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Dynamics of Arable Land and Development of Agriculture in Azerbaijan

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Abstract. *The problems related to environmental protection at the international level in recent years and their solutions are presented, and the concept of the "green economy" is discussed in this article. Due to the rapid increase in the world's population, it is reported that, according to UN calculations, the per capita use of the world's natural resources will increase by 70% by 2050. The issue of efficient land use through the effective use of resources in Azerbaijan's agriculture was investigated in the conducted research. It was determined that after 2020, compared to other agricultural crops, the expansion of cotton cultivation areas (7.7% of the total cultivated area) has led to an increase in the ecological load. The total area of fruit and berry orchards was 88.4 thousand ha in 2003, and this indicator reached 222.4 thousand ha in 2022. In other words, it has been determined that the increase in cultivated areas is mainly due to strategic crops such as cereals and legumes. From this point of view, it has been determined that agriculture leads to environmental problems through its negative impacts on sustainable development.*

Keywords: *Azerbaijan's agriculture, "green economy," strategic crops, orchards, ecological capacity*

Introduction

Global economic development, leading to environmental degradation, has created the need to develop new paradigms for sustainable economic growth. The "green economy" is a new model of economic development that includes economic growth, social development, environmental protection, and inclusive development for all. Europe's high-tech economy is considered a leader in the transition to a green economy. Developing countries consider green transformation important but, in many cases, rely on the extraction, processing, and export of raw materials.

These factors make it difficult for these countries to adapt to modern requirements, such as reducing carbon emissions (Blick, 1984; Getmanets & Kudzin, 1979; Mamedov, 2019; Shcherbakov et al., 1983). The "green economy" is an economic system whose main goals are the development of production, environmental protection, and the preservation of the planet's ecology, as well as addressing global problems through the implementation of the "green economy" concept.

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In the conditions of climate change and the transformation of the traditional foundations of economic development, the expansion of the raw material base and opportunities for growth through its widespread application are reduced (Hummatov et al., 2025; Linkina, 1990).

Achieving complete independence in terms of food security is one of the most important goals for Azerbaijan in reaching the level of developed countries. In order to implement this strategy, the existing potential of the country should be evaluated, and the issue should be approached from a scientific-analytical perspective (Mammadov, 2017).

Methods

The conducted research was carried out in accordance with generally accepted methodologies in soil science, ecology, and agrochemistry. The research object covered the agricultural regions of Azerbaijan. The provision of mineral fertilizers for individual crops and the productivity of agricultural plants were determined using the statistical publication *Agriculture of Azerbaijan* (Statistical Publication, 2022, p. 652). The methodological tools were based on *Agrochemical Methods of Soil Research* (Sokolov, 1975).

Results

The analysis of official statistical data showed significant changes in the structure of agricultural land use in Azerbaijan during the last two decades. These changes have directly influenced both agricultural production and the ecological sustainability of the sector. The application of mineral fertilizers remained relatively high during the study period (2018–2022). The total amount of mineral fertilizers varied between 88 and 159 thousand tons, while the average application rate ranged from 47 to 82 kg of active substance per hectare (Table 1). In 2022, 121.8 thousand tons of mineral fertilizers were applied, corresponding to 65 kg ha^{-1}. Cotton cultivation received the highest fertilizer application rate (114 kg ha^{-1}), considerably exceeding cereals (78 kg ha^{-1}), vegetables (72 kg ha^{-1}), orchards (66 kg ha^{-1}), and vineyards (36 kg ha^{-1}). These findings indicate that technical crops, particularly cotton, create a higher agrochemical load on agricultural ecosystems.

The structure of cultivated land also changed considerably during the investigated period. The total cultivated area decreased from 1.738 million ha in 2018 to 1.624 million ha in 2022 (Table 2). Nevertheless, cereals and grain legumes remained the dominant crop group, occupying approximately 986 thousand ha, or about 61% of the total cultivated land, in 2022. Fodder crops occupied approximately 373 thousand ha (23%), while technical crops covered 125 thousand ha (7.7%). Potatoes, vegetables, and melons occupied about 140 thousand ha, representing 8.6% of the cultivated area.

Long-term analysis demonstrated a substantial expansion of perennial plantations. The total area of fruit and berry orchards increased from 88.4 thousand ha in 2003 to 222.4 thousand ha in 2022, representing an increase of approximately 2.5 times. During the same period, vineyard areas increased from 7.7 thousand ha to 14.8 thousand ha. Consequently, perennial plantations currently occupy approximately 237.2 thousand ha, which represents a considerable share of arable land that could potentially be used for strategic cereal production.

A remarkable increase was also observed in technical crop cultivation. Cotton cultivation expanded from 66.8 thousand ha in 2003 to 132.5 thousand ha in 2018, almost doubling within fifteen years. Tobacco cultivation increased from 2.1 to 3.4 thousand ha, while sugar beet cultivation expanded from 3.6 to 8.6 thousand ha (Table 3). Overall, the cultivated area devoted to technical crops increased by approximately 72 thousand ha during the study period.

