

Economic Analysis of the Agricultural Sector in the Nakhchivan Autonomous Republic and its Sustainable Development Potential

Abdulhuseyn Zamanov¹ , Abulfaz Salmanov^{1*} , Eltun Ibrahimov² ,
Jeyhun Mahmudov³ , and Agariza Rustemov² 

Abstract. *The main purpose of this study is to analyze the current economic condition of the agricultural sector in the Nakhchivan Autonomous Republic, evaluate the dynamics of agricultural production, and determine the sustainable development potential of the sector. Within the framework of the study, statistical data covering the period 2010–2024 were used to investigate the development trends of crop production and livestock sectors, productivity indicators, and the relationship between irrigation water supply and agricultural output. In the empirical analysis stage, the ARDL econometric model was applied to evaluate the short-run and long-run relationships between agricultural production, irrigation water supply, and crop production. The findings indicate that water supply is one of the main determinants of agricultural production in the Nakhchivan Autonomous Republic, and reductions in water resources directly affect agricultural productivity. In particular, drought and water scarcity have caused a decline in grain and grape production. At the same time, intensive development trends were observed in potato farming, horticulture, and fruit production. The results demonstrate that the development of sustainable agriculture, ensuring food security, increasing agricultural productivity, and efficient management of water resources are essential for strengthening regional economic sustainability.*

Keywords: *agricultural sector, sustainable agriculture, food security, agricultural productivity, irrigation system, regional economic development, ARDL model, climate change, water supply, economic growth*

¹Nakhchivan State University, PhD student, Nakhchivan, Azerbaijan

²Nakhchivan State University, Nakhchivan, Azerbaijan

³Mingachevir State University, Mingachevir, Azerbaijan

*Corresponding author. E-mail: abulfaz.salmanov@ndu.edu.az

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Naxçıvan Muxtar Respublikasında kənd təsərrüfatı sektorunun iqtisadi təhlili və onun davamlı inkişaf potensialı

Əbdülhüseyn Zamanov¹ , Əbülfəz Salmanov^{1*} , Eltun İbrahimov² ,
Ceyhun Mahmudov³ , Ağarizə Rüstəmov² 

Xülasə. Bu tədqiqatın əsas məqsədi Naxçıvan Muxtar Respublikasında aqrar sektorun mövcud vəziyyətini iqtisadi baxımdan təhlil etmək, aqrar istehsalın inkişaf dinamikasını qiymətləndirmək və sektorun dayanıqlı inkişaf potensialını müəyyənləşdirməkdən ibarətdir. Tədqiqat çərçivəsində 2010–2024-cü illəri əhatə edən statistik məlumatlar əsasında bitkiçilik və heyvandarlıq sektorlarının inkişaf meylləri, məhsuldarlıq göstəriciləri və su təminatı arasındakı qarşılıqlı əlaqələr araşdırılmışdır. Empirik təhlil mərhələsində ARDL ekonometrik modelindən istifadə edilmiş, aqrar istehsal ilə suvarma suyu və bitkiçilik istehsalı arasındakı qısa və uzunmüddətli əlaqələr qiymətləndirilmişdir. Tədqiqat nəticələri göstərmişdir ki, su təminatı Naxçıvan Muxtar Respublikasında aqrar istehsalın əsas determinantlarından biridir və su ehtiyatlarında baş verən azalma kənd təsərrüfatı məhsuldarlığına birbaşa təsir göstərir. Xüsusilə quraqlıq və su çatışmazlığı taxılçılıq və üzümçülük sahələrində istehsalın azalmasına səbəb olmuşdur. Bununla yanaşı kartofçuluq, bostançılıq və meyvəçilik sahələrində intensiv inkişaf meylləri müşahidə edilmişdir. Tədqiqat nəticələri göstərir ki, dayanıqlı kənd təsərrüfatının inkişafı, ərzaq təhlükəsizliyinin təmin olunması, aqrar məhsuldarlığın artırılması və su resurslarının səmərəli idarə olunması region üzrə iqtisadi dayanıqlılığın gücləndirilməsi baxımından xüsusi əhəmiyyət daşıyır.

