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Armenia, Azerbaijan, Belarus, Georgia, Republic of Moldova, Ukraine

Analysis of problems in the agricultural sector in Azerbaijan related to climate change and preparation of proposals

BAKU 2022

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Abbreviations

GDP	Gross Domestic Product
ND-GAIN Index	GaThe Notre Dame-Global Adaptation Index
WBG	World Bank Group
ADB	Asian Development Bank
COP	Conference of the Parties
OJSC	Open joint-stock company
SSCA	State Statistics Committee of Azerbaijan
AWE	Amelioration and Water Economy
FAO	Food and Agriculture Organization
GHG	Greenhouse Gases
INDC	Intended Nationally Determined Contributions
TNC	The Nature Conservancy
UNEP	United Nations Environment Programme
SDG	Sustainable Development Goals
UNDP	United Nations Development Programme
UN	United Nations
CRA	Climate Resilient Agriculture
WRI	World Resources Institute
MENR	Ministry of Energy and Natural Resources
MC	Meat Consumption
EF	Emission Factor
GDP PC	Gross Domestic Product Per Capita
TNL	Total Number of Livestock
EFR	Environmental Flow Requirements
WSI	Water Stress Index
TWU	Total Water Use
WS	Water Supply

Scope of the task, responsibilities and description

In the scope of the project the UNDP Country Office in Azerbaijan contracted the services of the Environmental Research Centre to assist the project team with developing guidelines on mainstreaming climate change concept into the agriculture policy based on the report developed by the project in 2020 on integration of climate into the main sectors of the country, including the activities suggested on the reduction of the GHG emissions in line with strategic documents/roadmaps of the country.

Scope of the professional services includes:

- Analysis of the situation on climate change in the agricultural sector in the country
- Preparation of proposals on adaptation and mitigation plans of the agricultural sector
- Identification of gaps based on the current state of water use
- Development of new management technics and use schemes for the integration of climate change into water use
- Development of climate scenarios taking into account possible future changes (with maps and other graphical data)
- Development of proposals on rules for climate change in the agricultural sector

Introduction

Agriculture is one of the most important sectors of the Azerbaijanian economy. Approximately 7% of the GDP of Azerbaijan is contributed by agriculture sector. 36.3 % of its population engaged in the agriculture sector by 2020 according to the data of Statistics Committee of Azerbaijan. When the subject is agriculture and climate change it must be noted that Azerbaijan's water resources are 32 billion cubic meters, of which 70% is formed due to water coming from neighboring countries (mainly the Kura and Aras rivers), and 30% is formed within the country. Kura, Aras, and the inland rivers of Azerbaijan derive their water from rainfall in the mountains, melting snow and glaciers, and groundwater. The water of the Kura reaches its maximum level in April and falls to its minimum level in September. The water level in the Aras river reaches a maximum in May and a minimum in August.

According to a report presented by the International Institute of World Resources, Azerbaijan is among the countries facing the threat of drought, ranking 18th out of 33 countries. In addition, the deterioration of agricultural lands has accelerated due to inefficient use of irrigation water, inadequate irrigation and collector-drainage networks, and other factors.

Lack of irrigation water poses very serious problems for agricultural production. The volume of irrigated lands in the country is 1.4 million hectares. In recent years, the governments of Azerbaijan, Georgia, and Armenia, which use the water of the Kura and Aras rivers, are expanding irrigated arable land to produce more agricultural products. Such that Georgia's demand for water has increased by 2 billion cubic meters, Azerbaijan’s by 1.2 billion cubic meters, and Armenia’s by 1 billion cubic meters. This created an additional 4.2 billion cubic meters of water demand in the region.

As a result of the expected climate change in 2021-2050, surface water reserves are expected to decrease by 23% to 22.5 km3. Azerbaijan is the poorest country in the South Caucasus in terms of water resources. Considering that 70% of the country's water resources are formed in other neighboring countries, this situation will become even more severe. Because climate change will inevitably lead to water shortages in neighboring countries and increase the demand and pressure on available resources.

This report was designed to identify adaptation and mitigation opportunities, needed changes in the institutional and regulatory framework, monitoring and coordination mechanism on agriculture sector of the Azerbaijan Republic.

Climate risks involved with Agricultural sector

According to a recent assessment by the Intergovernmental Panel on Climate Change, the average global temperature has risen by 0.8 degrees over the past 100 years. There is a 90% chance of at least one year between 2021-2025 becoming the warmest on record, which would displace 2016 from the top ranking, according to the Global Annual to Decadal Climate Update. It is estimated that under current national commitments, average temperature increases will range from 2.9 °C to 3.4 °C by 2100. To keep us below 1.5 °C, the carbon emissions need to be cut by 45% by 2030 and reach *net zero* by 2050. The global average annual temperature is expected to increase by 40 °C by 20805.

Observations made in Azerbaijan over the past 100 years suggest that there are long-term climate changes in Azerbaijan, as in the rest of the world. Over the past 100 years, the average annual temperature in Azerbaijan has increased to 0.4-1.3° C. The temperature rise is unevenly distributed depending on the regions. In the last 10 years, the number and intensity of floods in small mountain rivers in Azerbaijan have increased.

Azerbaijan is located in a semiarid area, which is recognized as vulnerable to climate changes. Azerbaijan ranked 73rd out of 181 countries in the 2020 ND-GAIN Index.1. Due to its location in the southern hemisphere, the territory of Azerbaijan receives a lot of sunlight and heat. In higher elevations, winters are long, cold, and snowy, and summers are cool. On the plains, winters are cool and rainy, and sometimes snowy. Summers are hot and dry. The average winter temperature in Azerbaijan is 4° C, the average summer temperature is 26° C. The sunshine duration is 2200-2400 hours per year in the Kura-Aras plain, which occupies about 40% of the country's territory.

Much of the area is characterized by high thermal conditions, low rainfall, and in some places very low. Almost 110-350 mm of precipitation falls on the entire Kur-Aras lowland, the Absheron peninsula and the Arazboyu plain during the year. As a rule, the amount of precipitation in the mountainous area increases depending on the altitude. Accordingly, the role of precipitation in humidity is increasing due to the decrease in air temperature. At first glance, it seems that the total amount of precipitation in many areas is enough to meet the plant's need for moisture. However, the annual rainfall regime is such that at a time when the plant is growing intensively and transpiration is increasing, it is not sufficiently supplied with moisture.

Between 1991 and 2000, the temperature anomaly in the Kur-Araz plain was about +0.49 °C, in the Sheki-Zagatala region +0.48 °C, in the Ganja-Gazakh region +0.74 °C, in the South region +0.43 °C and in Nakhchivan +0.47 °C. Annual temperature and precipitation anomalies during 1991-2000 were analyzed using the data of a number of stations of the National Hydrometeorology Department of the Ministry of Ecology and Natural Resources. The analyzed temperature data showed that the average temperature in the country has increased by 0.41 ° C during 10 years and the largest increase was observed in 1998. This increase is higher than the increase in 1961-1990 (the increase was 0.34 ° C for 30 years), and the growth rate tripled during 1991-2000.

The future forecasts about temperature rise in Azerbaijan as a result of global warming are not promising too, as it is expected maximum and minimum temperatures are projected to rise faster than the global average according to "Climate risk country profile Report of 2021" (published by WBG and ADB). Temperatures in Azerbaijan are projected to rise at a faster rate than the global average. The strongest warming is expected to occur during summer months, with average temperatures between July and September projected to rise by almost 6°C by the 2090s. According to forecasts compiled by local climatologists through various programs, the average annual temperature increase in our country in 2021-2050 will be 1.5 ° C-1.6 ° C. As a result, the temperature rise in the first half of this century could be about 0.3 °C every ten years. Calculations also predict a 10-20% increase in precipitation by 2050 compared to 1961-1990 as a result of rising humidity.

Most of the territory of Azerbaijan has rather dry climate, and therefore, irrigation is very important in the Kura-Aras plain. Other areas that largely depend on irrigation are Absheron, Nakhichevan, Shaki-Zaqatala and Ganja-Gazakh. All these districts produce important agricultural goods, like wheat, grape, cotton, fruits, and vegetables. Irrigated crops are accountable for 85 % of total agricultural output, which will also be at risk from projected water shortages, and higher temperatures necessitating increased irrigation and better land and water productivity in order to maintain yields.

Water scarcity is a traditional problem in arid regions such as Azerbaijan and is a controversial issue among water users. Small farmers, who are relatively far from the water source, suffer the most from water shortages. Thus, farmers who are close to the water source often receive more water, which does not allow other farmers to irrigate on time.

As a result of reduced rainfall due to climate change, an acute shortage of moisture can be observed during planting and grazing. According to official statistics, more than 90 % of crop production in Azerbaijan is produced on irrigated lands. In this regard, the reduction of water resources due to climate change may put serious pressure on agriculture.

The negative consequences of climate changes in agricultural production may include:

- reduced crop quantity and quality due to the reduced growth period following high levels of temperature rise
- increased soil erosion due the increased rainfall
- reduced land fertility due to the accelerated decomposition of organic substances
- transformation of fertile lands into deserts as a result of increasing drought
- increasing need for irrigation due to temperature fluctuations
- the emergence of food safety risk as a result of the reduced productivity
- temperature increase by global warming gives rise to new types of pests

- natural disasters (extreme weather events such as floods, storms, heat waves) caused by climate change damage agricultural production and livestock

Agricultural policy and strategy of Azerbaijan

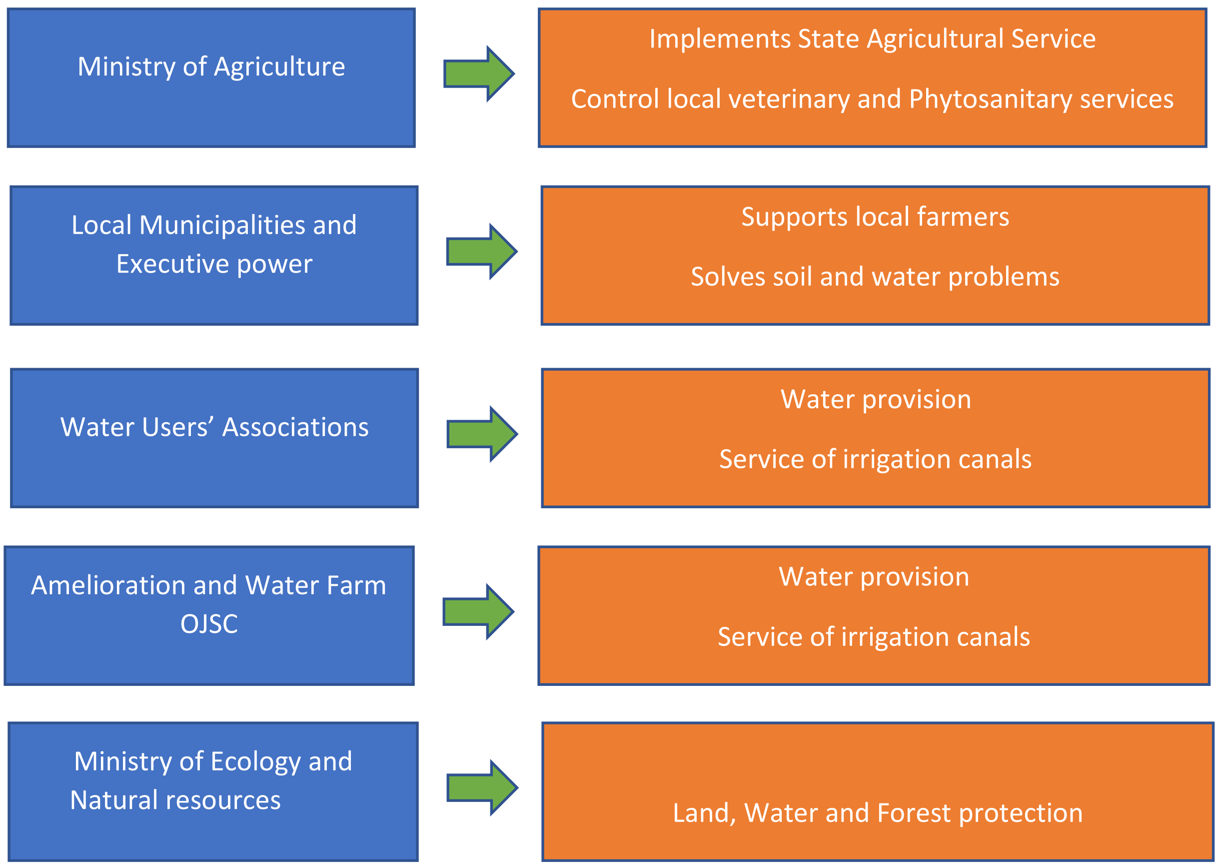
Agricultural policy of Azerbaijan is represented as a set of laws and programs related to improvement of agricultural markets and economic situation in rural areas of the country. They help to improve the activities involved in cropping and animal husbandry and actions related to marketing of agricultural products. The policy process continuously involves a broad range of stakeholders who exert influence in different forms to change the policy environment in their favorable. The government endeavors to lead policy processes by inducing changes in the agricultural sector such that both equity and efficiency are enhanced through various policy instruments.

Current Agriculture related institutional situation

The institutional situation in Azerbaijan is characterized by independently operating ministries and entities that form a group of water and land related stakeholders with limited coordination, mostly on an as-needed basis only. These include:

- Ministry of Agriculture
- Ministry of Ecology and Natural Resources
- Ministry of Emergency Situations with its State Agency for Water Resources Management
- Amelioration and Water Economy OJSC
- Azersu OJSC
- Municipalities
- Water Users Associations
- Private Landowners
- Small farmers

Figure 1 Stakeholders in Agricultural Sector



Current State Programs related to Agriculture

Current State Programs on development of Agriculture mainly concern increase of production of agricultural production. The purpose of the State Programs is to stimulate the development of agricultural production in order to meet demand in the country, increase exports of products and increase employment and livelihoods of the rural population. However, all the state programs, mostly related to the increase of agricultural fruits may also to contribute to the carbon sequestration. For example, The State Program on Citrus Fruit Development, along with the development of citrus fruit, the process of carbon sequestration may also accelerate, which is not specifically addressed in the program. The same can be said about most of other state programs as well.