Changes in crop structure further demonstrated a gradual shift from strategic food crops toward commercial crops. In 2003, cereals and legumes accounted for 63.7% of the total cultivated land, whereas this proportion decreased to 62.3% in 2018 (Table 4). During the same period, the share of technical crops increased from 7.3% to 9.2%. Although the numerical change appears relatively small, the expansion mainly resulted from cotton cultivation, which requires intensive fertilizer application and irrigation, thereby increasing environmental pressure on agricultural ecosystems.

The obtained results indicate that the present structure of agricultural land use does not fully correspond to the principles of sustainable agriculture and the green economy. The rapid expansion of technical crops and perennial plantations has reduced the proportion of strategically important cereal-producing areas while simultaneously increasing fertilizer consumption and ecological pressure. From the standpoint of food security and environmental sustainability, increasing the share of cereals and legumes through the gradual optimization of technical crop and perennial plantation areas would contribute to a more balanced and environmentally sustainable agricultural production system in Azerbaijan.

Discussion

The era of the "green economy" or "green revolution" led to the intensification of agriculture through the mass use of chemical fertilizers and pesticides, the mechanization of agricultural processes, and the genetic improvement of high-yielding crop varieties. It was characterized by a significant increase in the production of cereals such as maize. However, the negative consequences of this revolution have gradually become apparent, as the overall quality of ecosystems has declined due to adverse environmental impacts (Aydınalp, 2005).

Therefore, the main challenge today is to achieve sustainable agricultural development by preserving the integrity of agroecosystems and obtaining stable, high-quality food products through the application of science-intensive innovative technologies in agriculture. The "second green revolution" will depend on the ideas of a new generation of scientists who approach agriculture from a different perspective (Petersburgsky, 1989).

Digital transformation in agriculture, including the application of artificial intelligence for forecasting the dynamics of abiotic and biotic stress factors, has entered all spheres of human activity. This approach makes it possible to predict the spread of pests, assess the influence of climatic factors on their intensity, and prevent epiphytotic outbreaks.

The application of intelligent equipment capable of independently managing fertilizer and growth-stimulant requirements through satellite observation systems based on artificial intelligence technologies, as well as the application of chemicals against pests and diseases, will significantly contribute to increasing productivity and improving product quality in the future (Petersburgsky, 1989).

The use of beneficial microorganisms developed through genetic engineering, agricultural microbiomes, and biological pesticides elevates agricultural development to a new stage. This approach is economically beneficial because it reduces the costs associated with pesticides and fertilizers. For example, the artificial propagation of microorganisms created through genetic engineering can increase crop productivity, improve resistance to unfavorable climatic conditions, and enhance resistance to pests. The supply of mineral fertilizers to agricultural crops has increased during the last five years (Table 1).

Table 1
Providing mineral fertilizers of agricultural crops, 100% account in active substance

Indicators and plants	Years				
	2018	2019	2020	2021	2022
Total, thousand ton	141	159	152	88	122
Kg / ha of crops	72	82	81	47	65
Grain (without corn)	86	89	88	66	78
Cotton	84	127	131	70	114
Tobacco	141	131	137	67	15
Potatoes	81	81	87	49	46
Vegetables and melon	91	96	98	27	72
Fodder plants	35	26	29	9	11
Gardens	63	64	73	40	66
Vineyards	40	51	54	18	36
Specific weight of planting for fertilized areas	84	80	79	66	72

Source. Statistical database. www.stat.gov.az/source/agriculture/

The amount of mineral fertilizers used in agriculture is increasing every year. If the total application of mineral fertilizers, including NPK and other mineral fertilizers, amounted to 141.3 thousand tons (72 kg of active substance per hectare) in 2018, then in 2022 these indicators were 121.8 thousand tons (65 kg ha^{-1}). If we calculate the equivalent amount of manure applied to all cultivated fields, this indicator corresponds to approximately 871.5 thousand tons of manure, containing about 122 thousand tons of organic matter and mineral nutrients (according to the amount of NPK). Taking the above into account, it is considered necessary to prioritize the development of animal husbandry in all regions. The development of agriculture in this direction will have a positive effect on the gradual reduction in the use of mineral fertilizers by ensuring sustainable agricultural development. Furthermore, increasing livestock production and, consequently, the production of organic fertilizers will positively contribute to the transition toward a "green economy" in agriculture.

The indicators for 2022 (Table 2) show that the total cultivated area of the Republic of Azerbaijan was 1.624 million ha. Approximately 986.0 thousand ha (about 61% of the total cultivated area) were occupied by cereals and grain legumes, while 372.8 thousand ha (about 23% of the total cultivated area) were occupied by fodder crops.