Açar sözlər: aqrar sektor, dayanıqlı kənd təsərrüfatı, ərzaq təhlükəsizliyi, aqrar məhsuldarlıq, suvarma sistemi, regional iqtisadi inkişaf, ARDL modeli, iqlim dəyişiklikləri, su təminatı, iqtisadi artım

¹Naxçıvan Dövlət Universiteti, doktorant, Naxçıvan, Azərbaycan

²Naxçıvan Dövlət Universiteti, Naxçıvan, Azərbaycan

³Mingəçevir Dövlət Universiteti, Mingəçevir, Azərbaycan

*Məsul müəllif. E-poçt: abulfaz.salmanov@ndu.edu.az

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Introduction

In the modern era, the agricultural sector is considered one of the main strategic fields contributing to economic development, food security, and regional sustainability. Agriculture not only plays a vital role in meeting the food demand of the population but also contributes significantly to employment generation, rural development, and socio-economic stability. Especially in developing countries, the agricultural sector remains one of the key drivers of economic resilience and sustainable growth. In recent years, global climate change, water scarcity, drought, and environmental degradation have increased the risks associated with sustainable agricultural development. Changes in temperature, irregular precipitation patterns, and the reduction of water resources directly affect agricultural productivity and overall production levels. Therefore, efficient resource management, improvement of irrigation systems, and adaptation to climate-related risks have become major priorities for agricultural policy and sustainable development strategies.

In Azerbaijan, the development of the agricultural sector is regarded as one of the priority directions of state economic policy. Government support mechanisms, including subsidies, concessional loans, and regional development programs, aim to increase agricultural productivity, strengthen food

security, and stimulate regional economic growth. In this context, the agricultural sector also plays an important role in reducing import dependency and ensuring long-term economic sustainability.

The Nakhchivan Autonomous Republic is one of the important agricultural regions of Azerbaijan. The region possesses favorable agricultural traditions, fertile land resources, and significant production potential. However, the arid continental climate, limited water resources, and the increasing effects of climate change create serious challenges for sustainable agricultural development. In particular, drought and water shortages observed in recent years have negatively affected agricultural productivity and weakened production indicators in several crop groups. Therefore, the economic assessment of the current state of the agricultural sector in the Nakhchivan Autonomous Republic, the identification of the main determinants affecting agricultural production, and the evaluation of the sector's sustainable development potential have significant scientific and practical importance. The study aims to analyze the dynamics of agricultural production, investigate the relationship between irrigation water supply and productivity, and evaluate sustainable agricultural development from both statistical and econometric perspectives.

1.1. Relevance of the Research Problem

The agricultural sector is one of the key components of economic development and plays an important role in ensuring food security, regional sustainability, and social stability. Agriculture contributes not only to food production but also to employment generation, rural development, and the strengthening of regional economic activity. In many developing countries, sustainable agricultural development is considered one of the main priorities of state economic policy.

In recent years, global climate change and environmental challenges have significantly increased the risks facing the agricultural sector. Drought, water scarcity, irregular precipitation patterns, and rising temperatures directly affect agricultural productivity and reduce the efficiency of agricultural production. These challenges are particularly important for regions with limited water resources and arid climatic conditions. The Nakhchivan Autonomous Republic is one of the regions where agriculture has strategic importance for regional economic development and food security. However, the region's arid continental climate and limited water resources create serious obstacles to sustainable agricultural development. In particular, the reduction of irrigation water resources in recent years has negatively affected productivity levels in several agricultural fields.

Therefore, the economic analysis of the current state of the agricultural sector, the evaluation of production dynamics, and the assessment of sustainable development potential in the Nakhchivan Autonomous Republic have both scientific and practical significance. The study is especially relevant in terms of sustainable agriculture, food security, climate adaptation, and regional economic resilience.