Below is a list of other government programs that may be important in terms of carbon accumulation:

1. The State Program on socio-economic development of regions of the Republic of Azerbaijan for 2019-2023;
2. The State Program for Development of Tea-growing in the Republic of Azerbaijan for 2018-2027;
3. The State Program on Citrus Fruit Development in the Republic of Azerbaijan for 2018-2025;
4. The State Program for Development of Rice Growing in 2018-2025;
5. The State program for the Development of Azerbaijan Silkworm Breeding and Sericulture in the Republic of Azerbaijan for 2018-2025;
6. The state program on development of wine industry in the Republic of Azerbaijan for 2018-2025
7. The State Program on the development of cotton growing in the Republic of Azerbaijan for 2017-2022;
8. The State Program on Development of Agricultural Cooperation in the Republic of Azerbaijan for 2017-2022;
9. State Program for the Development of Tobacco production in the Republic of Azerbaijan for 2017-2021;
10. The Strategic Road Map for the Production and Processing of Agricultural Products in the Republic of Azerbaijan 2016-2020;
11. The State program for the development of the cadastral real estate system in the Republic of Azerbaijan, increasing the efficiency and use of land in 2016-2020;

12. The state program on development of industry in the Republic of Azerbaijan for 2015-2020;
13. The State Program on the development of viticulture in the Republic of Azerbaijan in 2012-2020;
14. The State Program on reliable food supply of population in the Azerbaijan Republic (2008-2015);
15. The development concept "Azerbaijan 2020: a look into the future".
16. State Program for the Development of Rice production in the Republic of Azerbaijan for 2018-2025 "

Gaps and needs in the current legal ground, agricultural policy and strategy

Few of the documents made by the government and reviewed here contains any specific mention of the important and emerging relationship of agriculture and climate change. Except the Strategic Roadmap other documents have no climate change, mitigation or adaptation content. Although some state programs can be looked as the "potential mitigation activity", they have a purely development goal.

The Strategic Roadmap for Production and Processing of Agricultural Products in the Republic of Azerbaijan, approved by the Decree of the President of the Republic of Azerbaijan dated December 6, 2016, No 1138, 7.1.1. The strategic targets of the Roadmap involve strengthening the sustainability of food safety, increasing production capacity of agricultural products, and developing the market of agricultural products.

According to the action 7.1.1, Impacts of climate change on agriculture will be assessed by regions of the country, sensitivity levels will be determined, and adequate adaptation and mitigation plans will be developed to minimize expected losses. The regions most affected by climate change in the country will be identified. The amount of damage that can be caused by climate change will be calculated and the amount of investment needed to eliminate the damage will be determined.

The Action 7.2.2 of the roadmap targets reduction of carbon dioxide emissions in the agricultural sector and promotion of the use of renewable energy. According to this target, livestock development activities in the country will be aligned with greenhouse gas emissions reduction measures. The Action 7.2.3 targets planting of protective forest stripes by 2015 along agricultural fields.

Assessment of the transition to a "green economy" in the agrarian sector and the use of alternative energy sources in the heating of greenhouses should be considered as one of the most important climate-related measures in the country. The measure envisages value chain development in the agrarian sector, reduction of losses and efficient use of waste. For example, the creation of biogas landfills in large livestock complexes, such as the collection of methane gas from animal waste and the use of alternative energy, as well as optimizing the cost of application of methane-derived fertilizer as a valuable organic fertilizer.

An analysis of the “Pasture Management Improvement” direction of Action 7.3.4 of this roadmap shows that the implementation of this measure in itself controls a large mitigation process. Given that more than 4,779,500 hectares of agricultural land (according to the 2019 land balance) is over 2,377,000 hectares of grassland and grazing, the prevention of natural land degradation in this volume would have a significant effect on the gas.

Although an extensive action plan has been implemented in agriculture so far, no steps have been taken to make climate change the mainstream of agriculture. In order to take these steps, work is required in the following areas:

- Increase existing opportunities to deepen adaptation activities and organize their effective use
- Development of various mitigation strategies in agriculture, implementing activities related to carbon sink, manure management, and methane removal:
- Implementation of state programs for CC Mitigation
- Improving knowledge and improving access to it in the context of increasing this knowledge
- Update of legislative documents or development of new legislative acts, rules and regulations, administrative codes
- The following is a brief overview of the measures that need to be taken in Azerbaijan. The measures outlined in this way should be identified with each poverty reduction, knowledge and skills increase.

Agricultural Emission sources

Agriculture is one of the substantial contributors to global climate change. In 2014, the amount of greenhouse gases generated by agricultural activities accounted for 24% of the total greenhouse gases emitted into the atmosphere worldwide. The management of agricultural soils, cultivation practices, rice production, biomass burning and livestock are among the most relevant sources of GHG emissions in agricultural-related activities. Main GHG emissions that generated by the agriculture sector are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). CO_2 may be emitted as a result of direct human activities such as forestry and other land use, such as deforestation, land clearing for agriculture, and land degradation. Methane (CH_2) emissions result from deposition of livestock manure and certain agro-industrial wastewater treatment systems, and it is the second most important manmade greenhouse gas (GHG) after carbon dioxide (CO_2).

In 2018, global emissions due to agriculture have been 9.3 billion tonnes of CO_2 equivalent (CO_2 eq) according to FAO report. The report also notes that methane and nitrous oxide emissions from crop and livestock activities contributed 5.3 billion tonnes CO_2 eq in 2018, a 14 % growth since 2000. Considering the role of agriculture in deforestation, the sector accounts for a fifth of greenhouse gas emissions among worldwide. This is a very large number that can be compared to the reach sector. In addition, this ratio may be even higher in developing countries as Azerbaijan.

Out of 8267 kha of land in Azerbaijan, 4773 kha are agricultural. Inefficient organization of production activities in agriculture has a serious negative impact on land, water resources, and climate. For example, according to official statistics, in 2015, the emission of GHG in Azerbaijan was 3.1 million tons of CO_2e for non-energy industrial activities, while in agriculture it was 7.2 million tons of CO_2 e. The agricultural sector contributes to about 15% of total GHG emissions of Azerbaijan. You can see detailed info of dynamic changes of agricultural GHG emissions in Azerbaijan charts below (Chart 1,2).

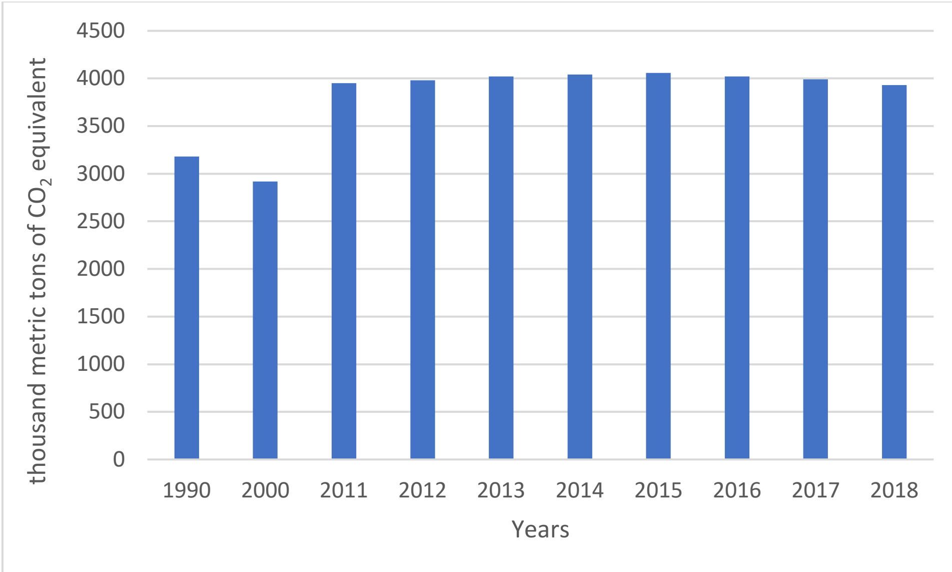


Chart 1. Agricultural methane (CH_4) emissions of Azerbaijan

Methane emissions from agricultural activities in Azerbaijan increased by 750,000 kMt CO2e from 1990 to 2018 from 3,180 to 3,930 kMt CO2e. This increase can be explained by the extensive development of livestock - an increase in the number of livestock, the expansion of pastures. The chart showing the annual growth rate for the mentioned indicators is shown in the following sections.

The primary sources of N_2O emissions are the fertilizer use and growth of nitrogen-fixing plants. According to the latest data published in 2018 by the World Bank, the amount of agricultural emissions of N2O (3480 kMt CO2e) is less than the amount of CH4 (3930 kMt CO2e), but compared to 1990, the increase is more than CH4 (750 kMt CO2e) which is 900 kMt CO2e (Chart 1). İt's worth to mention that according to the information published by the organization in the same year, the amount of N2O emissions from all sectors in Azerbaijan was 4,160 kMt CO2e.

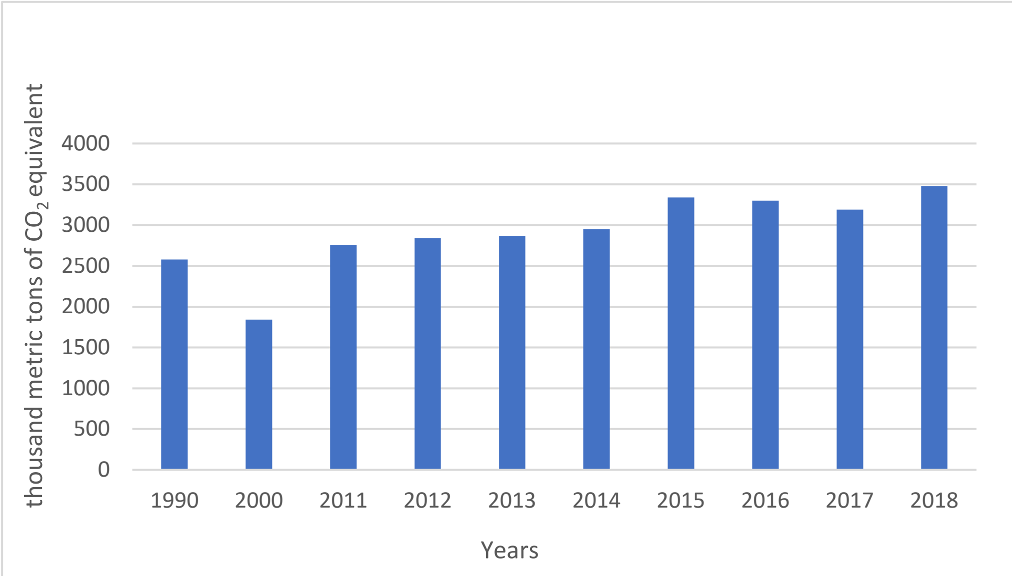


Chart 2. Agricultural nitrous oxide (N_2O) emissions

Although N2O emissions have increased over the years, we can see a decrease in the amount of fertilizers used in sowing areas compared to the 1990s, in a graph showing the change in the use of mineral fertilizers over the years. However, since 2015 there has been an increase in the amount.

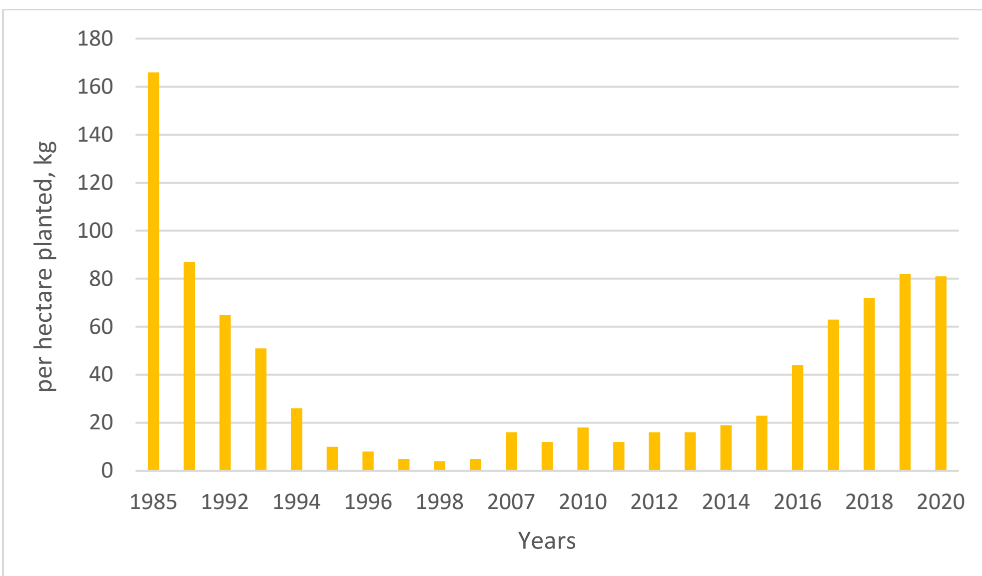


Chart 3. Dynamic changes of fertilizer amount used in sowing areas of Azerbaijan

The COP has set ambitious goals for 26 countries around the world, one of which is to reach the long-term zero-emission target by reducing GHG emissions. Currently, the transition to alternative energy in Azerbaijan is widespread, and by 2050 the country has set a goal to meet most of its needs with alternative energy. By 2030 Azerbaijan's INDC expresses a target to reduce 35% of greenhouse gas emissions compared to the 1990 base year as its contribution to the global climate change efforts. We will be unable to reverse growing agricultural emissions trends unless we address their root cause: rising demand for agricultural products, particularly those that are carbon intensive. Agricultural GHG emissions cannot be addressed simply as a problem of inefficient production on the supply side. A spotlight must be cast on the pressures that inefficient, unsustainable consumption patterns pose to global climate and land use.

