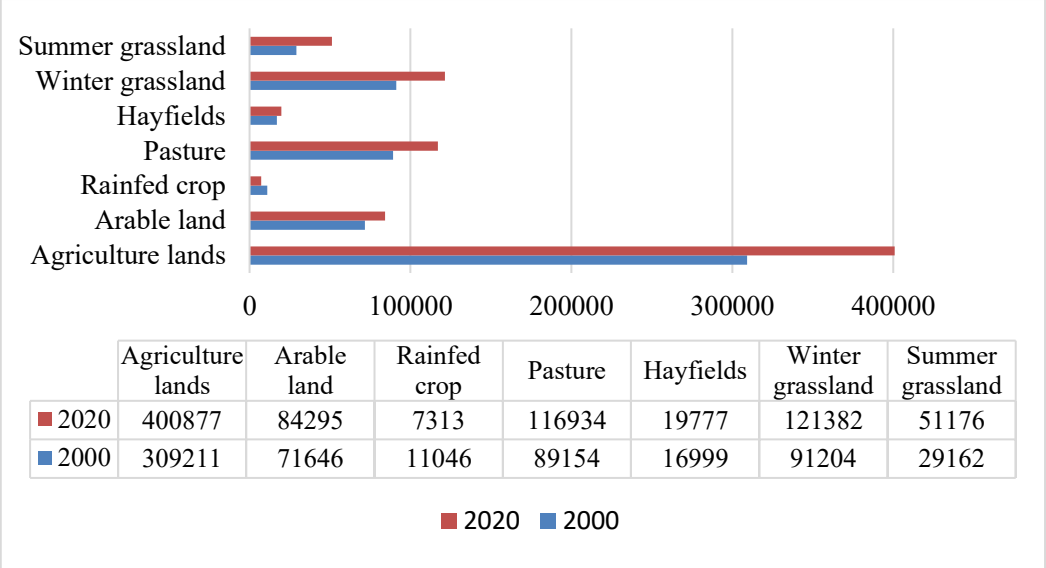
The expansion of cultivated areas under agri-cultural crops is also reflected in the NDVI va-lues. As can be seen in Figure 4, the area of areas with a vegetation coverage rate above 0.2 has expanded since 2000.

Despite the availability of sufficient pastures and grazing areas, there has been a recent decline in the number of livestock (Fig. 5). Since 2014, a decline in the number of both large and small horned animals has been observed. The reduction of pastures near major residential areas or their transformation into arable land has led to the need for additional sources to meet the feed needs of family and household farms for livestock pro-ducts. A reflection of this can be observed in the decrease in the number of livestock in the region in recent years and a significant increase in feed production.



N	Explication	Area ha	%	Legenda
1	Arable land under crops	79459	15%	
2	Fallow land	4836	1%	
3	Rainfed crop	7313	1%	
4	Pasture	116934	22%	
5	Hayfields	19777	4%	
6	Winter grassland	121382	23%	
7	Summer grassland	51176	10%	
8	Urban or rural settlments	37229	7%	
9	Forest	50647	10%	
10	Water body	19047	4%	
11	National parks and reserves	19274	4%	
	Total	**527074**	**100%**	

Figure 2. GIS based map of agriculture lands



	Agriculture lands	Arable land	Rainfed crop	Pasture	Hayfields	Winter grassland	Summer grassland
2020	400877	84295	7313	116934	19777	121382	51176
2000	309211	71646	11046	89154	16999	91204	29162

Figure 3. Spatial distrubition of agricultural lands in Ganja-Dashkasan economic district

In 2024, barley, wheat and fodder production areas accounted for 76 % of the territorial structure of agricultural crops. This figure is one of the main indicators of intensive livestock farming in recent times. Statistical figures show that the share of pastures and hayfields used by agricultural enterprises and individual entrepreneurs in the region is higher than in other economic regions. The reduction in competitiveness among agricultural participants, in other words, the occupation of pastures around the villages, has led to the owners of family farms tending to agriculture rather than livestock farming. Against the background of the ongoing processes, the interest of family and household farms, which have a major share in agriculture, in livestock farming has decreased.