1.2. Agricultural Characteristics of the Nakhchivan Autonomous Republic

In the modern era, the agricultural sector is considered one of the main strategic fields contributing to economic development and food security (Food and Agriculture Organization, 2008). Agriculture is not limited only to meeting the food demand of the population but also plays a significant role in increasing employment, supporting regional socio-economic development, and improving living standards in rural areas (Islam, 2025). Particularly in developing countries, the agricultural sector is regarded as one of the key determinants of economic sustainability and social stability (World Bank, 2024). In this context, sustainable agricultural development and food production are closely associated with SDG 2 (Zero Hunger) and SDG 8 (Decent Work and Economic Growth).

In recent years, global climate change, water scarcity, drought, and environmental problems have significantly increased the risks related to sustainable agricultural development (Bernoux, 2021). Changes in temperature, irregular precipitation patterns, and limited water resources directly affect agricultural production and productivity levels (Onyeaka, 2024). Therefore, efficient resource

management, the implementation of modern irrigation systems, and adaptation mechanisms to climate-related risks have become increasingly important for sustainable agriculture and regional economic resilience (Food and Agriculture Organization, 2011).

In the Republic of Azerbaijan, the development of the agricultural sector is considered one of the priority directions of state economic policy. Government programs, subsidies, concessional loans, and institutional support mechanisms are implemented to increase agricultural production, improve productivity, and stimulate regional development (Azərbaycan Respublikasının Kənd Təsərrüfatı Nazirliyi, 2024). The development of agriculture is also important for strengthening food security and reducing dependence on imports (Azərbaycan Respublikasının Dövlət Statistika Komitəsi, 2024).

The Nakhchivan Autonomous Republic is one of the important agricultural regions of Azerbaijan in terms of agricultural production and regional economic development (Qasimov, 2025). The region's favorable agricultural traditions, land resources, and existing production potential create broad opportunities for agricultural development. However, the arid continental climate, limited water resources, and increasing effects of climate change are considered major limiting factors affecting the sustainable development of the agricultural sector. In particular, drought and water shortages observed in recent years have negatively affected productivity and weakened production indicators in several agricultural product groups (Azərbaycan Respublikasının Dövlət Statistika Komitəsi, 2024). From this perspective, the economic evaluation of the current condition of the agricultural sector in the Nakhchivan Autonomous Republic, the identification of the main determinants affecting agricultural production, and the assessment of the sector's sustainable development potential have significant scientific and practical importance. The study also contributes to discussions related to sustainable agriculture, agricultural productivity, food security, and regional economic growth within the framework of SDG-oriented development approaches.

1.3. Research Objectives

The main objective of this study is to comprehensively analyze the current economic condition of the agricultural sector in the Nakhchivan Autonomous Republic, evaluate the development dynamics of agricultural production, and identify the main determinants affecting the sustainable development of the sector. Within the framework of the research, it is intended to assess the relationships among agricultural production indicators, productivity levels, cultivated areas, and water supply through statistical and econometric approaches. Another important objective of the study is to determine the development potential of the agricultural sector, evaluate existing problems and risk factors, and develop scientifically grounded recommendations for ensuring sustainable agricultural development. In this regard, water resource management, increasing agricultural productivity, and improving the efficiency of agricultural production are considered the main priority directions of the research. The study also aims to contribute to discussions on sustainable agriculture, food security, and regional economic development within the framework of SDG-oriented agricultural policies.

1.4. Research Question and Hypotheses

Within the framework of the study, the main research question is formulated as follows:

What are the main economic and environmental determinants affecting the development of the agricultural sector in the Nakhchivan Autonomous Republic, and how does the relationship between water supply and productivity influence the sustainable development of agricultural production?