Climate change induced water problems

Along with land resources, it is important to achieve sustainable use of water resources. Azerbaijan lags far behind developed countries in terms of freshwater resources. The water resources availability in Azerbaijan is estimated to be only about 15% of the total of the South Caucasus region. Water per area and per person in Azerbaijan is 7.7 and 8.3 times less than in Georgia, and 2.2 and 1.7 times less than in Armenia, respectively. During drought years in Azerbaijan, less than 1,000 cubic meters of freshwater per capita.

The Kura and Aras rivers, the main water arteries of Azerbaijan, have become more mineralized and polluted with heavy metals and other toxic substances. As a result of anthropogenic impacts, the flow of some rivers in the country has changed dramatically. Rivers sometimes dry up in the summer months and flood in the spring and winter.

The development of the agrarian sector in Azerbaijan is based entirely on irrigated agriculture. Thus, 85-90 % of crop production and all cotton is grown on irrigated lands. According to the Azerbaijan Amelioration and Water Management OJSC, 6430 million cubic meters of water is currently used for irrigation and agricultural supply in Azerbaijan. In 2014, one-third of the water supply was lost before it reached consumers, and a large proportion of these losses were attributed to agricultural water. On average, about 26 % of total freshwater abstraction is lost during transport according to European Environment Agency. Unfortunately, no significant improvement was observed in the efficiency of water transport between 2000 – 2017. In fact, the agricultural sector accounts for 89 % of the total water supply and three-quarters of lost water. According to the statistics provided by the State Statistics Committee of Azerbaijan on water from natural resources, its consumption and loss, Azerbaijan ranks first in water loss with 28% among the countries of the Commonwealth of Independent States.

According to SSCA there is 1480.2 thousand hectares irrigated lands in Azerbaijan by 2020. You can get see detailed picture of change of irrigated land fields during years the graphic below: (Chart 4)

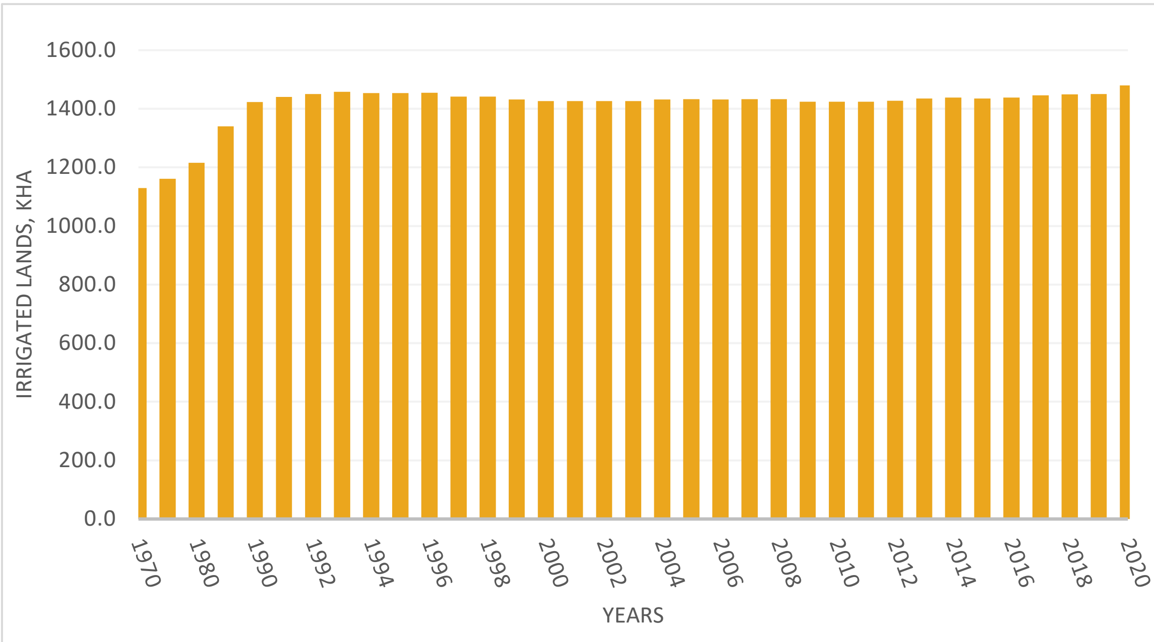


Chart 4. Irrigated lands during years in Azerbaijan (kha)

Water losses in the irrigation sector further reduces the declining irrigation water. Flood irrigation, which is a traditional irrigation method, is the most widely used irrigation method among farmers. This method of irrigation is not suitable for saving water, soil and fertilizer. One of the main reasons for the increase in water losses is the lack of awareness and interest among farmers in saving water. Another cause of water loss is open irrigation canals (especially in rural areas), which are less efficient than modern infrastructure. 70-73% of the existing networks are ground channels. In addition, irrigation canals, collector-drainage networks, and hydraulic structures built in the 50s and 80s of the last century were subjected to physical erosion and these overdated structures are one of the main causes of water losses too. In general, the causes of water loss can be summarized as follows:

- ✓ Leaks from open ground channels
- ✓ Lack of desire/awareness to save water among farmers.
- ✓ Old irrigation methods
- ✓ Expired water installations

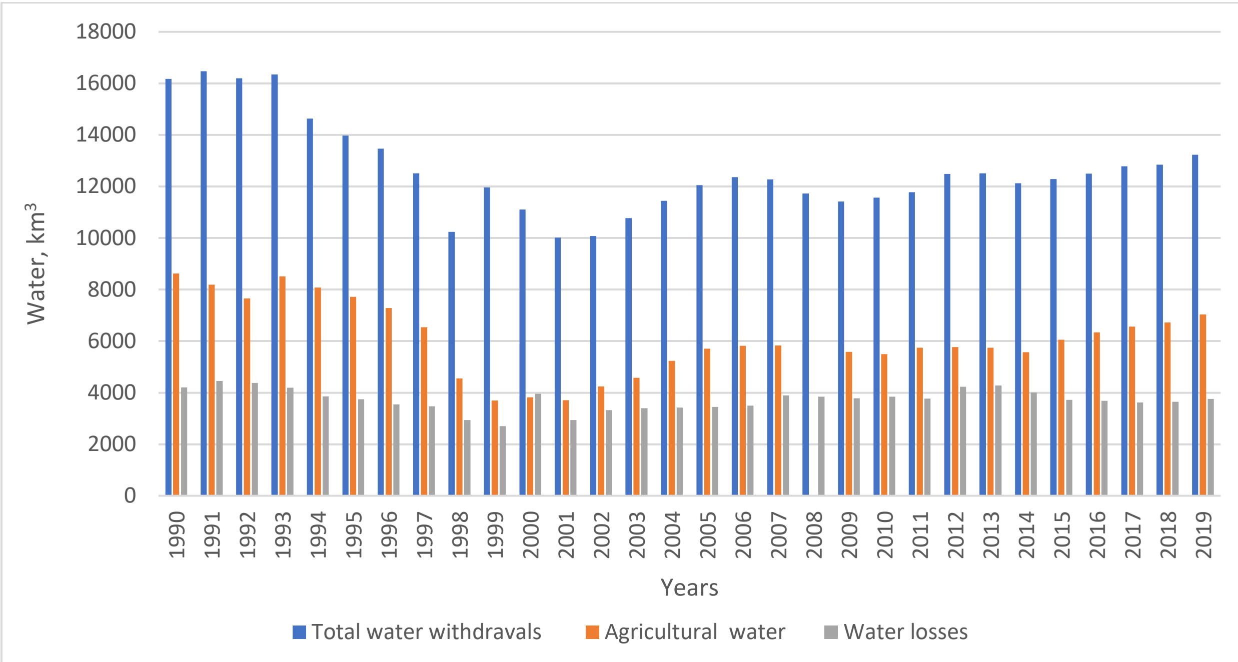


Chart 5. Water withdrawal's and water losses by years

Official estimates agree on an average of water withdrawal in Azerbaijan 12 billion cubic meters per year. Though Azerbaijan freshwater withdrawals fluctuated substantially in recent years, it tended to increase through 1997 - 2017 period ending at 12 billion cubic meters in 2017. According to the State Statistics Committee, at least 4 million m3 of water is lost in the distribution network and irrigation. However, due to many reasons, it is still impossible to prevent these losses due to irrigation water share/usage in the agricultural sector.

Salinization and Swamping

According to the Ministry of Agriculture of Azerbaijan, 55.2 % of Azerbaijan's land fund (4780.1 kha) is suitable for agriculture, and most of it belongs to the arid zone, where there is a lack of moisture, so it is impossible to produce agricultural products without irrigation. Thus, more than 90 % of crop production all cotton is grown on irrigated lands. (1480.2 out of 1630.9 kha)

Improper irrigation of lands, excess water salinization of soils. The most influential factor in soil salinization is the method of flood irrigation. The most influential factor in soil salinization is the method of flood irrigation. When this method is used, some of the water seeps into the lower layers of the soil, causing groundwater to rise. And when the water evaporates, and the salt rises to the top layers of the soil. This leads to swamping and salinization of the soil, resulting in a decrease in arable land.

According to the information of Azerbaijan Amelioration and Water Management OJSC as of January 1, 2016, 16.8% of irrigated lands are weak, 8.4% moderately and 3.3% are strongly salinized. At present, reclamation measures are required on 495,166 hectares of irrigated lands in the country.

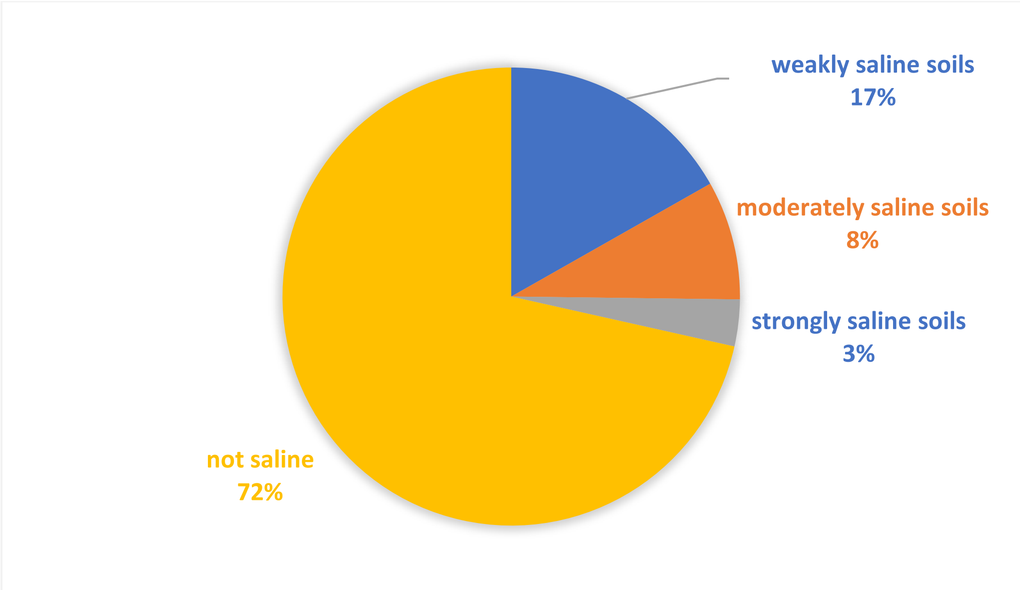


Figure 2. Salinization percentage of irrigated lands in Azerbaijan

80% of salinization is observed in the Central Aran regions, especially Ujar and Zardab. Other areas facing the threat of salinization of our country are mainly in the Kurdamir, Sabirabad, Saatli, Salyan, Neftchala districts in the Kur-Araz lowland.

In addition, excessive application of irrigation water to the soil changes its physical and chemical composition, the process of easy decomposition of organic matter, and thus regulates the air, salt and heat regime of the soil, which also results in a decrease in arable land.

Salinization exacerbates the problems of food production in our country, which is already limited in arable land. To prevent swamping and salinization, collector-drainage networks are being built in the irrigated areas. However, at present, the activity of this network is not very satisfactory. Thus, the filling of most collector canals does not allow groundwater to be removed from the irrigated area. This, of course, leads to rising groundwater levels and re-salinization of the area.

Climate change induced droughts

Global climate change is causing a steady decline in rainfall and water shortages, which poses major challenges for the country's agriculture. Recently, water shortages in this area are the common issues that face farmers. Droughts with longer durations are closely linked to rising temperatures and reduced rainfall in all afore- mentioned regions. For example, the 2014 drought has hugely affected on the reduced agricultural production. Irrigated crops are accountable for 85 % of total agricultural output (Rzayev, 2007), which will also be at risk from projected water shortages, and higher temperatures increased irrigation to maintain yields. Due to climate changes, it is expected that there will be more need for water for agricultural production, which will cause adverse impacts on food security of children. The low output from agricultural activity and harvests will be aggravated by increasing temperatures and increased water stress.

As a result of the severe drought in recent years, the water content of rivers has decreased and it was not possible to collect enough water in reservoirs. According to the Azerbaijan Amelioration and Water Management OJSC on September 23, 2020, 9 billion 990 million cubic meters of water remained, which is 590 million cubic meters less than in the same period last year. According to the TNC, droughts are likely to reduce water supply by 23% during the 2021 to 2050 period in the country.

The drought in 2020 was one of the causes that contributed to a decrease in sown areas compared to the previous year. Cultivation has been limited in some locations due to low annual precipitation. The sown area of cereals and legumes decreased by 6.5%, while the sown area of technical crops decreased by 5.9%, as shown in the table below (Table 4).