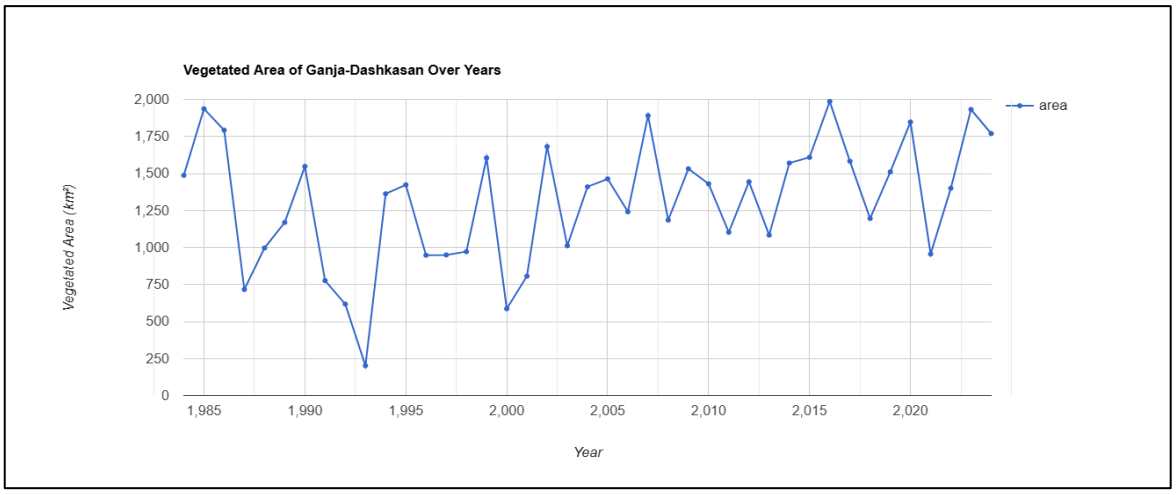


Figure 4. Vegetation cover changes over years based on Landsat 4, 5, 6, 7, 8, 9 satelite images.

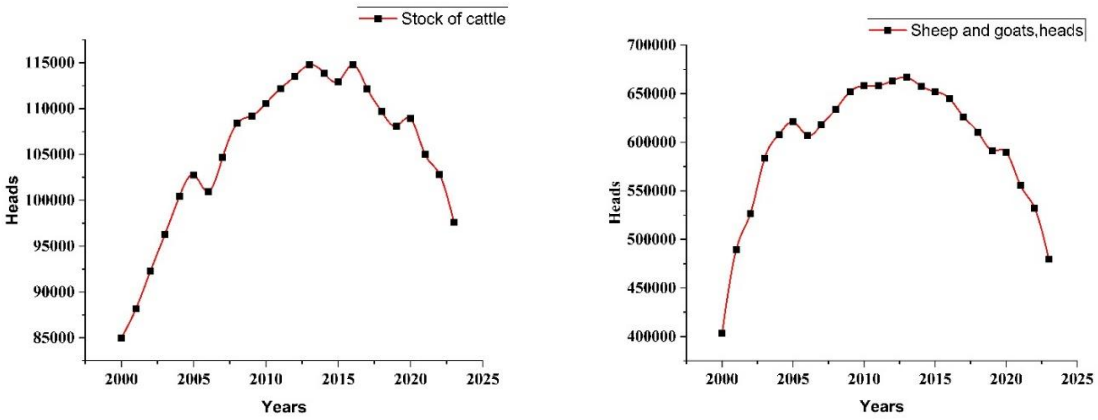


Figure 5. The stock of cattle and sheep and its dynamics of change over the years (Ganja-Dashkasan economic district)

The presence of extensive winter and summer pastures in the region opens up wide opportunities for the development of small-horned livestock, in particular. The pasture and grassland area per cattle in 2020 is 2.84 hectares, and for sheep and goats it is 0.52 hectares [7]. Currently, the share of pastures and grazing areas in agricultural land is 77 %. The main goal of expanding pastures and winter pastures in the last 20 years is directly related to the state's special emphasis on the development of livestock. However, contrary to this, during these periods, a decrease in the number of animals and a positive growth dynamics in the production of milk and eggs from livestock products were observed. In 2024, milk production reached a record high of 129,289 tons. This is a 3-fold increase compared to the figures for 2000. Egg production increased 2.8 times for the corresponding period.