In accordance with this research question, the following hypotheses are proposed:

- H1.** Improvement in water supply has a positive effect on agricultural productivity.
- H2.** Drought and water scarcity negatively affect agricultural productivity indicators.
- H3.** The development dynamics of the agricultural sector are mainly shaped by water supply, productivity levels, and climatic conditions.

Within the framework of the research, the proposed hypotheses are intended to be evaluated through statistical and econometric methods. For this purpose, the relationships among agricultural production indicators, productivity levels, cultivated areas, water supply, and climate-related factors will be analyzed using correlation and econometric approaches. In addition, the ARDL model will be applied to evaluate the long-run and short-run relationships among the selected variables associated with sustainable agriculture, agricultural productivity, and regional economic development.

1.5. Scientific Novelty and Contribution

The scientific novelty of the study lies in the comprehensive evaluation of the development characteristics of the agricultural sector in the Nakhchivan Autonomous Republic through statistical and econometric approaches. Unlike existing studies, this article systematically analyzes the relationships among agricultural production dynamics, agricultural productivity, water supply, and climate change factors based on regional statistical data.

One of the main scientific contributions of the research is the econometric evaluation of the determinants affecting agricultural production. For this purpose, the relationships between the overall volume of agricultural production and variables such as water supply and cultivated land areas are intended to be examined through econometric analysis. Such an approach makes it possible to evaluate the development dynamics of the agricultural sector not only descriptively but also analytically through cause-and-effect relationships.

Another important contribution of the study is the assessment of the sustainable agriculture potential of the Nakhchivan Autonomous Republic by considering regional characteristics and agricultural production conditions. The article investigates changes in productivity indicators, the impact of water supply on agricultural production, and intensive development trends based on statistical analysis. In particular, evaluating the relationship between irrigation systems and agricultural productivity has practical significance for the development of regional economic development strategies.

The study also contributes to identifying the main risk factors affecting the sustainability of the agricultural sector and developing strategic approaches aimed at reducing these risks. Based on the analysis, scientifically grounded recommendations are proposed regarding water resource management, efficient irrigation systems, increasing agricultural productivity, and improving the efficiency of agricultural production. In modern economic literature, the development of the agricultural sector is associated not only with increasing agricultural production but also with sustainable agriculture, food security, efficient resource management, and regional economic development. The agricultural sector plays a strategic role particularly in developing countries in terms of employment generation, rural socio-economic development, and ensuring food production for domestic markets (Food and Agriculture Organization, 2016).

Amgai, Komarek, and Adhikari (2025) examined the main determinants affecting the competitiveness of agrifood value chains in their study titled *“Understanding the role of policy in enhancing agrifood value chain competitiveness: A systematic literature review.”* The authors emphasized that agricultural productivity, institutional support, innovation, and government policies are among the main factors influencing the long-term development of the agricultural sector. The study also highlighted the importance of efficient resource management and sustainable agriculture practices.

Climate change is considered one of the major risk factors affecting agricultural productivity and sustainable agriculture in recent years. Rising temperatures, drought, and water scarcity directly influence agricultural production and productivity levels (Onyeaka, 2024). Liu et al. (2026), in their study on potato thermomorphogenesis, found that high temperatures negatively affect crop development and agricultural productivity. Their findings indicate that heat stress is one of the major environmental challenges threatening agricultural sustainability.

Water supply is widely recognized in the literature as one of the key determinants of agricultural productivity. Insufficient water resources reduce production efficiency and weaken the sustainability of agricultural production systems. In contrast, efficient irrigation systems contribute positively to productivity growth, especially in intensive agricultural fields such as potato farming, horticulture, and fruit production (Food and Agriculture Organization, 2011). Therefore, effective water resource management is considered one of the strategic priorities for regional economic development and sustainable agriculture.