Table 1. The sown area of main agricultural products, hectares

Name of crops	Sown area (ha)		In 2020, compared to 2019, in %
	2020	**2019**	
Total sown area	**1,643,963.0**	**1,717,059.0**	**-4.3**
Cereals and legumes	**1,002,662.0**	**1,072,344.0**	**-6.5**
wheat	598,193.0	670,020.0	**-10.7**
barley	347,862.0	342,214.0	**+1.7**
oats	5,872.0	5,487.0	**+7.0**
corn	34,603.0	32,840.0	**+5.4**
paddy	3,001.0	4,037.0	**-25.7**
Legumes	12,687.0	17,181.0	**-26.2**
Technical plants	**122,511.0**	**130,155.0**	**-5.9**
cotton	100,295.0	100,112.0	**+0.2**
sunflower	11,396.0	16,551.0	**-31.1**
sugar beet	4,975.0	7,346.00	**-32.3**
tobacco	3,144.0	3,134.00	**+0.3**
Potato	**56,988.0**	**56,921.0**	**+0.1**
Vegetables	**66,544.0**	**69,354.0**	**-4.1**
Melon plants	**20,005.0**	**21,358.0**	**-6.3**
Forage plants	**365,676.0**	**366,922.0**	**-0.3**

In this period, there was an increase in the production of crops except for cereals, legumes, and sunflowers. The increase in the production of main crop products in 2020 compared to the previous year was mainly due to increased productivity. As a result, while sown area fell by 3.6 %, crop production rose by 0.8 %.

Table 2. Production of the main types of crops, thousand tons

Name of crops	Quantity of yield in thousand tons		In 2020, compared to 2019, in %
	2020	**2019**	
Cereals and legumes	3,257.1	3,538.5	**-8.0**
Cotton	336.5	295.3	**+14.0**
Sunflower	24.8	34.8	**-28.8**
Sugar beet	253.3	237.0	**+6.9**
Tobacco	6.9	6.0	**+15.1**
Potato	1,037.6	1,004.2	**+3.3**
Vegetables	1,738.9	1,714.7	**+1.4**
Melon plants	448.1	447.6	**+0.1**
Fruits and berries	1,133.1	1,099.7	**+3.0**
Grapes	208.0	201.8	**+3.1**
Green tea leaves	931.5	929.4	**+0.2**

Source: *State Statistical Committee*

In addition, the change in crop structure in recent years has been one of the factors affecting the increase in total yield per hectare. For instance, the area of perennial crops has been constantly increasing over the past three years.x

Animal husbandry in Azerbaijan

Livestock is of special importance in meeting the needs of the population of Azerbaijan in meat and dairy products. Sheep-breeding is one of the fields of animal husbandry with special traditions. This livestock sector, which allows us to make maximum use of natural resources, has a special place in meat production, along with livestock. As a result of special economic policy pursued in the country in recent years, significant achievements have been made in the development of industrial poultry farming. At present, the country has a full supply of poultry meat and eggs.

The agricultural policy pursued by the Government of Azerbaijan is to further increase the production of agricultural products in the country and to be completely free from dependence on imports in this area. This is a factor that will lead to an increase in greenhouse gases in the agricultural sector in the future. This is confirmed by the sharp increase in the number of animals in the country in recent years (Chart 6,7).

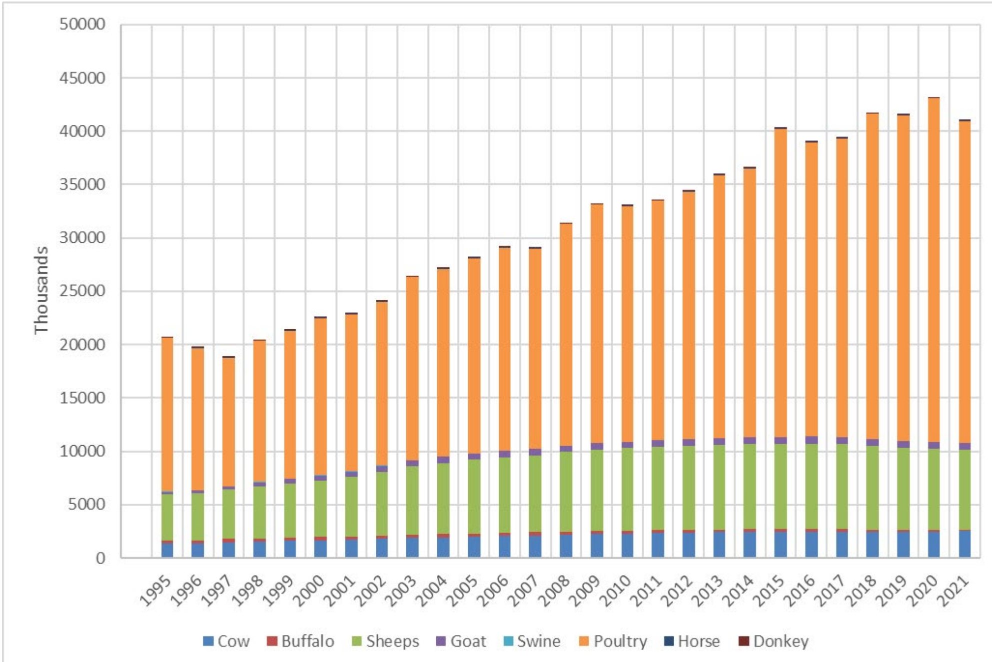


Chart 6. Number of livestock and poultry in Azerbaijan by years

The number of farm animals in the country was 10,740.4 (2650.7 cattle, 8089.7 sheep and goats) by 2020. This is an increase of 34.93% and 41.83%, respectively, compared to the beginning of the century.

The extensive production method currently used in animal husbandry is common for the country's agriculture. Despite the increase in the number of livestock and poultry, fodder production in the country is very weak and alfalfa production is preferred in irrigated areas. No changes were made in the composition of animal feed to reduce greenhouse gases and and there is no manure management activity in the country, which is one of the main problems of the agriculture sector of the country. As a result, greenhouse gas emissions in agriculture are constantly increasing. Also, means used to reduce enzymatic fermentation still do not provide adequate results.

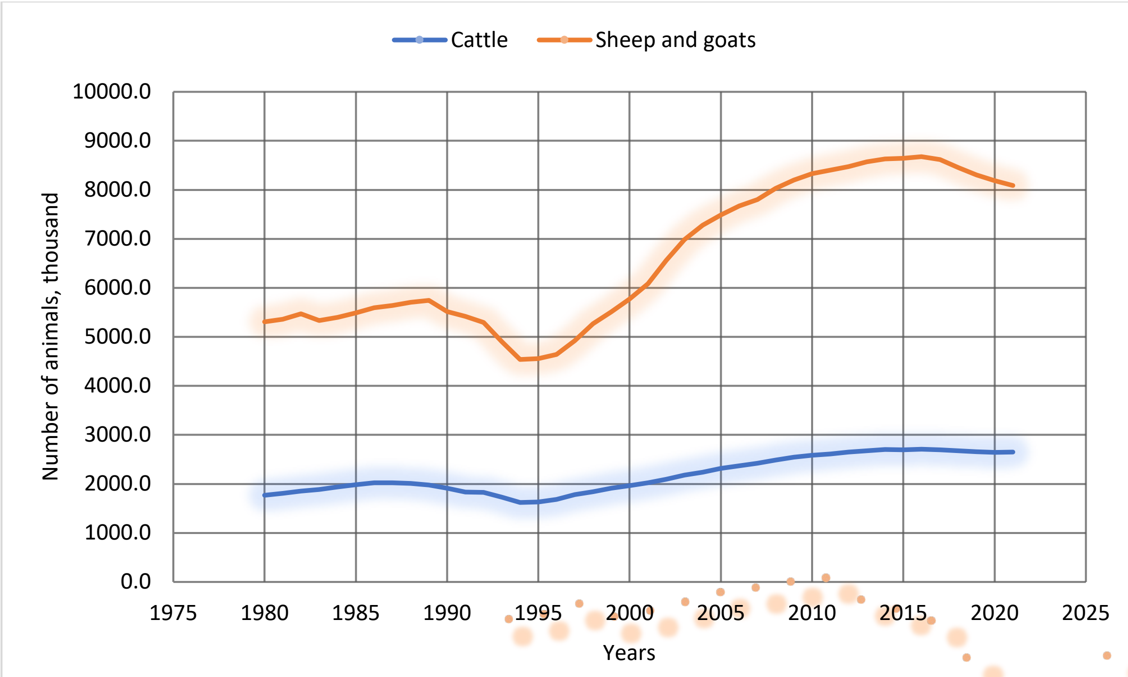


Chart 7. Dynamics changes in the number of livestock

Chart 8. Dynamic changes of area of pastures and hayfields

The annual increase in the number of agricultural animals leads to the deepening of additional effects of livestock, such as the capture of new pastures, increased erosion and increased methane gas emissions. According to the latest data published by the Azerbaijan Statistics Committee in 2020, there are 2,423,000 hectares of hayfields and pastures in the country (Chart 8).

Agriculture emissions increased by 2.4 MtCO2e (49%) from 1992-2012, due almost entirely to enteric fermentation and manure left on pasture, according to the data of WRI CAIT. It is attributed to the increase and the growth of the livestock sector. Production of both meat and milk more than doubled from 1992-2012. Despite the apparent improvement in productivity, emissions grew only by half. The BUR notes the situation as a result of the government's few activities to limit emissions from the agriculture sector.

Mitigation opportunities in Agricultural sector

In this section, we'll try to reveal possible mitigation opportunities in the Azerbaijanian agricultural sector in order to reduce GHG emissions from agricultural activities, with the aim of dealing with climate change. Mitigation involves reducing the flow of heat-trapping greenhouse gases into the atmosphere by human intervention or enhancing the "sinks" that accumulate and store these gases, such as forests, and soil. Studies show that 75 % of the mitigation potential of the agriculture sector comes from changes in diet and the other 25 % from reductions in food loss and waste. That is, mitigation effects in agriculture need to be paired with efforts to improve the efficiency of production.

Meat production and GDP

The next indicator we will analyze is meat production and consumption. As meat production is directly dependent on the increase in the number of livestock, the amount of meat consumption indirectly affects the increase of agricultural GHG emissions too.

The forecast of meat consumption in the agricultural sector, as the main determinant of the emissions, is done using the relationships between GDP and meat production. The forecast of GDP per capita for the target year is taken from national projections done by the government of Azerbaijan. The second variable is population. So, rates of meat consumption in the target year is closely depend on two main variables which can be described as following nonlinear multiplied regression:

- ***MC=a (GDP PC) +b(Pop)+c***

Where, MC is an amount of the meat consumption in a target year, GDP PC is a GDP per capita, Pop is population.

According to IPCC 2006 Guidelines, CH4 emissions can be calculated as a multiplication of the number of animals by an emissions factor.

The basic formula is given below:

- ***T(CH4) = TNL*CH4 EF***

Where, T(CH4) = Total CH4 emissions, TNL=total number of livestock, CH4 EF= CH4 Emissions Factor.

According to this methodology, the three main stages to calculate emissions of methane for livestock methane emissions are as follows:

- Collect data on animal population and animal characteristics data
- Estimate the emissions factor for the animal type;
- Multiply the emission factor estimate by the population to get the total methane emission estimate for the population.

Results

According to econometric models, approved by the national Statistical Committee of Azerbaijan, GDP per capita in Azerbaijan is expected to be 11200 USD by the end of 2030. Extrapolation predicts that GDP per capita may increase up tp 14000 USD by 2040. This forecast takes into consideration future shifts in economy that includes growth in industry, energy and service sectors.

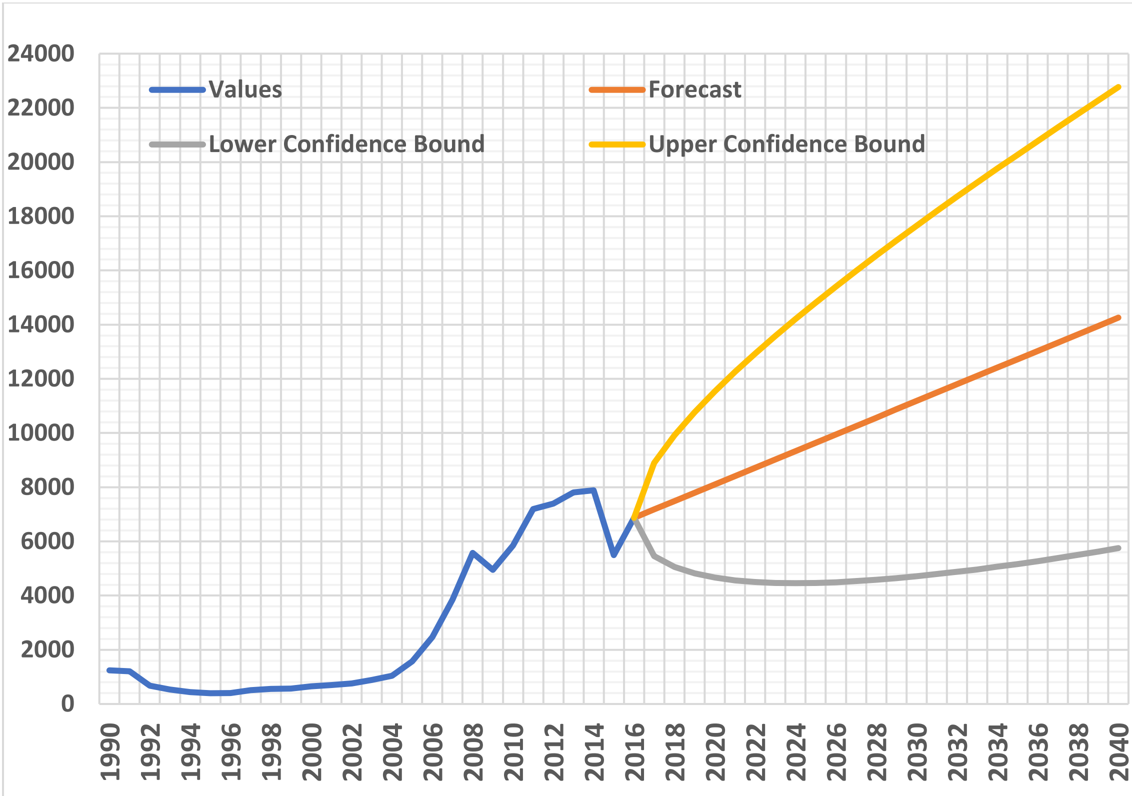


Chart 9. GDP per capita forecasted

As noted, there are very close relationships between personal incomes and meat production. As noted, increase of meat consumption is directly related to the affordability. Increased meat production is closely depending on GDP per capita. Relationship between GDP per capita and meat production well demonstrates meat production is a manifestation of the increase in incomes of people.

