Green agricultural model in Azerbaijan: Challenges and trends

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Abstract

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The article reveals the advantages of developing a green economy in agriculture, in the context of global climate change, population growth and pressure on natural resources. It is noted that the trend of economic growth based on the total exploitation of natural resources has led to irreversible consequences. Agricultural activity leads to the depletion of natural resources, in particular land degradation, water shortages, changes in agricultural landscapes, loss of biodiversity etc. Azerbaijan is a country that also suffers from the effects of climate change under anthropogenic influence. The paper analyzes the main problems of modern intensive agriculture. Only the transition to green agriculture, the use of green technologies and management methods can help preserve natural ecosystems, and ensure social well-being. Important features of a "green" economic model are the efficient use of natural resources, reduction of pollution, protection and improvement of ecosystems and biodiversity, low carbon emissions, as well as growth of income and employment.

Keywords: climate change; natural resources; agriculture; ecosystems; green economy

Introduction

Scientific and technological progress has led to dynamic economic growth throughout the world. However, the development of industry and agriculture, as well as population growth, cause many environmental problems. As a result of ill-considered measures, environmental pollution is growing, forest areas are shrinking, water shortages and soil degradation are occurring. Taking these factors into account, many scientists call the current economic model "brown" (Lyaskovskaya and Grigorieva, 2018; Baimuratov and Zikirayev, 2020).

In 1934, Simon Kuznets, the author of the concept of GDP, speaking before the US Congress, pointed out that the well-being of a nation cannot be adequately measured by national income alone (FRASER, 2024). GDP measures relative well-being without taking into account social costs and environmental impacts. However, neoclassical theory adopted the method of measuring economic well-being through GDP. It was not until decades later, in the second half of the 20th century, that the importance of environmental impact was recognized. Economists began to talk about the environment as the main asset that creates GDP, but they viewed it as a constant variable. Later, the term "natural capital" appeared - essentially, this is undepreciated capital. It was not until the 1970s, that the first attempts were made to estimate the nature capital. The transition to a "green" economy recognizes the value of natural capital, and has made it relevant to increase investment in natural capital for economic grows (Sulich and Zema, 2018; Rhode, 2017).

This raises a question. What is a green economy? It can be defined as an economy that aims to reduce environmental risks and deficiencies, and to achieve sustainable development without polluting the environment. A green economy serves to enhance social equality by improving human well-being, and reducing environmental risks. This is a system of economic activity involving the production, distribution and consumption of goods and services that achieves long-term welfare gains and sustainable economic develop-

ment, without exposing future generations to serious environmental risks and deficiencies.

According to the United Nations Environment Program (UNEP), a green economy "improves human well-being and social equity, while significantly reducing environmental risks and degradation." As the UN report "The Future We Want" emphasizes, the concept of a green economy does not replace the concept of sustainable development, but it is now recognized that the key to achieving sustainability depends on the "right" management of the economy (UNEP, 2024).

Therefore, the green economy is also a model of economic development, based on sustainable development and knowledge of ecological economics. The green economy aims to create a system, in which economic growth is combined with care for nature, and agriculture plays a key role in this strategy. The green economy and agriculture are closely linked through the pursuit of sustainable development and minimizing negative impacts on the environment. Let's look at how agriculture affects the environment, and identify the benefits of a green model of agricultural development.

Materials and Methods

The crises of recent years show the instability of the current model of economic development in Azerbaijan. An important drawback of this model is that it does not allow to fully solve social and environmental problems. In this regard, a number of works have been carried out in the direction of ensuring the transition to a green economy in our republic. Thus, the fifth priority of the program «Azerbaijan 2030: National Priorities of Socioeconomic Development» is called «Country of Clean Ecology and Green Development». The document defines specific tasks for the use of environmentally friendly technologies, stimulating waste recycling, and restoring contaminated areas, expanding the use of environmentally friendly «green» technologies. In order to minimize the burden on the environment, water shortages, inefficient use of natural resources, high energy consumption, unsustainable agricultural practices and food security issues, as well as proper waste management.

One of the reasons for the disruption of natural ecosystems and the deterioration of the quality of water resources is the increasing intensification of agricultural production. The use of scientifically based farming systems and integrated land reclamation allows reducing the load on the soil, and ensuring balanced biological productivity of agricultural landscapes (Roiss and Medvedeva, 2022).