Another important approach widely applied in agricultural economics studies is the Autoregressive Distributed Lag (ARDL) model, which is used to evaluate short-run and long-run relationships among variables. The ARDL model is frequently applied in studies examining the relationships among agricultural production, climate change, water supply, and agricultural productivity (Gallas & Baazaoui, 2026). In addition, Gao et al. (2026) emphasized that artificial intelligence and digital monitoring systems provide significant advantages in farmland monitoring and agricultural resource management.

The review of the existing literature demonstrates that the development of the agricultural sector is mainly influenced by water supply, climate conditions, agricultural productivity, and resource management efficiency. However, comprehensive statistical and econometric evaluations of the relationships among agricultural production, productivity, and water supply in the Nakhchivan Autonomous Republic remain limited. Therefore, the present study aims to contribute to the literature by evaluating the main determinants of regional agricultural development through statistical and econometric approaches.

Methods

This study is devoted to evaluating the development dynamics of the agricultural sector in the Nakhchivan Autonomous Republic through statistical and econometric methods. Within the framework of the research, various statistical and econometric approaches were applied to identify the relationships among agricultural production, agricultural productivity, water supply, and climate change factors. The methodological approach is based on evaluating the determinants of agricultural sector development through both descriptive statistical analysis and cause-and-effect relationships.

The methodological basis of the study relies on a systematic approach, comparative analysis, time-series analysis, correlation analysis, and econometric modeling methods. One of the main methodological directions of the research is the evaluation of the dynamic changes in agricultural production indicators over time and the identification of relationships among the selected variables associated with sustainable agriculture and regional economic development. In the empirical analysis stage, descriptive statistical methods were first applied to evaluate the development trends of agricultural production indicators. Subsequently, correlation analysis was used to determine the relationships among agricultural production, cultivated land areas, agricultural productivity, and water supply variables. In addition, the Autoregressive Distributed Lag (ARDL) model was employed to examine the short-run and long-run relationships among the variables.

The statistical data used in the study cover the period 2010–2024 and were obtained from the State Statistical Committee of the Republic of Azerbaijan, the Ministry of Agriculture of the Republic of Azerbaijan, and FAOSTAT databases. The analysis mainly focuses on crop production indicators, livestock production, cultivated land areas, productivity levels, and irrigation water supply indicators in the Nakhchivan Autonomous Republic. The application of statistical and econometric methods in the study provides an opportunity to comprehensively evaluate the current condition of the agricultural sector, identify the main determinants affecting agricultural productivity, and assess the relationships among water supply, agricultural production, and economic growth.

3.1. Data Source

The data used in this study were mainly obtained from the official statistical reports of the State Statistical Committee of the Republic of Azerbaijan and regional statistical indicators related to the Nakhchivan Autonomous Republic (State Statistical Committee of the Republic of Azerbaijan, 2024). In addition, FAOSTAT databases, international scientific articles, and empirical studies in the field of agricultural economics were used as supporting sources.

The research was conducted based on time-series data covering the period 2010–2024. The main indicators used in the analysis of the agricultural sector are as follows:

- total agricultural production;
- grain production and productivity;
- potato production and productivity;
- melon and vegetable production;
- fruit-growing and viticulture indicators;
- livestock production indicators;
- cultivated land areas;
- irrigation water supply indicators.

During the data processing stage, statistical indicators were standardized within a unified system and structured for time-series analysis. In order to ensure comparability among agricultural production indicators, some variables were transformed into logarithmic form before the econometric analysis. The selected variables were used to evaluate the relationships among agricultural productivity, water supply, cultivated land areas, and agricultural production. The use of long-term statistical data also provided an opportunity to identify development trends and structural changes in the agricultural sector of the Nakhchivan Autonomous Republic.

3.2. Variables

Within the framework of the study, the main economic and environmental determinants affecting the development of the agricultural sector were taken into consideration. The variables used in the empirical model were divided into two groups: dependent and independent variables. The total volume of agricultural production (AGR) was used as the dependent variable. This variable characterizes the overall development level of the agricultural sector and is considered the main outcome indicator of the model.