The link between current incomes and meat consumption in Azerbaijan suggests that as incomes increase, increasing demand for meat will lead to an increase in the number of animals in the country in the future and will stimulate the development of livestock in agriculture. The relationship between meat consumption and GDP per capita is shown below. Although the link between GDP and meat production is not very strong, it helps to clarify the overall picture (Chart 10).

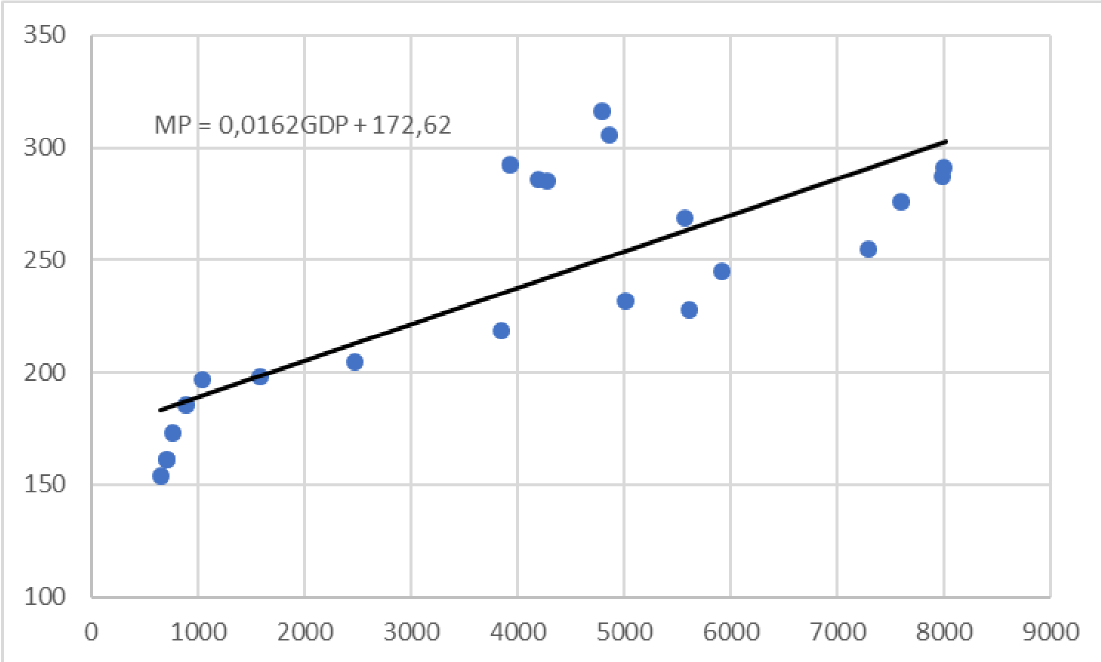


Chart 10. Relationships between GDP per capita and meat production

Using the above graphs, it can be concluded that the increase in per capita income in the country in the future will directly lead to an increase in meat production in the country. In addition, the state program to be adopted in Azerbaijan on the development of agriculture envisages increasing meat production in the country in 2021-2026, which will lead to an increase in the number of animals.

According to the proposed methodology, the number of cattle by 2040 was calculated and, accordingly, the carbon equivalent was calculated. As the growing population's demand for animal products increases so does the number of livestock. Estimates show that if growth continues at the same pace, the number of livestock in Azerbaijan will exceed 14 million in 2040 (Chart 14) and pastures will expand their borders accordingly. However, if mitigation measures are not taken, it is questionable whether we will have the resources to expand pastures.

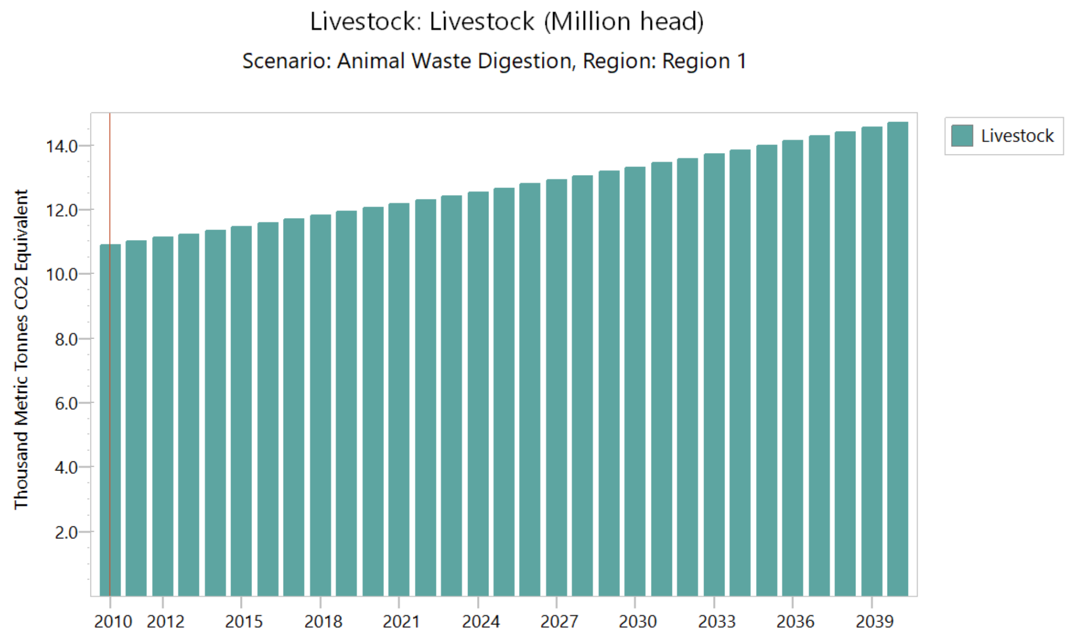


Chart 11. Animal waste digestion scenario for 2040

As it mentioned above there are 2,423,000 hectares of hayfields and pastures in the country (55.1% of the total agricultural lands). Global estimates show that reducing grazing land area and increasing management associated with land-use intensification will significantly change the amounts of carbon sequestered in grazing land soils. The method covers converting extensively managed pastures into intensively managed agriculture or urban development. Unlike extensively managed agriculture, intensive management is an effective method that allows to achieve the desired results using less resources. We hope the continuation of this trend to have major impacts on our regional climate, potential future carbon sequestration, and greenhouse gas emissions.

Current pasture management strategies - like fertilization strategy and grazing management, are generally aimed at increasing forage production to match animal stocking rates or forage demand from hay. However, pasture management can also promote carbon storage in the soil. In fact, most techniques used to improve forage production promote carbon inputs to the soil and increase soil carbon sequestration. For instance, fertilization, irrigation, grazing management, fire regimen, introduction of legumes, and use of improved grass species can boost plant productivity while promoting soil carbon sequestration. Well-managed grazing lands generally maintain or even increase soil carbon accumulation compared with native ecosystems. Also, livestock benefit from well-managed lands because the grass usually has higher nutrient concentrations because of proper fertilization. Opportunities for increasing soil carbon sequestration in response to management practices vary in intensity and are specific to each ecosystem.

The Chart below show the predicted amount of methane emissions from animal husbandry of Azerbaijan in 2039 and the relationship between the possible reduction of greenhouse gas emissions as a result of the replacement of extensive method to the intensive method in agricultural development (Chart 16,17).

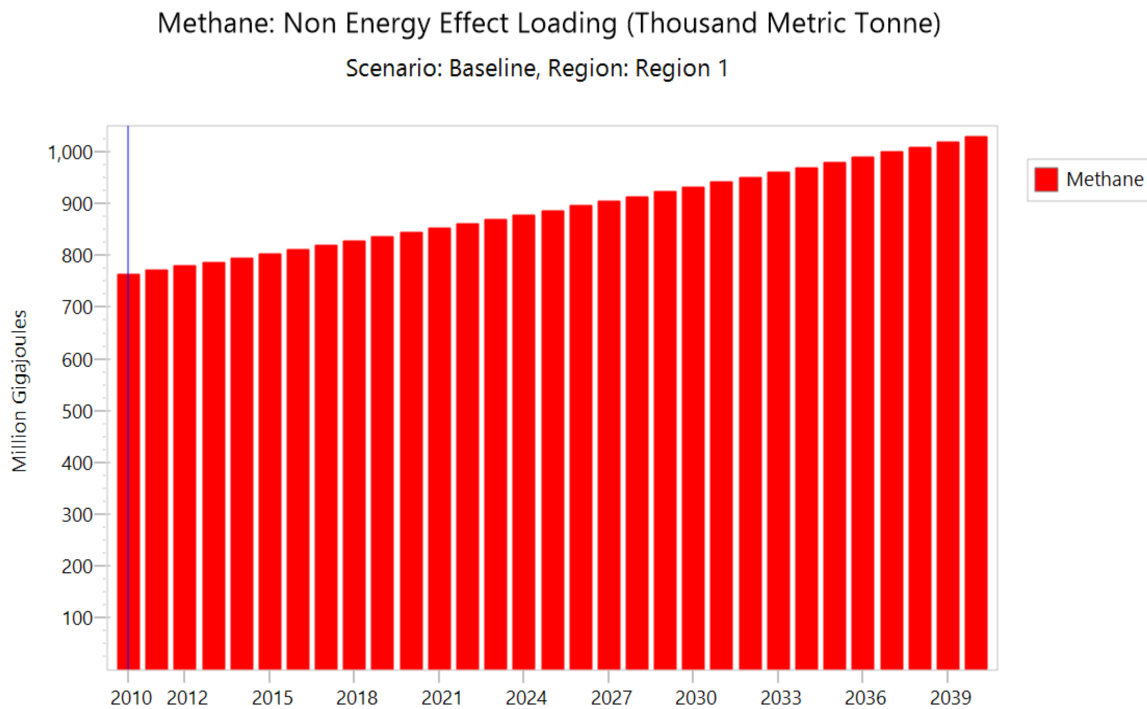


Chart 12. Predicted amount of methane emissions from animal husbandry of Azerbaijan in 2039

Grazing management and carbon sequestration

To show the advantages of the mitigation methods we suggest in the field of animal husbandry, let's first review the comparison of the two forecast models that our study contains. The study uses a basic scenario analysis approach to compare future changeable scenarios with the current scenarious that may continue in the future as well. The scenarios assess current "business as usual (BAU)" agricultural practices and its current values. It uses sector output indicators and compares them with potential "New Agricultural policy (AGRON)" outputs to assess the potential of shifting from BAU to AGRON.

AGRON consider reduction of methane emissions from cattle using the following options

- tinkering with the cattle's diet;
- adding supplements that slow down the production of methane;

- breeding climate-friendly cows;
- capturing methane;
- decreasing livestock numbers and etc.

The Agron model introduces many options to reduce GHG emissions, while there are no possible changes in BAU model. When setting up these options, it was assumed that all the factors affecting methane reduction would be used in an integrated manner, resulting in methane reduction in the agricultural sector. And now let's take a wide look at each mitigation opportunity that can be done in the animal husbandry sector.

Because grazing lands occupy a vast area throughout the world, small changes in the amounts of carbon stored in this ecosystem can have significant consequences on the overall carbon cycle and atmospheric CO2 levels. It would be useful to bring some information to your attention to emphasize the importance of pastures as a carbon sink. Studies show that an increase (or loss) of only 1% of the soil carbon in the top 4 inches of grazing-land soils is equivalent to the total carbon emissions from all US cropland agriculture (Follett et al. 2001). This trend underscores that how important are grazing lands to mitigate at least part of global atmospheric CO2 emissions.

It is estimated that the number of livestock in the country can be reduced to 8 million by 2039 by ensuring the intensive development of agriculture. This figure is not only lower than the number projected for 2039 but also lower than the current number of livestock (Chart 15).

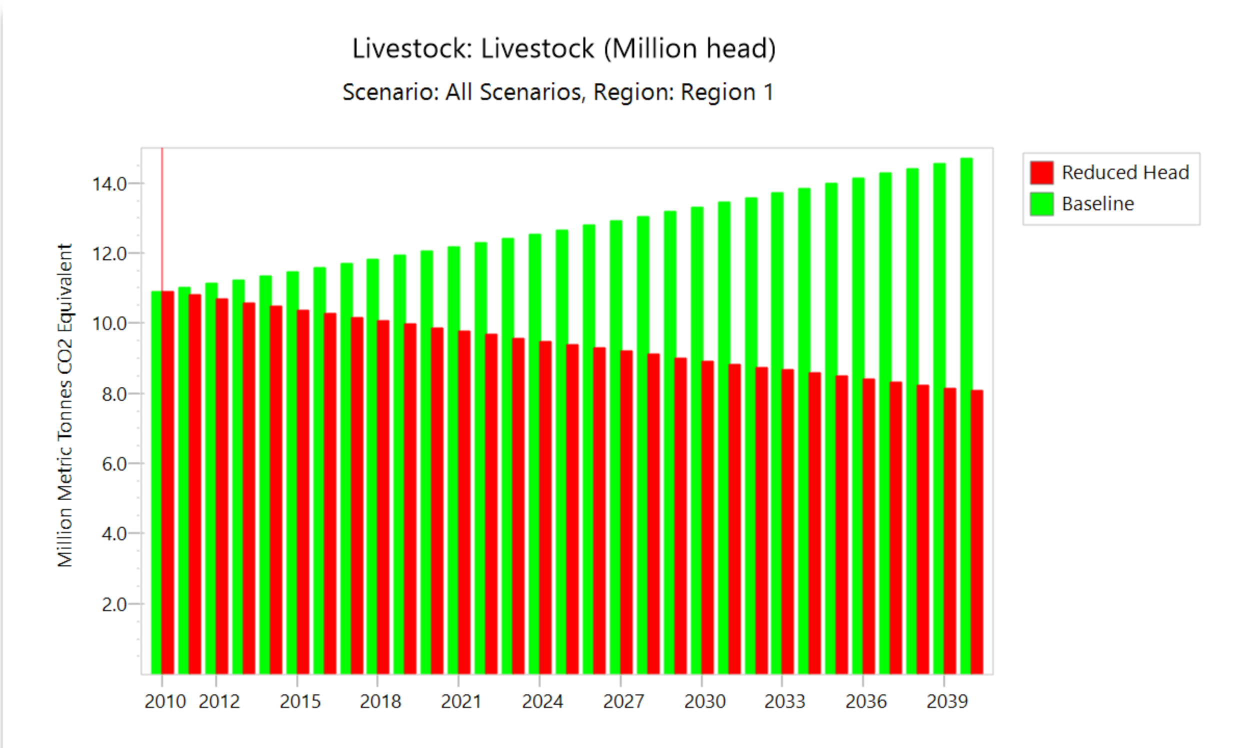


Chart 13. The predicted number of animals for intensive and extensive agricultural models in 2039 in Azerbaijan