Compared to previous years, the physical volume index of agriculture increased by 123% in planting, 79% in animal husbandry, and 95% in total during the period 2003-2023. (Fig. 6). The development of livestock breeding in the Goygol and Samukh districts is progressing more rapidly due to modern livestock farms. While Samukh and Goranboy districts specialize in the production of primary agricultural products, the city of Ganja is distinguished mainly by the activities of processing industrial enterprises.

The main share in the structure of agricultural crops in the region is winter grain and fodder production. The expansion of barley and fodder production, especially in recent times, is closely related to the development of intensive livestock breeding. Winter grain crops have a significant advantage over spring crops both in terms of productivity potential and earlier ripening periods. They make better use of natural soil and climatic resources, including autumn and early spring heat and moisture, suffer less from summer droughts and therefore play a primary role in increasing grain production[10]. This can also be observed in the strong correlation of productivity (Fig.7) by year and the low coefficient of variation (Table 1).

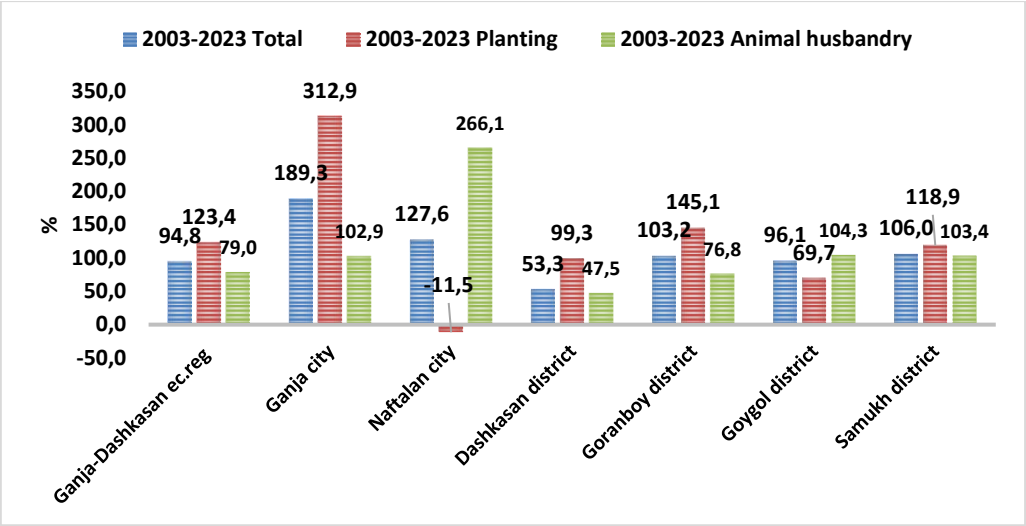


Figure 6. Physical volume index of agricultural production over years

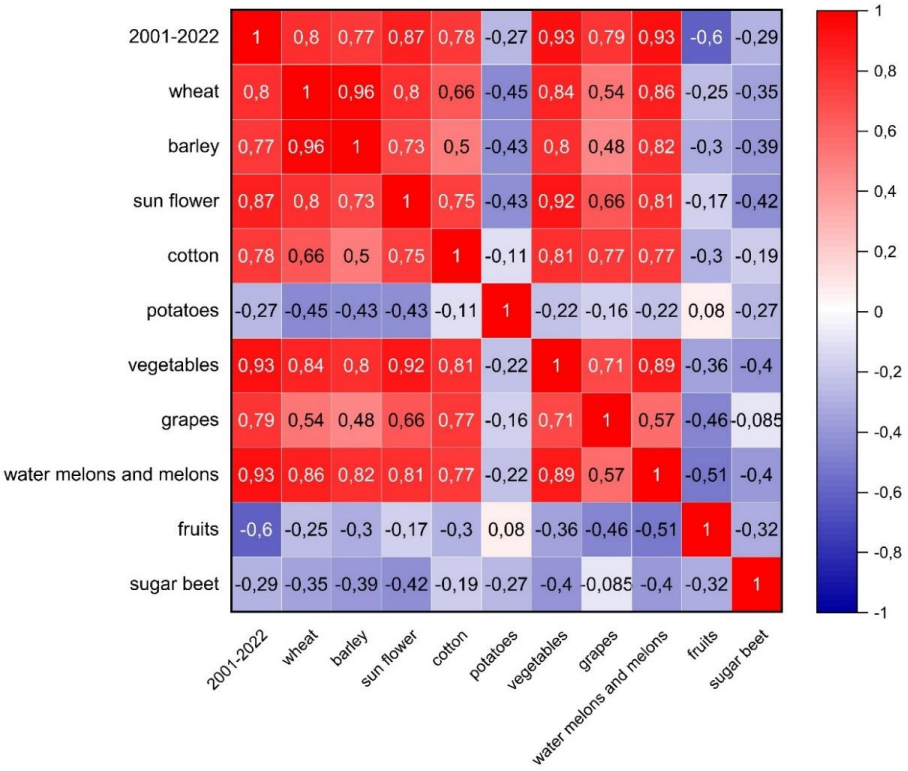


Figure 7. Correlations of productivity among agricultural crops in Ganja-Dashkasan economic district

A correlation coefficient close to 1 indicates an increase in the productivity of the products over the years. The coefficient of variation (CV) is a statistical measure that expresses the extent of variability relative to the mean of a dataset. According to Table 1, a coefficient of variation of agricultural crop productivity indicators below 10 is considered the most efficient for that crop, between 10 and 20 is considered moderately efficient, and above 20 is considered low-efficient.

Of course, although coefficient of variation (CV) are closely related to soil and climate factors, issues related to the organization of the agricultural system also play a special role here.

In addition, row crops such as sunflower, cotton, sugar beet, corn, potatoes, vegetables, melons, etc. are also cultivated in agriculture. The negative characteristics of the cultivation of these plants are high evaporation from the soil surface, low competition in the fight against weeds, and increased soil erosion. The high irrigation requirements of vegetables and melons considerably limit their cultivation on irrigated lands.

Table 1

Productivity indicators of the most commonly cultivated plants in the Ganja-Dashkasan economic district between 2013 and 2023