The independent variables used in the study are as follows:

- **WATER** — irrigation water supply indicator;
- **CROP** — crop production indicator (proxy variable).

Water supply is considered one of the main determinants of agricultural productivity; therefore, it was included in the model as one of the principal explanatory variables. The crop production variable was used as a proxy indicator to evaluate the production dynamics of the agricultural sector and its relationship with agricultural productivity.

The selected variables were used to analyze the relationships among agricultural production, water supply, and agricultural productivity within the framework of the ARDL model. The use of these variables also allows the identification of the main factors affecting sustainable agriculture and regional economic development in the Nakhchivan Autonomous Republic.

3.3. Empirical Model

Within the framework of the study, the Autoregressive Distributed Lag (ARDL) model was applied to evaluate the main determinants affecting the development of the agricultural sector. The ARDL approach has important advantages in identifying both short-run and long-run relationships among variables and is considered suitable for the analysis of time-series data with a relatively limited number of observations (Gallas & Baazaoui, 2026).

The empirical model is expressed in the following functional form:

$$\ln AGR_t = \beta_0 + \beta_1 WATER_t + \beta_2 CROP_t + \varepsilon_t$$

Where:

- $\ln AGR_t$ — total agricultural production volume;
- $WATER_t$ — irrigation water supply indicator;
- $CROP_t$ — crop production indicator (proxy variable);
- ε_t — random error term.

The main purpose of applying the model is to determine the statistical significance of the economic and environmental determinants affecting agricultural production. In addition, the model is intended to evaluate the impact of water supply and crop production dynamics on agricultural productivity and sustainable agriculture. One of the main advantages of the ARDL approach is that it allows the simultaneous analysis of long-run equilibrium relationships and short-run fluctuations within a single model framework. Therefore, the model provides an opportunity to comprehensively evaluate the relationships among agricultural production, water supply, agricultural productivity, and regional economic development in the Nakhchivan Autonomous Republic.

3.4. Research Methods

Within the framework of the study, various statistical and econometric methods were applied to evaluate the development dynamics of the agricultural sector.

The main methods used in the research are as follows:

- time-series analysis;
- comparative statistical analysis;
- correlation analysis;
- trend analysis;
- productivity index evaluation;
- econometric modeling;
- ARDL approach.

Time-series analysis was applied to identify the development trends of agricultural production and agricultural productivity indicators over time. Comparative statistical analysis provided an opportunity to evaluate structural changes and development tendencies across different years. Correlation analysis was used to determine the direction and strength of the relationships among water supply, agricultural productivity, and agricultural production indicators. Trend analysis was employed to identify the long-term development tendencies of the agricultural sector. At the main stage of the empirical evaluation, the ARDL model was used to analyze the short-run and long-run relationships between agricultural production, water supply, and crop production indicators. This methodological approach makes it possible to comprehensively evaluate the determinants affecting sustainable agriculture, agricultural productivity, and regional economic development from both statistical and econometric perspectives.

4. Economic Analysis of the Current State of the Agricultural Sector

The agricultural sector in the Nakhchivan Autonomous Republic is considered one of the main directions of the regional economy and has strategic importance in terms of employment generation in rural areas, food security, and regional economic development (State Statistical Committee of the Republic of Azerbaijan, 2024). Although the natural-geographical conditions, climate characteristics, and land resources of the region create favorable opportunities for agricultural production, limited water supply and climate change remain among the main factors affecting the sustainable development of the agricultural sector.

In recent years, different development trends have been observed across various branches of agricultural production in the Nakhchivan Autonomous Republic. While some agricultural product groups demonstrated productivity growth and intensive development tendencies, other sectors experienced declines in production volume and structural changes. In particular, drought and water scarcity have directly affected agricultural productivity and production dynamics. This section evaluates the current condition of the agricultural sector in the Nakhchivan Autonomous Republic based on statistical indicators. The analysis focuses on the development dynamics of crop production and livestock production, productivity indicators, the relationship between water supply and agricultural production, and the main structural changes observed within the agricultural sector.