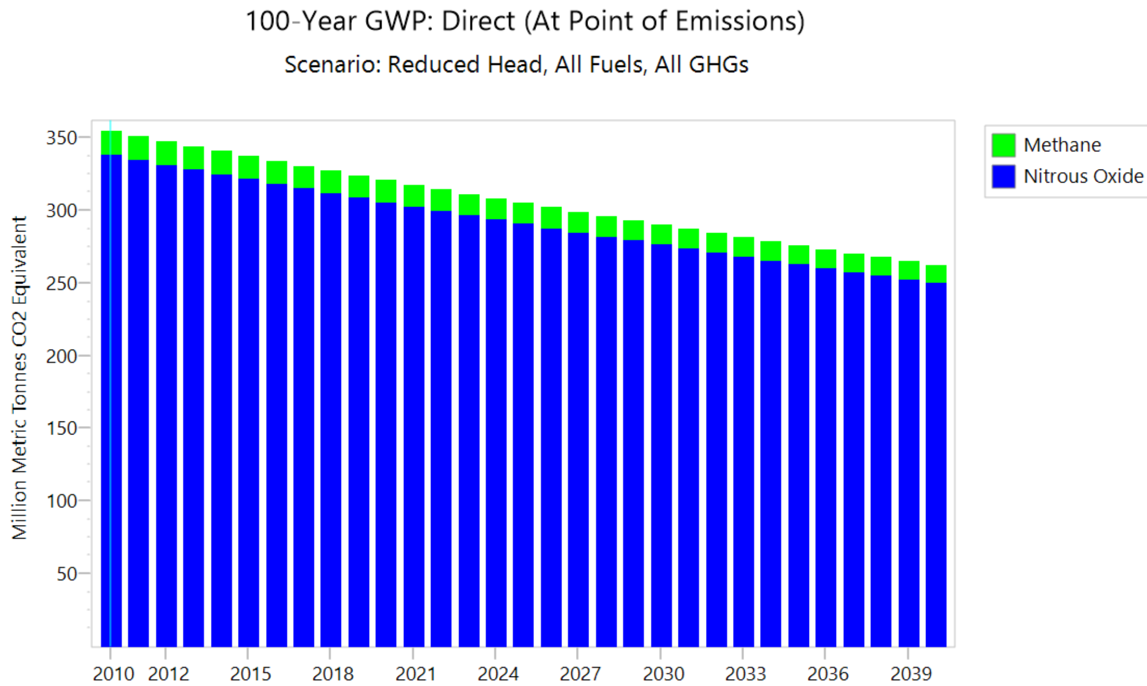


Chart 14. Scenario for the impact of the reduction in the number of livestock on the reduction of GHG emissions for 2039

Given that livestock sector emits more methane gas in the country's whole agricultural sector, and if this sector is not controlled, then the agricultural sector will continue to be a source of greenhouse gases that cause global warming.

Carbon sequestration by agricultural plants

Agricultural ecosystems store a significant amount of carbon, primarily in the soil organic matter. Carbon sequestration in the agriculture sector refers to the capacity of agricultural lands and forests to remove carbon dioxide from the atmosphere. Carbon dioxide is absorbed by crops, trees through photosynthesis and stored as carbon in biomass in tree trunks, branches, roots and soils. The ability of agricultural lands to sequester carbon depends on several factors, including type of crop or vegetation cover and management practices, also climate and soil type. The following farm methods promote carbon sequestration by either increasing carbon storage or decreasing carbon loss:

- Implementation of crop rotations
- Reducing the amount of land that is left fallow

- Avoiding excessive fertilizer application
- Proper management of tillage and residues
- Establishment of agroforestry systems

Also, it is advisable to cultivate plants with relatively high carbon sequestration to reduce carbon emissions. The carbon sequestration potential of fruit crops given in the Table 6.

Table 3. Carbon sequestration potential of fruit crops of Azerbaijan

Fruit Crop	The carbon sequestration potential of fruit crops (t/ha/year)
Apple	7.96
Sunflower	41
Corn	48
Tea	49
Grape	49.5
Orange	76
Grass (fertilized and non-fertilized)	105

In the chart below, which shows the sown areas for a given crops, we see that there is a large area of grass which has a high carbon sequestration (Chart 11). It would be more expedient to expand the sown areas of tea and corn crops.

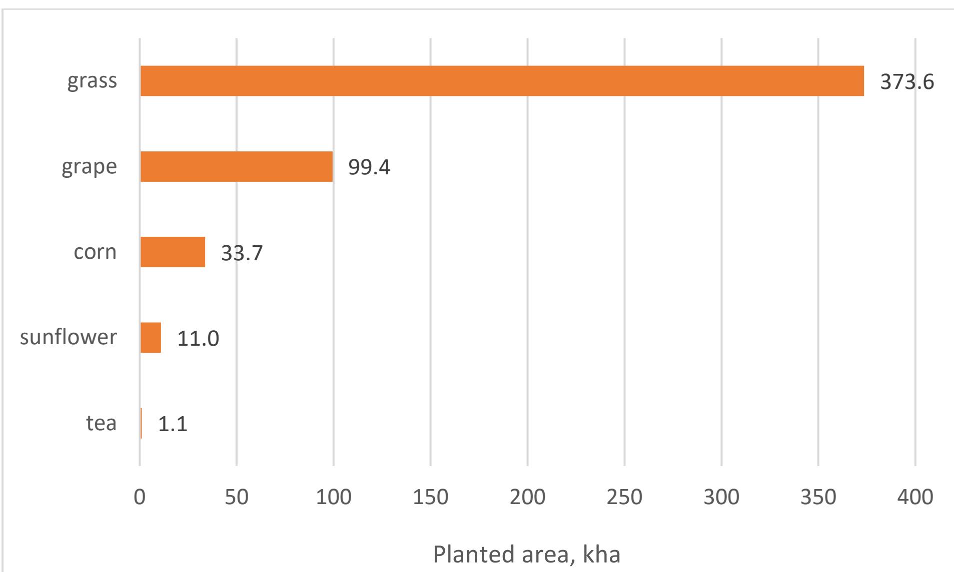


Chart 15. Planted areas of crops in 2020

Due to the high carbon sequestration capacity of grasslands, extensive use of pastures may also play a role in increasing GHG emissions. The chart shows the dynamic changes of perennial grassland areas in Azerbaijan over the years (Chart 12).

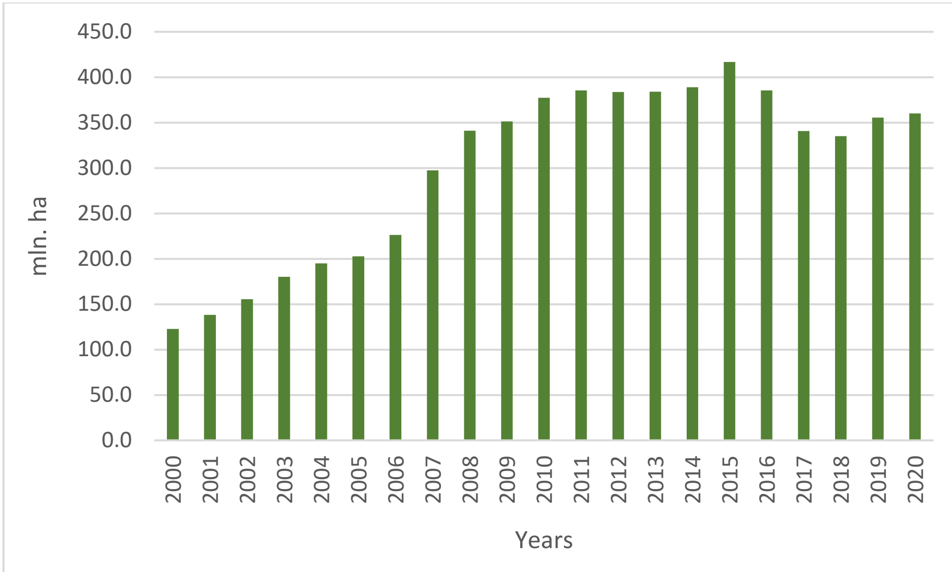


Chart 16. Dynamis changes of pastures and hayfilelds in Azerbaijan

Soil fertilization and energy use

World Resources Institute published prediction of annual agricultural production emissions for 2050. The chart shows predictable ammount of some indicators that results in increase of agricultural production emissions, such as rice methane, soil fertilization, energy supply and etc. (Chart 13)

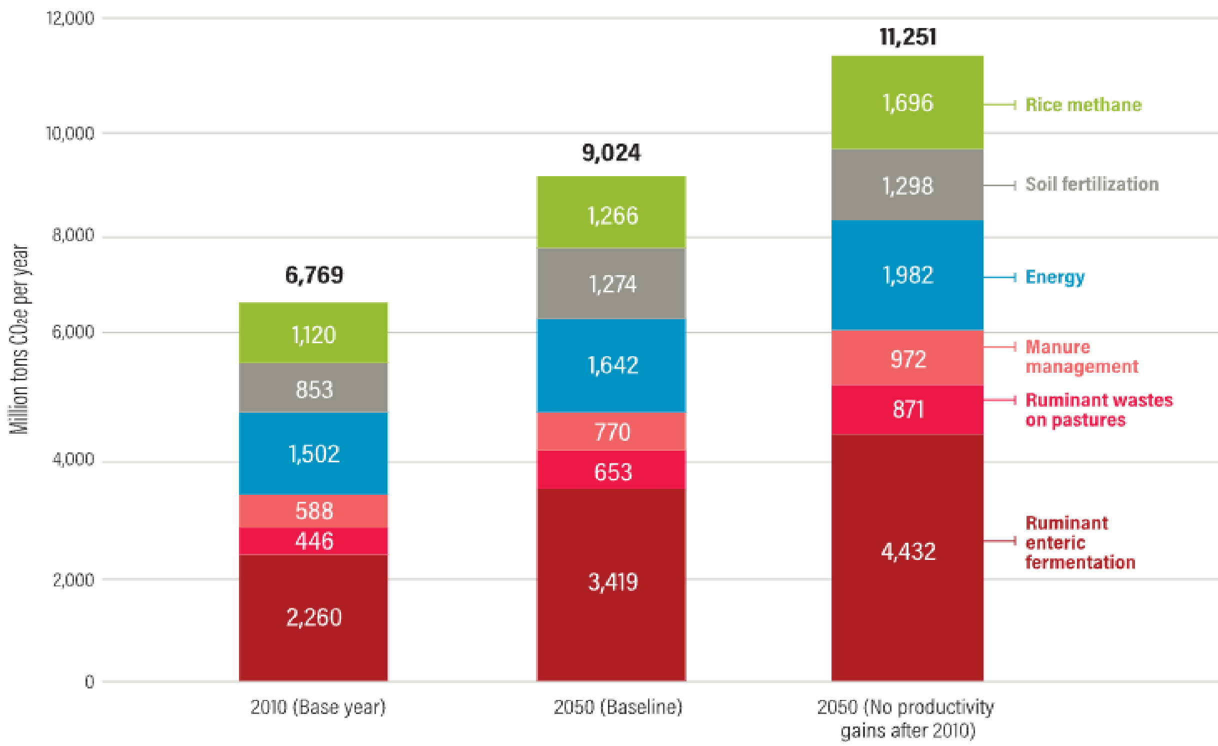


Chart 17. Prediction of annual agricultural production emissions for 2050 by World Resources Institute

Considering results of the chart calculated by the WRI we offer some additional ways to implement in agricultural sector of the country:

- Increasing the efficiency of nitrogen utilization to reduce fertilizer emissions
  Reducing fertilizer overapplication and increasing fertilizer absorption by plants through:
  - *changes in management*
  - *changes in fertilizer compounds, or*
  - *breeding biological nitrification inhibition into crops*

- Adaptation of emissions-reducing rice management and varieties via
  - *variety selection*
  - *improved water and straw management*

- Increasing agricultural energy efficiency and shifting to non-fossil energy sources
  Fossil fuels can be replaced with renewable energy sources such as:
  - *geothermal*
  - *wind*
  - *solar electric (photovoltaic)*
  - *biofuel production from crops or crop residues, etc.*

Cover crops

Using cover crops to improve the GHG balance may help to mitigate climate change by decreasing CO2e emitted in cropping systems which can represent a decrease in annual GHG emissions of the agriculture and forestry sector. Cover crops are sown to avoid bare soil between two main crops and to provide multiple services. It is established between the harvest of a main crop and the sowing of the next main crop.

We suggest that significant investments in time and resources should be devoted to developing annual crops for carbon farming. These crops will allocate an increasing amount of carbon to the reproductive sinks, and to the below ground stores for the dual purpose of mitigating global warming due to rising atmospheric CO2 levels and improving soil health for increased crop productivity.

As we already mention above, the area of perennial crops has been constantly increasing over the past three years in the country. That's why we think using cover crops would be one of the appropriate ways to reduce agricultural CO2 emissions. However, if not well managed, they also could create water management issues in watersheds with shallow groundwater.

Improving stored manure practices in industrialized livestock systems

The extensive production method currently used in animal husbandry is common for the country's agriculture. Despite the increase in the number of livestock and poultry, fodder production in the country is very weak and alfalfa production is preferred in irrigated areas. No changes were made in the composition of animal feed to reduce greenhouse gases and and there is no manure management activity in the country, which is one of the main problems of the agriculture sector of the country . As a result, greenhouse gas emissions in agriculture are constantly increasing. Also, means used to reduce enzymatic fermentation still do not provide adequate results.