Table 2
Agricultural crops in Azerbaijan (th. ha)

Indicators	Years				
	2018	2019	2020	2021	2022
Total cultivated area	1738	1717	1631	1645	1624
Cereals and pulses (total)	1083	1072	989	999	986
Including wheat	679	670	588	572	547
Including legumes	26	17	43	10	12
Technical plants (total)	159	130	122	122	125
Potatoes, melons, and vegetable crops (total)	150	148	144	145	140
Fodder plants (total)	346	367	376	379	373

Source. Statistical database. www.stat.gov.az/source/agriculture/

In the cultivated areas, technical crops accounted for 125.2 thousand ha, while potatoes, vegetables, and melons occupied 140.3 thousand ha, totaling 265.5 thousand ha. Thus, 16.3% of the total cultivated area was occupied by technical crops, potatoes, vegetables, and melons. Taking the above into account, we consider it appropriate to increase the area under cereals and legumes by 265.5 thousand ha through the gradual optimization of areas occupied by technical crops, vegetables, melons, and potatoes, which constitute 16.3% of the total cultivated area, in order to strengthen the sustainable development of agriculture.

On the other hand, the area of fruit and berry orchards in the country was 88.4 thousand ha in 2003, and this indicator increased to 222.4 thousand ha in 2022, according to the State Statistical Committee (Agriculture of Azerbaijan, 2022). The corresponding figures for vineyards increased from 7.7 thousand ha in 2003 to 14.8 thousand ha in 2022, while fruit and berry orchards increased from 88.4 thousand ha to 222.4 thousand ha. Thus, 237.2 thousand ha of land occupied by fruit, berry, and grape plantations (222.4 thousand ha + 14.8 thousand ha = 237.2 thousand ha) could more appropriately be used for cereals and legumes. Therefore, we note that during the last 20 years, the area of fruit orchards has increased almost threefold, while vineyard areas have approximately doubled. The gradual conversion of land occupied by fruit, berry, and vineyard plantations to cereals and legumes would have a positive effect on the sustainable development of agriculture. The area under cotton cultivation was 66.8 thousand ha, tobacco occupied 2.1 thousand ha, and sugar beet covered 3.6 thousand ha in 2003, with a total technical crop area of 72.5 thousand ha. By 2018, these indicators had increased to 132.5 thousand ha, 3.4 thousand ha, and 8.6 thousand ha for cotton, tobacco, and sugar beet, respectively, demonstrating a significant increase in the cultivated area compared with 2003 (Table 3).

Table 3
Plantation areas of agricultural crops, th. ha

Agricultural plants	2003	2013	2015	2016	2017	2018
Cotton	66.8	23.5	18.7	51.4	136.4	132.5
Tobacco	2.1	1.2	1.4	2.4	3.2	3.4
Sugar beet	3.6	5.5	4.9	7.1	13.9	8.6

Source. Statistical database. www.stat.gov.az/source/agriculture/

This increase amounted to 65.7 thousand ha for cotton, 1.3 thousand ha for tobacco, and 5.0 thousand ha for sugar beet. It was determined that the total increase in the cultivated area of technical crops reached 72.0 thousand ha in 2018. The total cultivated area under technical crops was 144.5 thousand ha in 2018. Thus, using 144.5 thousand ha of arable land currently occupied by technical crops for cereals or legumes is considered more favorable from the viewpoint of food security. According to the 2003 data, cereals and legumes accounted for 63.7% of the cropping structure, while technical crops accounted for 7.3%. However, different results were obtained in 2018. Thus, the cultivated area of strategic crops (cereals and legumes) decreased by 1,400 ha and reached 62.3% of the total cultivated area. The area under technical crops increased by 2,000 ha in 2018 compared with 2003 and reached 9.2%, which is considered unfavorable from the standpoint of food security (Table 4).

Table 4
The structure of cultivated areas, %

Agricultural plant groups	2003	2013	2015	2016	2017	2018
Cereals and legumes (total)	63.7	63.8	60.1	61.3	58.7	62.3
Technical plants	7.3	2.5	2.4	4.5	10.8	9.2
Fodder plants	15.5	23.5	27.0	24.2	21.4	19.9
Potatoes, vegetables and melon plants	13.5	10.2	10.5	10.0	9.1	8.6

Source. Statistical database. www.stat.gov.az/source/agriculture/

From this point of view, it is considered more appropriate to expand the cultivated areas of cereals and legumes as strategic agricultural crops at the expense of technical crops. In 1998, 2,032 collective farms and state farms were reformed. As a result of the reform, land shares were distributed to 869,268 families. In addition, in cities and towns where land reform has not been carried out, as well as in summer cottage areas and garden plots, land has been used to a certain extent for the production of fruit and vegetable crops as household plots.

Conclusion

The following activities are considered essential for the sustainable development of agriculture:

- Scientific and practical support for the transformation processes in agriculture and rural habitats; systematic interdisciplinary research for sustainable development; and personnel training.
- Development of methodologies for program formation in agriculture and its sectors at the state, regional, and municipal levels.
- State measures for the resocialization of research methods in the agricultural economy and the reassessment of the agricultural, recreational, cultural, and gastronomic potential of rural areas in Azerbaijan, thereby increasing the value of agricultural products.
- Research on food trade and scientific research expeditions within the framework of rural heritage study programs.

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