In this research, we will try to determine the advantages of the green model of agricultural development in Azerbaijan. To do this, we will conduct a comparative analysis of the main factors that have a negative impact on the environment, and on this basis will determine the prospects for green agricultural development.

Results and Discussions

Greening the agricultural sector aims to combat poverty and meet the nutritional needs of a growing global population, while minimising environmental degradation associated with certain agricultural practices. The UNEP Green Economy Report highlights that "greening" involves making greater use of agricultural practices and technologies (UNEP, 2024). The key objectives here are to maintain and improve productivity and profitability, while ensuring the sustainability of food products and ecosystem services; educing negative externalities (e.g. emissions), and increasing positive externalities (e.g. carbon sequestration or biodiversity) over time, and restoring natural capital through more efficient use of resources. All of this, in turn, is consistent with the Sustainable Development Goals.

Livestock and plant growing create their products using natural elements such as soil, water, air etc. Therefore, agriculture should be considered as a huge consumer of natural resources, on the one hand, and a creator of the natural elements, on the other. It should be noted that at the present stage of economic and social development, agriculture is also a huge polluter of the environment. With the development of the application of scientific and technological progress in agricultural production, agriculture began to take more from nature, and in return threw out a large amount of waste generated, as a result of its activities. Therefore, environmental problems in agricultural production are very relevant.

The environmental impacts of agriculture include the following:

Firstly, soil degradation, that means excessive use of chemicals and improper irrigation systems, which leads to decreased fertility, increased erosion and desertification (Mustafayeva et al., 2024). The world's agricultural land area is about five billion hectares, or 38 percent of the total land area. About a third of this is arable land, and two thirds are grasslands and pastures. Between 1961 and 2016, as the world's population continued to grow, the demand for food more than doubled. At the same time, pressure on land, a limited resource, has increased. Between 1961 and 2016, the world's per capita crop area steadily decreased, from 0.45 hectares per person in 1961 to 0.21 hectares in 2016. Globally, 12 million hectares of agricultural land are lost every year due to land degradation (FAO, 2021).

The process of erosion is widespread in Azerbaijan. As a result of the erosion process, the soil formed over many

years is washed away and destroyed, its fertility decreases, valuable land areas gradually become unusable, the amount of humus in the soil decreases, its composition changes, microbiological processes in the soil are weakened, and the microflora changes. 36.4% of the republic's lands have been subject to erosion of varying degrees. Of these, 14.1% are slightly eroded, 10.7% are moderately eroded, and 11.6% are severely eroded. Depending on the natural conditions of individual regions of Azerbaijan and anthropogenic impact, the intensity and form of erosion processes developed to varying degrees. Thus, 30.8% of the lands in the Mil and Karabakh plains, 48.2% in the Guba-Khachmaz zone, 40.3% on the Absheron Peninsula, 27.7% on the Shirvan plain, 55% in the Sheki-Zagatala zone, and 7% have been subject to erosion (MENRAR, 2022). This includes all soils subject to water, wind, and irrigation erosion. Since soil erosion is a gradually developing process, it is necessary to regularly take measures to combat it.

Secondly, excessive or overuse of water and pollution of water bodies. Over the past 50 years, per capita drinking water supply has decreased by 60 percent. 70 percent of the total water is consumed in agriculture, 20 percent in industry and 10 percent in households. According to forecasts, by 2030, 47 percent of the world's population will face water shortages (UN WWDR, 2023).

Water shortage is one of the main problems in Azerbaijan: limited water resources, population growth, climate change and inefficient use of water aggravate the situation. Thus, as a result of inefficient use, losses in irrigation systems reach 70%. Untreated wastewater discharges cause pollution of rivers and reservoirs. Water shortage negatively affects agriculture, reduces productivity, and pollution of water sources leads to deterioration of the environment.

Agriculture in Azerbaijan is mostly irrigated. The area of land under general crops and perennial crops is 2.2 million hectares, of which 1.5 million hectares are irrigated. At the same time industrial livestock farming requires the use of large volumes of water from rivers, lakes and other bodies of water, which has a significant impact on the condition of these bodies of water and the environment as a whole. Industrial livestock farming is a major consumer of water, as 5 m^3 of water are needed to produce 1 m^3 of milk, and 20,000 m^3 of water to produce 1 ton of meat (Ibragimov et al., 2021). Water is also used to maintain sanitary and hygienic conditions on farms. Along with the increase in water consumption for livestock needs, the discharge of manure-containing wastewater into water bodies is also increasing, which leads to their pollution and loss of useful properties.