While mitigation interventions that target stored manure management do not benefit productivity, they also present no serious food security risks and have other co-benefits (e.g., water quality). Unlike many mitigation options, manure management has been addressed through progressive policies in many countries.

- Capturing biogaz from manure

The use of manure for energy production will not only reduce carbon emissions but also prevent pollution of groundwater and surface water sources.

Livestock manure is a valuable resource that can significantly increase plant productivity, help maintain soil fertility, and replace significant amounts of chemical fertilizers. When manure is applied to the soil, it can revitalize the soil and increase its fertility many times over. However, when used improperly, manure not only pollutes the air, but also becomes a source of greenhouse gases entering the atmosphere. Improperly managed manure is also an agent that pollutes water sources.

According to NDC, By 2030 the Republic of Azerbaijan targets 35% reduction in the level of greenhouse gas emissions compared to 1990/base year as its contribution to the global climate change efforts. İn agricultural sector, collection of methane gas from manure of livestock and poultry, use of alternative sources of energy and modern technologies is considered one of the main options.

When decomposed under anaerobic conditions, animal urine and manure are the main sources of methane and nitrogen oxides. Nitrogen oxide is formed during nitrification-denitrification of nitrogen in livestock waste. Anaerobic conditions are common when manure is stored in large piles or settlement ponds (eg dairy farms, beef feedlots, pig and poultry farms) to cope with the large amount of waste that is managed indoors.

Ruminants excrete 75-95 % of the nitrogen they consume. Ruminants in wet spring pastures often consume more protein (including nitrogen) than they need, but they are often limited by energy, resulting in ruminal ammonia concentrations being excreted in the urine.

With the biogas production system, large volumes of manure are digested under low oxygen conditions and then produced to burn methane to destroy methane and generate heat or electricity. Waste sludge is usually returned to the soil as fertilizer, either in the form of sludge or granules.

Biogas producing technologies are usually added to prevailing manure storage ponds. The process of using biogas is as follows:

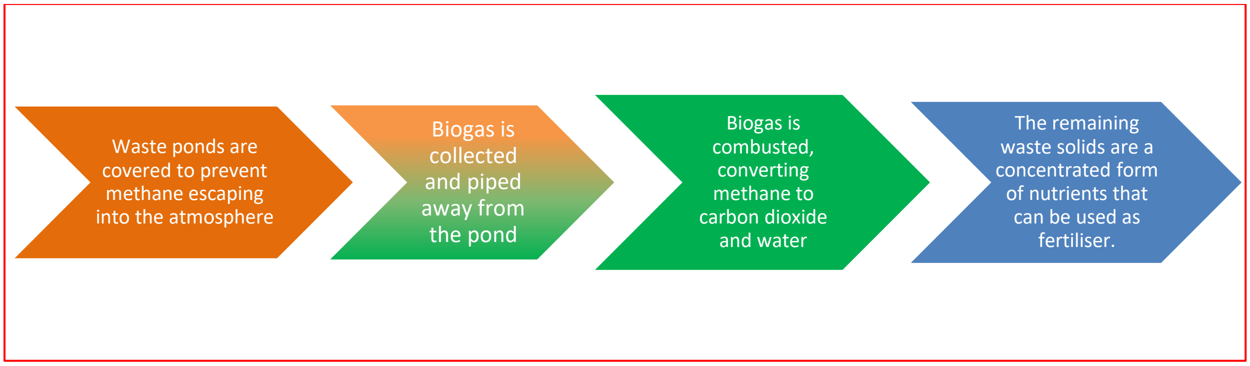


Figure 3. The process of using biogas

In the first stage, various technologies are used to capture methane. For this purpose, the manure is placed in a closed digester, and the methane produced in this digester is transferred through a pipe to the places of use or gas collection points without being able to escape into the atmosphere. In the next stage, methane can be used for various purposes. For example, methane can be burned to generate electricity or be transmitted directly to homes as gas. This use may vary, primarily depending on the physical and geographical location of the area, as well as the potential potential of the infrastructure.

In recent decades, many livestock companies have taken a keen interest in methane gas capture and use. World experience shows that in remote rural areas it is more profitable to heat homes using biogas. It should be noted that a medium-sized biogas plant can provide energy to a settlement with a population of 5,000 to 8,000. The share of biogas in the total energy balance of Denmark is 18 %, in Switzerland — 10 %. In countries such as China, India, Nepal and Vietnam, small biogas plants are widely used. It should be noted that the composition of biogas is very close to natural gas and is obtained from the decomposition of organic waste by bacteria.

At the national level, the capture and use of biogas is one of the main priorities, and the importance of activities in the Azerbaijan INDC has been highlighted. Currently, a significant part of methane gas emitted into the atmosphere in the agricultural sector of Azerbaijan is methane from manure, and therefore the use of methane gas from biogas is considered one of the main priorities.

It should be noted that modern technologies that allow the use of methane capture are widespread in Europe, and one of the main activities in this direction is to help spread the European experience in Azerbaijan. Biogas generation systems can help intensive livestock farmers reduce greenhouse gas emissions while also increasing farm output. The rapid growth in agriculture of Azerbaijan is creating new opportunities for electricity generation from biomass-derived from forestry and food processing waste, agricultural waste, and other biological substances. The Ministry of Energy estimates a technical potential of 380 MW for total biomass production.

Since 2014, the solar and biogas plants installed by the Gunesh Science and Production Association together with the Turkish company Kiska Engineering to meet the electricity and heating needs of homes in the Ismayilli and Lerik regions have been successfully operating in test mode. Although some parts of the equipment used for the pilot project were imported, the main work is being done in our country. Similar devices are planned to be tested in other regions in the near future. There are already projects for the construction of large biogas plants in a number of regions, but the issue has not yet been resolved.

- displacing synthetic fertilizer with recycled nutrients
- replacing fossil fuels with renewable energy

Fossil fuel (non-renewable energy) usage in agricultural equipment is the other source of GHG emissions. Thus, replacing fossil fuels with renewable energy used in the agriculture sector may be a good way to help mitigation of climate change.

Reducing food loss

If food loss and waste were a country, it would be the third biggest source of greenhouse gas emissions, says Inger Andersen Executive Director of UNEP. Food waste exacerbates food insecurity making it a major contributor to one of the planetary crises - climate change. That's why SDG 12.3 aims to halve food waste and reduce food loss by 2030.

According to the UNEP's food waste index report of 2021 average food waste in upper middle-income countries as Azerbaijan is 76 kg/capita/year at the household level. (Insufficient data for Food service and Retail phases). Although this figure is lower than in developed countries (79 kg/capita/year), it is still quite high. It is worth noting that the global average of food waste is 74 kg/capita/year and total food waste 569 mln tonnes by 2019.

According to the report, the estimated food waste for Azerbaijan is 93 kg/capita/year (934 872 tonnes/year), while a similar figure is 101 kg/capita/year in Georgia (403 573 tonnes/year) and 33 kg/capita/year in Russia (4 868 564 tonnes/year) respectively.

Food loss and waste must be reduced for greater food security and environmental sustainability. The efficient use of climate resources in agricultural production is one of the important tasks in solving the food problem. By reducing food waste, we can achieve a reduction in demand. To implement this, it is necessary to deeply study the characteristics of our region to identify potential opportunities for more efficient and rapid development of agriculture.

Adaptation opportunities

Adaptation measures are methods aimed at adapting to climate change. As the climate changes, our water resources are declining. In this case, we need to develop new plans - adaptation methods to save water. The following measures are recommended to be applied to agricultural activities.

6430 mln m^3 of water is currently used for irrigation and agricultural supply in Azerbaijan. And according to the statistics for 2014, one-third of the water supply was lost before it reached consumers, which's large proportion were attributed to agricultural water. Taking into account water losses, it is very important to minimize the amount of water used for irrigation and water losses.

Along with large-scale water losses, the need for water for agricultural products is also a factor that increases water waste. In this regard, the expansion of paddy crops should be noted.

Recently, paddy production has also started to expand in the country. The increase in paddy production is not considered favorable both in terms of efficient use of water resources and methane emissions. Thus, paddy is not only water-intensive, but also a major source of methane emissions.

There are permanent immersion and short-term immersion methods in paddy irrigation. In Sheki-Zagatala, Agdash-Ujar zone, permanent flooding, and in Lankaran zone, short-term flooding during planting is predominant. The development of paddy takes place in two stages. should be buried in water. Mass methane emissions from the area occur during flooding, along with high water consumption.

The following figure provides statistics on paddy production in Azerbaijan (Chart 18).

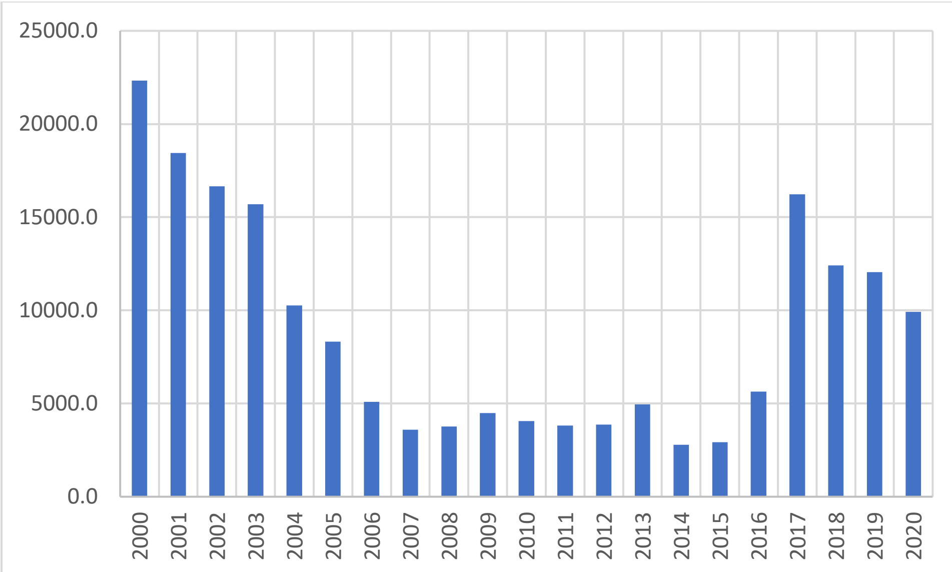


Chart 18 Rice production in Azerbaijan

The State Program on the Development of Rice in the Republic of Azerbaijan for 2018-2025 aims to increase paddy production. As a result of the implementation of the State Program, in 2025, the average yield will be 40.0 s / ha, paddy fields will be increased to 10,000 hectares, and production will reach 40,000 tons. The state program does not provide for the cultivation of low-methane emission paddy varieties. This could increase methane emissions from paddy fields by up to four times by 2025. At the same time, the demand for water may increase sharply in the regions where paddy is grown.

To reduce the amount of water used for irrigation, it is recommended to abandon traditional methods and switch to new irrigation methods. To implement this, large financial investments are required in the irrigation sector. While the state has a great responsibility in this matter, private organizations can also participate in this process. The new irrigation methods we recommend for use in Azerbaijan are

- sprinkler
- drip/trickle
- pillow and so on.

These methods has an important role in saving water without affecting crop productivity. For example, sprinkler method has water-saving up to 30% - 50 %.

We can say that some work is being done in this area in the country. One of them is a project implemented by UNDP in Azerbaijan's Shaki region. İn Shaki, more than half the population works in the agriculture sector, contributing to 14% of the country's wheat harvest. Since this region plays a vital role in Azerbaijan's food production, the country intends to implement another agricultural program the UNDP Agro-Biodiversity funded to introduce new technology to traditional practices. In 2019, farmers are receiving new irrigation methods, small grants and training in the Shaki region. UNDP predicts that after receiving these resources, farmers can efficiently harvest more produce using less water. There will be economic benefits that enable farmers to buy more food themselves while providing more food for citizens. So far, four farming families have changed their irrigation methods to the drip method.

However, since the measures taken cover a very small part of the country, we can say that the work done is not enough. It is very important to replace the old methods with new ones in much of the irrigated lands, no matter how costly, because the lost water not only harms the economy but also contradicts the principles of sustainable development and is a serious risk for the country's future water supply in all sectors.

Issues related to transboundary water governance

Azerbaijan is a country located in the South Caucasus at the crossroads of Asia and Europe. Most of the country is below sea level. Therefore, Azerbaijan is a downstream country for large rivers flowing through the country. Therefore, there are serious problems with the country's water supply. This problem is naturally more pronounced in the plains of the country than in the mountainous areas (Lesser Caucasus and Greater Caucasus). The two largest rivers in the country, the Kura and the Aras originate in neighboring countries. Depending on the annual regime of rivers and the water intake (water use) of upstream countries, especially in the spring and summer months, there are difficulties in providing the country's population with drinking and irrigation water. Given the growing demand for water and the declining water resources due to global warming, it is not difficult to predict that the problem of water scarcity will deepen if appropriate adaptation measures are not taken.

Due to its geographical location, Azerbaijan has the lowest water resources among the countries in the South Caucasus region and covers only 15% of the water resources in the whole region. There are only 310 billion m^3 of water in the Caucasus, and the share of water per capita in Azerbaijan is the lowest compared to neighboring republics.

67-70% of the country's river-water resources are formed by transboundary rivers, and the rest (local flow) is formed in the internal rivers of the country. The water reserves of the rivers of Azerbaijan as a whole are 28.1-30.3 km3, and in dry years this reserve decreases to 20-21 cubic kilometers according to Azersu OSJ. The inflow from neighboring countries to the territory of the republic is 19.7-20.3 km3 or 70-72%. The volume of flow formed in the country is 7.81-10.6 km3. Thus, the inflow from neighboring countries is 2.0-2.5 times higher than the local inflow (MENR).