Crops	Mean productivity sent/ha	Standart deviation	Coefficient of variation (CV) %	Share in the agricultural structure ha (%) (2024)	Share in agricultural production ton (%) (2024)
Barley	29,9	2,91	9,7	29%	16%
Wheat	30,4	3,84	12,6	19%	11%
Cotton	21	7,71	36,7	2%	1%
Sunflower for seed	22,5	2,75	12,2	7%	3%
Potatoes	105	5,92	5,6	1%	2%
Vegetables	94	10,9	11,6	3%	6%
Water melons and melons	174	20,7	11,9	0%	1%
Grapes	88,5	12,3	13,9	2%	3%
Fruits	80,4	5,3	6,6	8%	11%
Sugar beet	335	126	37,6	0%	1%
Grain maize	44,9	11,25	25,1	2%	5%
Fodder	-	-	-	28%	40%
Total	**-**	**-**	**-**	**100%**	**100%**

The region has had considerable problems in meeting its irrigation needs in the last decade, especially near Goranboy district in the cultivated areas on the left banks of the Goranchay River, which has been observed that the planting areas are often abandoned fallow in seasonal time. Although the low coefficient of variation indicates that potatoes and perennial crops are suitable for the natural-climatic conditions of the area, the productivity decreases from year to year. The low coefficient of variation (6,6%) of the yield indicators of perennial crops over the last decade indicates that their production is more efficient in agricultural production. Sunflower, the most widely grown crop in the region after cereals and legumes and perennial crops , appears to be more adapted to the region's natural climatic conditions. The region meets a significant portion of the country's demand for sunflower. In some years, this figure has exceeded 30%.

The region has extensive experience in the field of viticulture. Large viticulture farms and processing and industrial enterprises operate, especially in the Samukh and Goygol districts. Goygol district specializes mainly in the production of technical grapes, and Samukh district specializes in the production of table grapes. The total area of vineyards is 1831 hectares according to statistical data for 2024. After 2019, a decrease in total grape yield has been observed.

Cotton production is cultivated only in the Goranboy region. Its productivity varies sharply from year to year and does not have a sustainable development. In this regard, the coefficient of variation of cotton has been 36.7% in the last ten years. Only thanks to the subsidies provided recently with the support of the State, its production has revived after 2015. In recent years, its production has decreased significantly.

Against the background of similar events, the connection of the processes occurring with natural-climatic phenomena is considered to be a widely discussed issue. In particular, sufficient research has been conducted in the field of assessing the impact of global climate change on agriculture and taking preventive measures.