Azerbaijan is among the countries that have already faced the consequences of global climate change, and will suffer from a shortage of water resources (in recent years, the area of irrigated land has increased by 13%). It is necessary to abandon traditional irrigation methods, which lead to large losses of water resources, and also lead to salinization of agricultural lands. Given this fact, it is important to take into account the use of water in agriculture, including the use of modern irrigation methods, such as sprinkling and drip irrigation.

Modern irrigation systems have been installed on 10 percent of irrigated agricultural land in Azerbaijan. Unlike the traditional flood irrigation, modern irrigation systems (pivot, drip etc.) allow for a multiple increase in crop yields. Farmers initially pay only 20 percent of the total cost for the construction of modern irrigation systems, 40 percent is covered by the state, and they receive an interest-free loan for the remaining amount for 5 years.

Thirdly, the increase in agricultural land due to the destruction of forest reserves and the loss of natural landscapes. The first results of the FAO Global Remote Sensing Survey of Forests show that between 2000 and 2018, agricultural activities remain the main cause of deforestation in all regions of the world except Europe, where urban and infrastructure development are more significant factors. According to the data obtained, agricultural expansion is responsible for almost 90 percent of deforestation worldwide: 52.3 percent of forest loss is due to conversion to cropland, 37.5 percent of forest loss is due to expansion of pasture land, 5.6 percent is due to urban and infrastructure development, and 4.6 percent is due to other causes (FAO Remote Sensing Survey, 2021).

Agriculture requires large areas, so this territory has the most significant impact on the environment. In particular, the transfer of large areas to crop rotation leads to a change in landscapes. For example, on the Great Chinese Plain, subtropical forests have disappeared due to agricultural culture (Liu et al., 2019), the same problem is observed in the Amazon forests (Numata and Cochrane, 2012). There are thousands of such examples in the world. Agricultural landscapes are vulnerable to water and wind erosion. There are also examples in world experience when improper land reclamation leads to desertification, soil salinization or loss of crop areas. Agriculture is a real disaster for wild animals. By cultivating fields, people displace them from their natural habitat. This affects the population, and then the ecosystem.

In the 19th centuries, 35% of the current territory of Azerbaijan was covered by forests. Currently, the total area of Azerbaijani forests is 1,021 thousand hectares. This is 11.8 percent of the territory of Azerbaijan. 49 percent of our country's forest resources belong to the Greater Caucasus region, 34 percent to the Lesser Caucasus region, 15 percent to the Talysh zone and 2 percent to the Aran zone (Fig. 1.). There are 0.12 hectares of forest land per person.
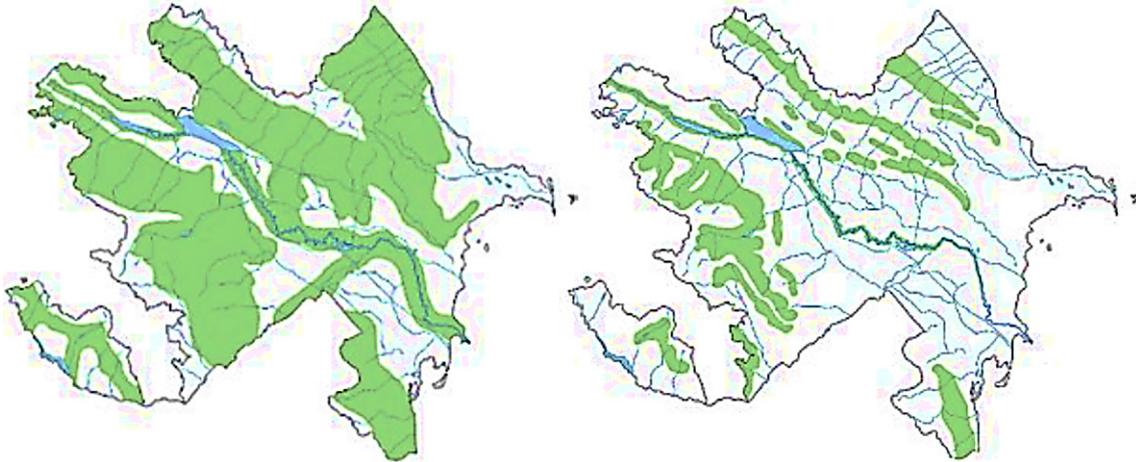
Fig. 1. Decreasing of forest area over the centuries
Source: Elaboration based on statistical data