In recent years declining rainfall, rising average annual temperatures lead to a decrease in water resources and drought, and all of which affect the country's drinking water supply, as well as the supply of irrigation water for the agricultural sector. Water shortages in Azerbaijan can be reflected in the water supply per 1 km2 of land. Provision of the territory of the country with the local flow is 90-122 thousand m3 / year, and the water supply of the country as a whole is 324-350 thousand m3 / year taking into account the inflow from foreign countries (MENR).

Water resources of the Kura and Araz rivers are reduced by up to 20% as a result of use in neighboring countries. This leads to an increase in water shortages in the country (about 4-5 km per year) and makes it difficult to meet water needs in Azerbaijan. Pollution of the Araz and Kura rivers by neighboring countries also aggravates the situation (as well as within the country). The Kura and Araz rivers, the main water arteries of the country, are polluted with various chemical elements and compounds and organic substances before entering the country. All this makes negotiations with upstream countries even more necessary.

The decline in water resources is also reflected in the area of glaciers in Azerbaijan. Thus, over the past 70 years, the area of glaciers on mountain peaks has decreased significantly. At present, the area of glaciers is about 6.6 square kilometers, and water reserves are 0.08 cubic kilometers. In addition to the reduction of glaciers, in recent years in the mountainous areas of the Greater and Lesser Caucasus, which play a special role in the formation of water resources of the country, there is a decrease in snow-covered areas and a rise in the lower limit of the snow cover as a result of climate change.

All this leads to a general reduction in our water resources, and appropriate measures must be taken to avoid water shortages in the future. As long as climate change has not exacerbated the situation, it is important to implement new water use strategies.

Prevention of water loss during transportation

On average, about 26 % of total freshwater abstraction is lost during transport. Given that the big part of water use belongs to agriculture, it can be assumed that the bulk of water losses relates to this sector too. As 70-73% of the existing networks in Azerbaijan and are ground channels, in order to reduce water losses during transportation, measures should be taken to minimize the amount of water lost as a result of evaporation from open ground water facilities. Irrigation channels, collector-drainage networks, and hydraulic structures built in the 50s and 80s of the last century are one of the main causes of water losses too. Repairing expired water installations can be another option to avoid water loss.

Using water sparingly

Agriculture is the highest water-demanding sector in Azerbaijan. Report published by European Environment Agency shows that about 75.8 % of total annual freshwater use is accounted for by this sector in 2017. And annual freshwater use increased by 76.5 % by agriculture between 2000 and 2017 in Azerbaijan.

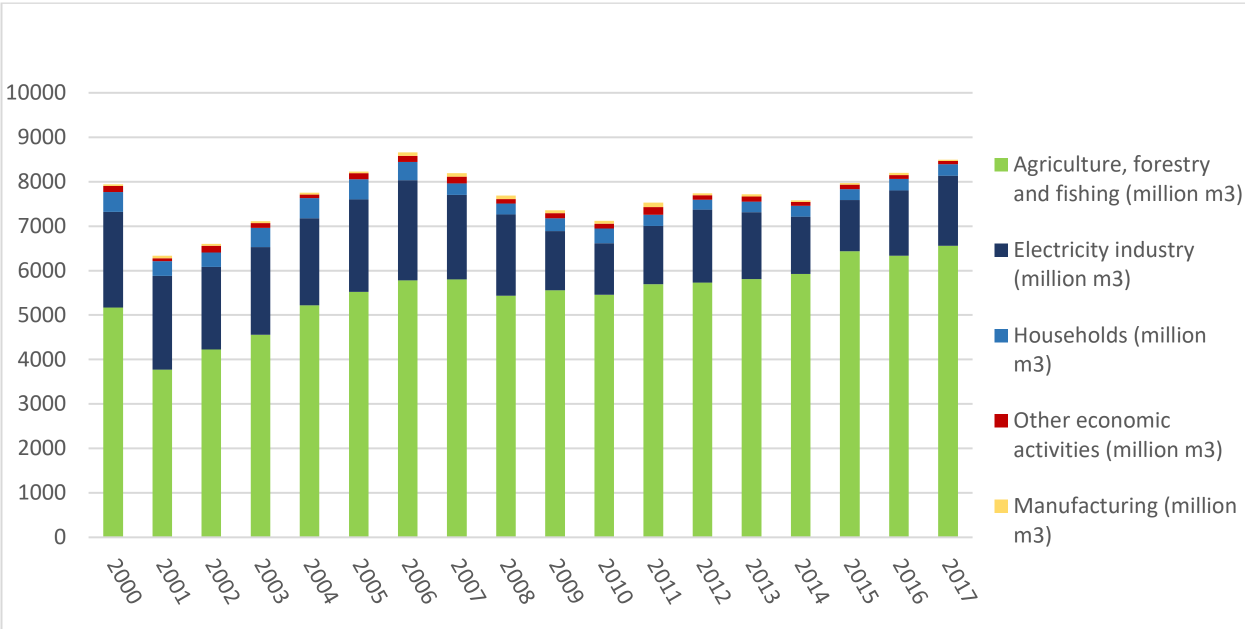


Chart 19. Development of total water use by economic activities in the Republic of Azerbaijan (2000-2017)

Agriculture water reuse is a rediscovered as an important sustainability, conservation and cost-reduction opportunity. Reuse of water and rainwater harvesting are good ideas to avoid waste of water. Multiple use of water and wastewater has many opportunities to produce sustainable and more stable access to water rather than single pass use, as well as for generating valuable products such as agricultural nutrients, soil amendments. Farmers are benefiting from wastewater recycling, and industries also can achieve cost reductions by more water recycling. Currently 6430 mln. m^3 of water is used for irrigation and agricultural supply in the country. Every year 7-8 billion m^3 of water is discharged into the Caspian Sea through collectors. The water collected in the collector drainage networks can be collected and used for re-irrigation.

Cultivation of drought plants

Although most of the cultivated soils of Azerbaijan are based on watering, since various plants have different resistance to water, the demand for water of the cropland is different in accordance with the product being grown. Given that Azerbaijan is among the countries suffering from water scarcity, we recommend the cultivation of drought-tolerant crops.

As can be seen from the chart, the most water-demanding crops grown in Azerbaijan are corn, vineyard, cotton and grain.

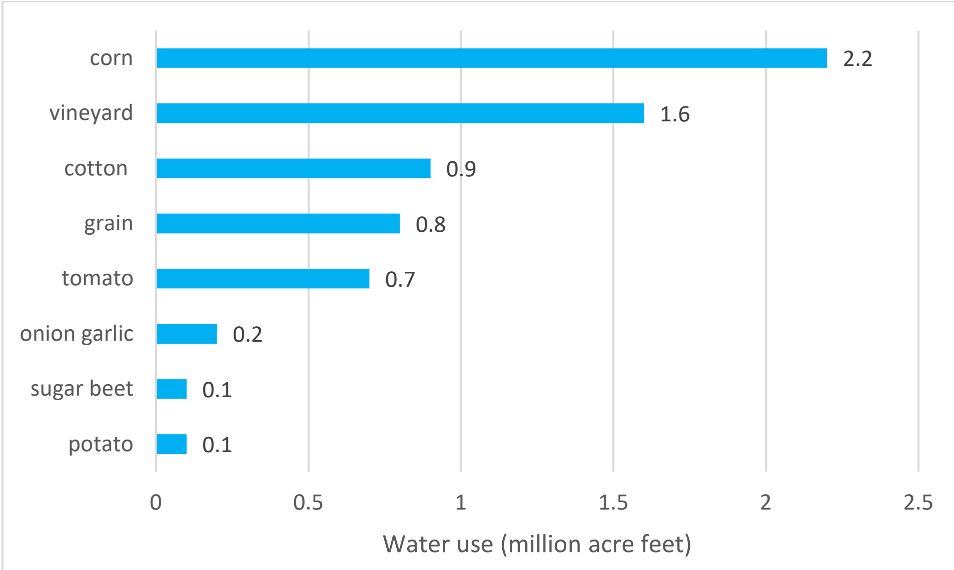


Chart 20. Irrigation water requirements of crops

The most widely grown of these products in Azerbaijan are grain cotton and vineyard, which have high water demand. Sugar beet, onion/garlic and potato crops, which require less water, take up fewer areas, but expanding their planting areas can save water.

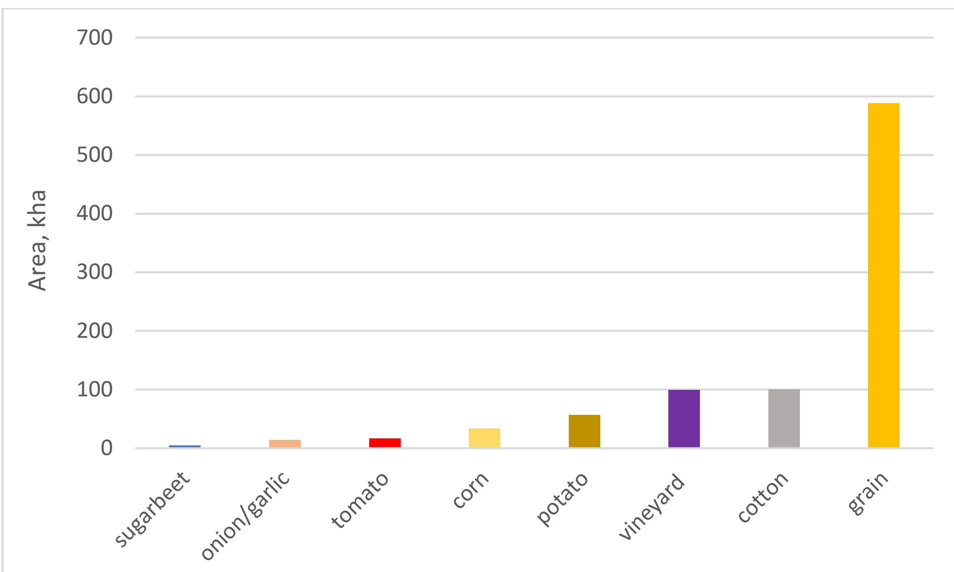


Chart 21. Planted area of crops in 2020

Replacing high water-demanding plants with water-resistant plants is also a good way to save water. However, this process requires extensive botanical researchs - the study of climatic conditions, soil properties and other factors.

Creating food reserves and ensure Food security

Our recommendations should focus on GHG mitigation options while also supporting food security and climate resiliency needs.

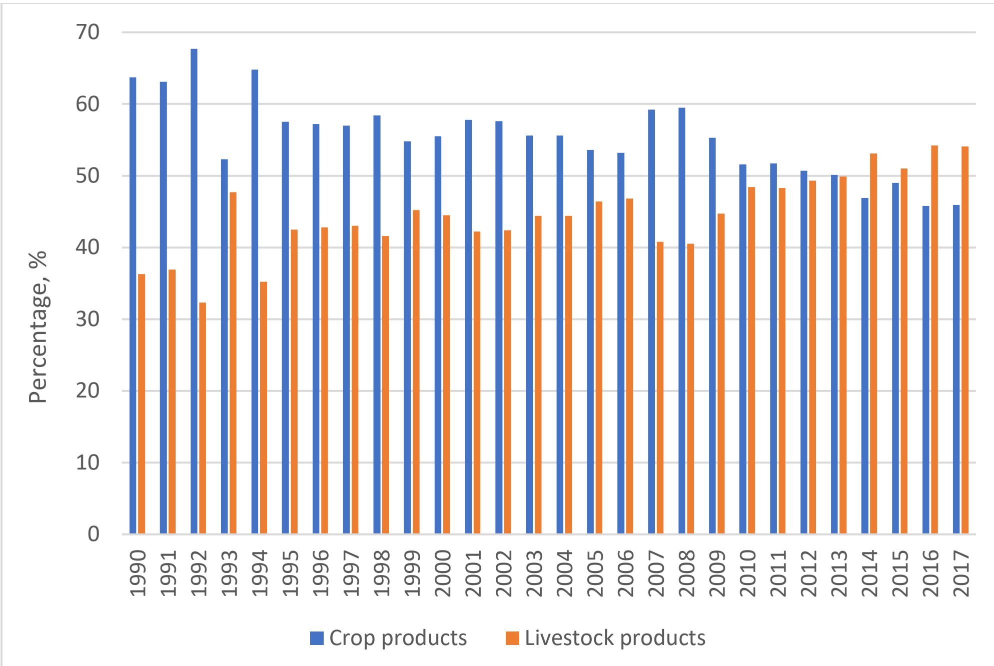


Chart 22. Percentage of crop and livestock products

Conclusion

Ensuring the economic efficiency of agriculture, along with obtaining stable yields of agricultural crops, can be achieved through the economical use of all resources, agro-technically correct and accurate irrigation and operational management. To do this, it is necessary to first analyze the problems and the gaps in this area and ensure that measures are taken to address them. Ensuring the involvement of people working in the field of agriculture- farmers, small entrepreneurs, individual landowners in trainings can also be one of the measures to contribute to th’e process.

This report is designed to identify the sources of agricultural GHG emissions and analyzes the results. The purpose of the mitigation and adaptation methods listed above is to build a climate-resilient agriculture (CRA) model and ensure food security in Azerbaijan.

According to the methodology proposed in the report, the number of livestock in Azerbaijan until 2040 was calculated, and then the methane and carbon equivalents were calculated according to that amount. This scenario is called the BAU scenario. According to the AGRON scenario against the BAU scenario, a policy on mitigation of climate change in the country's agriculture has been proposed and a potential reduction has been calculated for that policy. Calculations show that by implementing appropriate policies in the agricultural sector, it is possible to significantly reduce carbon dioxide.

Above we have presented you 3 scenarios that can be realized under the influence of climate change and human factors. As we have already seen, the water stress indices of the forecasts are 0.8, 0.6 and 0.5, respectively. This means that the forecast, which promises us a better future, is the third scenario. which will allow us to use our water resources sparingly and make us more resilient to climate change. This model not only shows us how important it is to negotiate with upstream countries but also clearly explains the changes that need to be made in the country's water use strategy and the steps that need to be taken. We hope that the necessary mitigation and adaptation measures will be done in this area soon and Azerbaijan will become a country resistant to climate change.

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