Drought is a natural phenomenon that has a wide and serious impact on livestock and agriculture. The increase in drought in recent years has a great impact on the degree of vegetation cover of an area, which also has a great impact on the productivity of aboveground biomass and agricultural crops. Reports to the UNCCD from more than 100 countries revealed that 1.84 billion people were affected by droughts in the 2022–2023 biennium (UNCCD, 2023). These effects can manifest in difficulties accessing water and feed sources for animals, negative impacts on animal health and welfare, decreased production efficiency, and economic losses [9]. In this regard, it is very important to make strategic decisions to determine how drought events in the field have changed over the past 40 years against the backdrop of agricultural production.

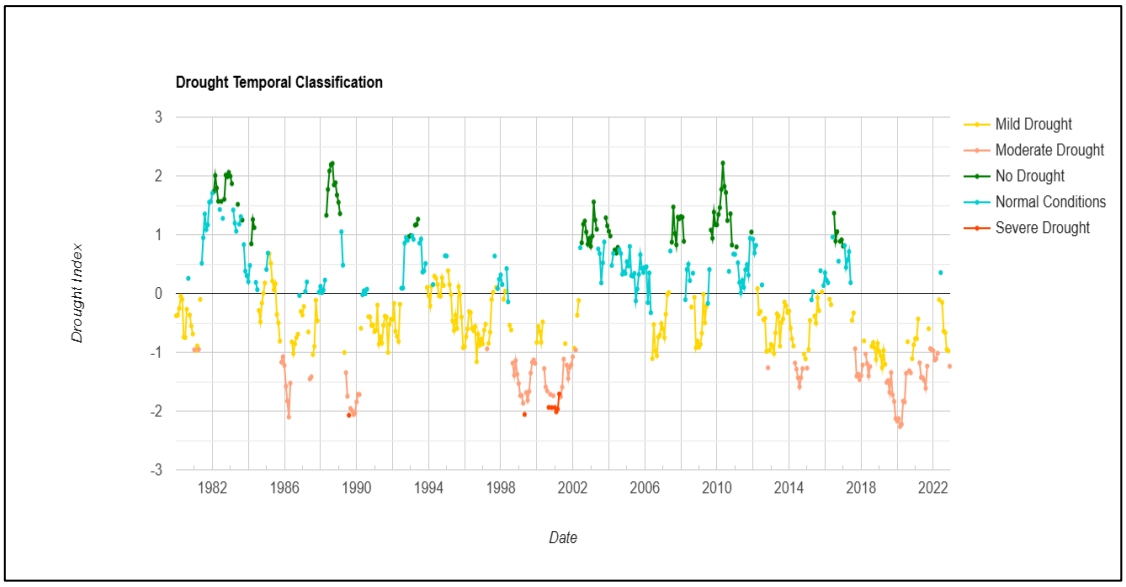


Figure 8. Drought index of Ganja Dashkasan economic district

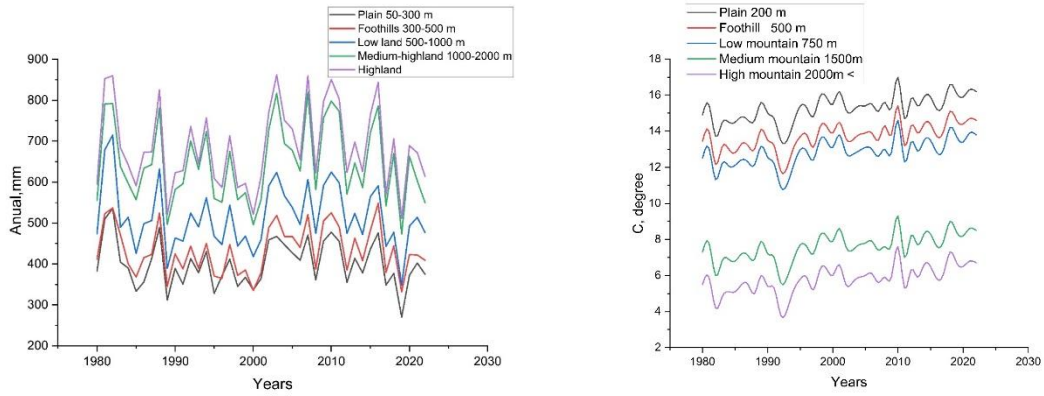


Figure 9. Spatial distrubition of annual precipitation and average temperature in Ganja-Dashkasan economic district

The classification of drought by periods, obtained from multi-year temperature and precipitation data obtained for the region, shows that from 2012 to 2022, with the exception of exceptional years, mild and moderate degrees of drought are more prevalent (Fig. 8).