According to data, over the last century the forest area in Azerbaijan has significantly decreased, and the main reason for deforestation is the involvement of fertile forest lands in crop rotation. The most effective means of preventing climate change and the greenhouse effect is to work on preserving forests. Therefore, many countries are trying to increase the amount of green spaces, forests in order to absorb carbon dioxide, which is formed as a result of human activity. Azerbaijan is located in a semi-desert zone, and we have a very large amount of agricultural land that requires irrigation. And in order for the land not to dry out, it is necessary to plant trees that will not allow the land to deplete so quickly. In addition, trees also help to lower the temperature in general. All this leads to the fact that for Azerbaijan, the solution to the problem is the preservation of green spaces. In order to increase and protect the country's forests from water and wind erosion, from droughts, it is necessary to increase the area of forests in the next 20 years.

Thoughtful forest management and reforestation of degraded lands reduces erosion, increases the stability of slopes, and therefore maintains basic environmental services, such as regulated water flows and protection from natural disasters.

Fourth, agricultural production increases greenhouse gas emissions. Livestock production is a significant source of greenhouse gases, with exact percentages depending on the specific studies and calculation methods. According to the FAO, livestock production, as a whole, is responsible for approximately 14.5% of all anthropogenic (human-caused) greenhouse gas emissions. The main gases include methane (CH_4), which accounts for about 44% of emissions, nitrous oxide (N_2O), which accounts for about 29%, and carbon dioxide (CO_2), which accounts for about 27%. These percentages can vary by region, type of production, and calculation methods (Gerber et.al., 2013). The accumulation of large quantities of manure from livestock farms and complexes, and waste from poultry farms creates major problems.

The development of livestock farming on an industrial basis is accompanied by the creation of a powerful forage base and the expansion of distant pastures. At the same time, a large concentration of livestock occurs in a limited area, which causes soil compaction, resulting in a decrease in air exchange.

Another problem is air pollution from agricultural machinery emissions. Today, industrial agriculture has reached such a scale, that it is impossible to work without special machines. And this affects the environment. Thus, according to foreign studies, gas emissions from automobile and tractor equipment are in first place in terms of their quantitative composition and the degree of negative impact on flora and fauna. For example, when burning 1 kg of diesel fuel, about 80-100 g of toxic components are released, of which the most harmful - carbon monoxide (CO) takes up 20-30 g. It should be added that diesel devices emit about 20 times more nitrogen oxides than gasoline ones. Emissions pollute the air and thus negatively affect human health and the environment.

Fifthly, use of chemicals. Nowadays, the productivity of modern agriculture largely depends on the use of fertilizers and pesticides. This need leads to pollution of the soil and surface water. It should be taken into account that fertilizers contain both essential nutrients and ballast substances. For

example, chlorine also gets into the soil along with potassium fertilizers. In small doses, it is not dangerous. However, farmers who want to get more harvest sometimes exceed the norms, and then the level of pollution reaches toxic levels. In addition, up to 30-50% of all applied mineral fertilizers are lost in agricultural practice. Thus, about 40% of the total nitrogen is absorbed in the field, 18-33% remains in the soil, and 10-30% evaporates. In addition, it is necessary to remember that every year the soil is processed and collected with chemicals. These substances can enter the body of animals and humans through the food chain. In general, this type of pollution leads to a decrease in soil fertility and productivity. This, in turn, reduces the productivity and quality of agricultural products.