The processes occurring especially affect the agrolandscape of the semi-desert and dry steppe zones, where drought is more prevalent. The period of decreasing drought index in the region coincides with the dynamics of decreasing animal numbers, and has a positive correlation.

4.Conclusion.

The region is undergoing a significant transition from extensive to intensive farming. While total arable land has expanded and the number of livestock has decreased since 2014, productivity in animal husbandry has reached record highs—notably a 3-fold increase in milk production. This indicates that modern agroparks and industrial farming methods are successfully replacing traditional family-farm livestock grazing.

The encroachment of arable land into pastures surrounding residential areas has created a "competitiveness gap" for small-scale farmers. Forced to find alternative feed sources, many family farms have shifted their focus from livestock to crop cultivation (primarily barley and fodder), which now dominates 76% of the crop structure.

Climate change and increasing drought frequency are actively reshaping the region's geography. The decline in rainfed crops and the abandonment of fallow lands near the Goranchay River highlight a growing dependency on irrigation. The preference for winter grains over spring crops is a strategic adaptation to utilize early-season moisture and avoid the peak summer heat.

Goranboy and Samukh function as the primary production engines (crops and modern livestock).

Sunflower and Perennial crops remain the most stable and efficient outputs (indicated by low coefficients of variation), whereas cotton remains a high-risk, subsidy-dependent sector due to its extreme yield volatility (36.7% CV).

While the expansion of cultivated areas is reflected positively in NDVI vegetation values, the long-term sustainability of the region depends on addressing irrigation shortages and the declining yield in viticulture and potatoes. The successful integration of intensive livestock farming suggests a model for growth, provided that the remaining 77% of pasture land is managed efficiently to balance ecological health with agricultural output.

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GƏNCƏ-DAŞKƏSƏN İQTİSADİ RAYONUNUN KƏND TƏSƏRRÜFATINA YARARLI TORPAQLARININ SƏMƏRƏLİ İSTİFADƏSİNİN GEO MƏKAN VƏ STATİSTİK MƏLUMATLAR ƏSASINDA QİYMƏTLƏNDİRİLMƏSİ.

R.İ.Quliyev

Xülasə. Tədqiqat ərazisində son 20 ildə bitkiçiliyin və heyvandarlığın inkişaf dinamikasının, eləcə də kənd təsərrüfatına yararlı torpaqların müasir strukturunun və transformasiya meyillərinin kompleks analizi aparılmışdır. Qlobal iqlim dəyişiklikləri və ərzaq təhlükəsizliyi çağırışları fonunda, aqrar təyinatlı torpaqların potensialının qiymətləndirilməsi və onlardan səmərəli istifadə yollarının müəyyənləşdirilməsi strateji əhəmiyyət kəsb edir. Tədqiqatda böyük həcmli peyk məlumatlarının emalı üçün Google Earth Engine (GEE) kimi müasir hesablama platformalarından və Coğrafi İnformasiya Sistemləri (CİS) metodlarından istifadə edilmişdir. Bu texnologiyalar ərazinin təbii-coğrafi şəraitini detallı şəkildə öyrənməyə və kənd təsərrüfatı istehsalının nəticələrini elmi cəhətdən əsaslandırmağa imkan vermişdir.Coğrafi məkanda baş verən dəyişikliklərin sosial-iqtisadi münasibətlərə təsirini nəzərə alaraq, məkansal göstəricilər ilə rəsmi statistik məlumatların qarşılıqlı analizi aparılmışdır. Bu inteqrasiya olunmuş yanaşma, kənd təsərrüfatındakı iqtisadi indikatorları kəmiyyət və keyfiyyət baxımından qiymətləndirməyə, habelə sahənin gələcək inkişaf istiqamətlərini proqnozlaşdırmağa şərait yaradır. Tədqiqatın nəticələri torpaq ehtiyatlarının idarə olunmasında innovativ metodların tətbiqinin zəruriliyini sübut edir və regionun aqrar potensialının optimallaşdırılması üçün elmi baza rolunu oynayır.

Açar sözlər. Quraqlıq, NDVI, məhsuldarlıq, CV, korrelyasiya, torpaq.