As can be seen from the figure, in Azerbaijan, on average, there are 183 kg per unit area. The amount of mineral fertilizers applied per unit area varies considerably depending on the soil type, climate conditions and the type of crops grown (Fig. 2).
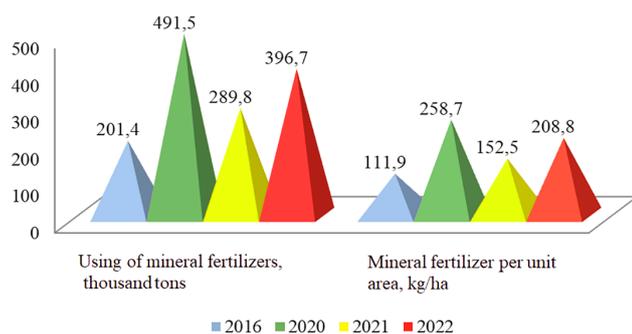

Fig 2. Using of mineral fertilizers
Source: Authors' own elaboration on the basis of https://www.stat. gov.az (AzSTAT, 2022)

As we can see, preference is given to the use of nitrogen and phosphorus fertilizers, which varies depending on the composition of the soil and the type of plant (Fig. 3). In Azerbaijan, grain crops are predominant in the structure of sown areas (Mustafayeva et al., 2024).

Given all these negative consequences for the environment, the movement of environmentally friendly products began in the 60s of the XX century. According to reports, there were 3.7 million organic food producers worldwide in 2021. The organic area is 76.4 million hectares, which is approximately 1.6% of the total cultivated area. The global organic market has shown rapid growth in recent years, and the global organic market is valued at approximately €124 billion. For comparison, this figure was $25 billion in 2002. The largest organic market in the world was €48.6 billion in the United States, €15.9 billion in Germany, and €12.7 billion in France.
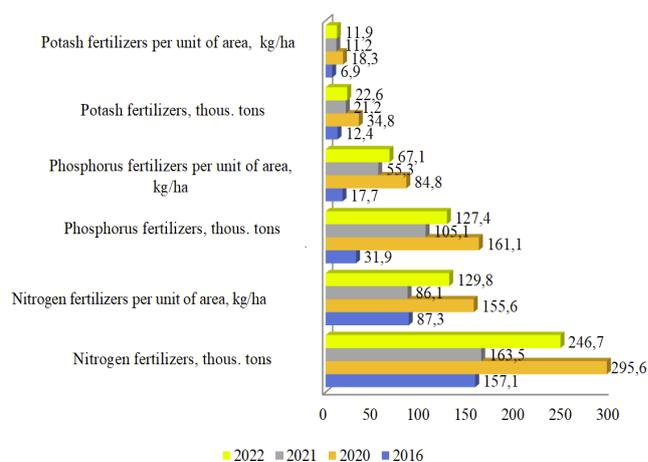

Fig 3. Using of the different types of mineral fertilizers in Azerbaijan
Source: Authors' own elaboration on the basis of https://www.stat. gov.az (AzSTAT, 2022)

According to data, 40 779 hectares were organically certified in Azerbaijan in 2020. Of these, 38 080 hectares were agricultural land, 2 126 hectares were wild fruits, nuts, berries and aromatic medicinal plants, and 573 hectares were aquaculture (Gengenbach, 2022). In 2020, there were 466 producers, the organic market amounted to 3 million euros. Azerbaijan is among the top ten Asian countries, with the highest share of organic agriculture in total agricultural area.

Considering that organic farming rejects modern agricultural technologies, prohibits the use of chemicals and focuses on natural farming methods, which often mean low productivity but high quality products and sustainable use of resources, the development of green agriculture is the best solution.

Green agriculture seeks to find a balance between productivity and sustainability. It can use hybrid methods to reduce the negative impact on the environment, but does not necessarily abandon high-productivity methods such as modern fertilizers. Green farming can include innovative solutions such as precision farming, sustainable agricultural technologies and more efficient production methods, to simultaneously maintain high productivity and reduce the ecological footprint. Green agriculture finds a balance between productivity and sustainability.

Conclusion

The main benefits of a green economy in agriculture can be characterized as follows: conservation of natural resources, increased soil fertility, efficient use of water, reduced

greenhouse gas emissions, economic sustainability, social benefits, improved product quality, support for local ecosystems and biodiversity.

Taking into account the above, the following measures should be taken to develop green agricultural model in Azerbaijan: develop sectoral programs for the transition to a green economy; create agricultural enterprises based on green technologies; minimize investments in production that has a negative impact on the environment; use of a lending mechanism on preferential terms for the creation of «green» enterprises; provide green subsidies to agricultural producers; ensure the transition to circular production; considering the fact that the majority (70%) of agricultural producers in Azerbaijan are small farms, the transition to a green development model will require significant educational work in this direction; create a control mechanism (environmental audit).

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