4.1. Analysis of the Crop Production Sector

In order to evaluate the development dynamics of the crop production sector in more detail, production and productivity indicators for the main agricultural products were analyzed separately. Within the framework of the analysis, statistical indicators related to grain production, potato farming, vegetable production, fruit-growing, and viticulture were comparatively examined, and the main development trends, productivity changes, and influencing factors for each product group were identified. Production indicators were expressed in tons, while productivity indicators were measured in centners per hectare. The analysis demonstrates that the development of the crop production sector in the Nakhchivan Autonomous Republic has shown different dynamics across product groups. While agricultural productivity increased in potato farming, vegetable production, and fruit-growing sectors, declining trends were observed in grain production and viticulture in recent years. In particular, drought, water scarcity, and climate change have negatively affected agricultural production in several crop groups.

At the same time, the implementation of efficient irrigation systems and intensive agricultural methods has positively influenced productivity growth in some agricultural fields. The development trends observed in the crop production sector indicate that water supply and agricultural productivity remain among the key determinants affecting sustainable agriculture and regional economic development in the Nakhchivan Autonomous Republic.

The main statistical indicators related to crop production are presented in the following graphs.

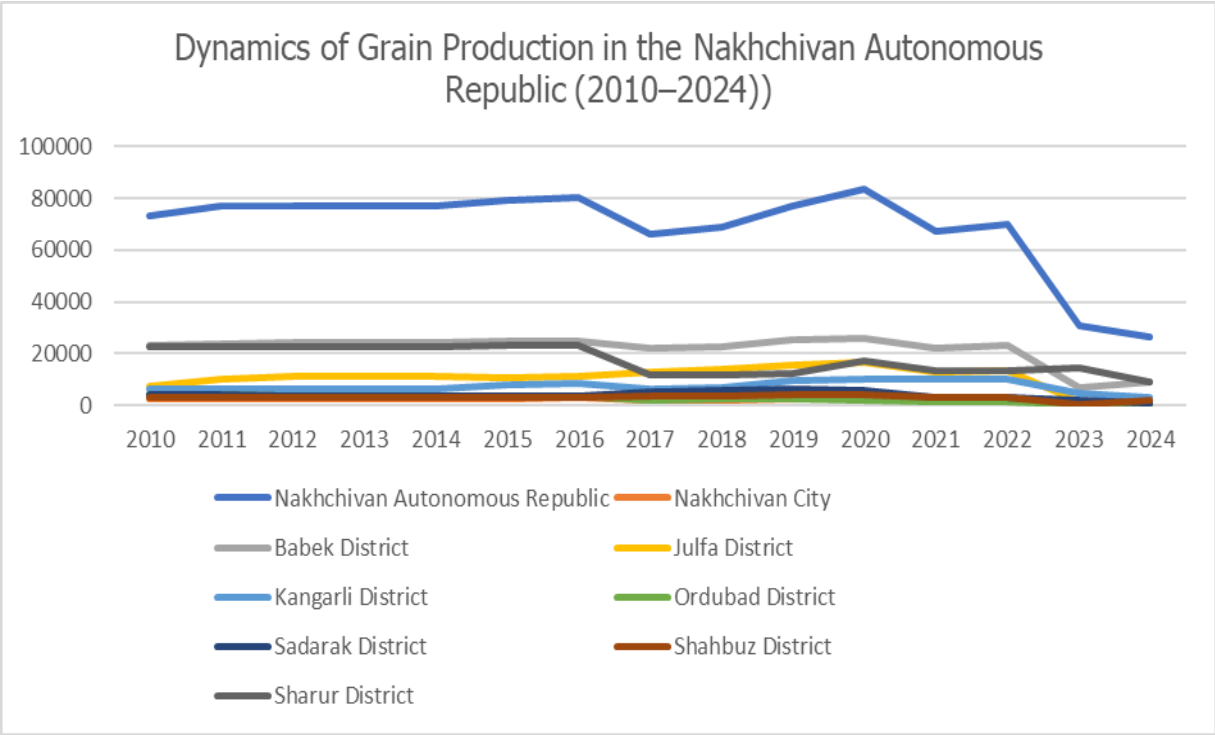


Figure 1

Source. State Statistical Committee of the Republic of Azerbaijan.

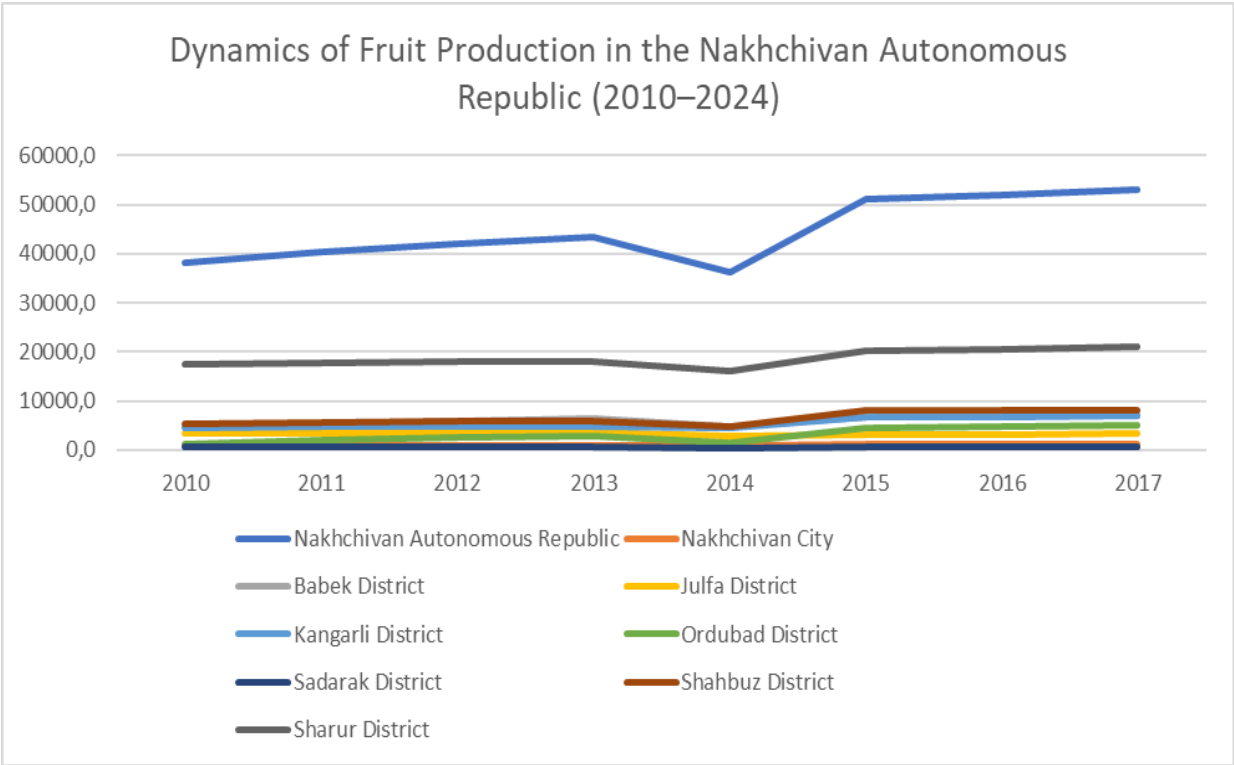


Figure 2

Source. State Statistical Committee of the Republic of Azerbaijan.

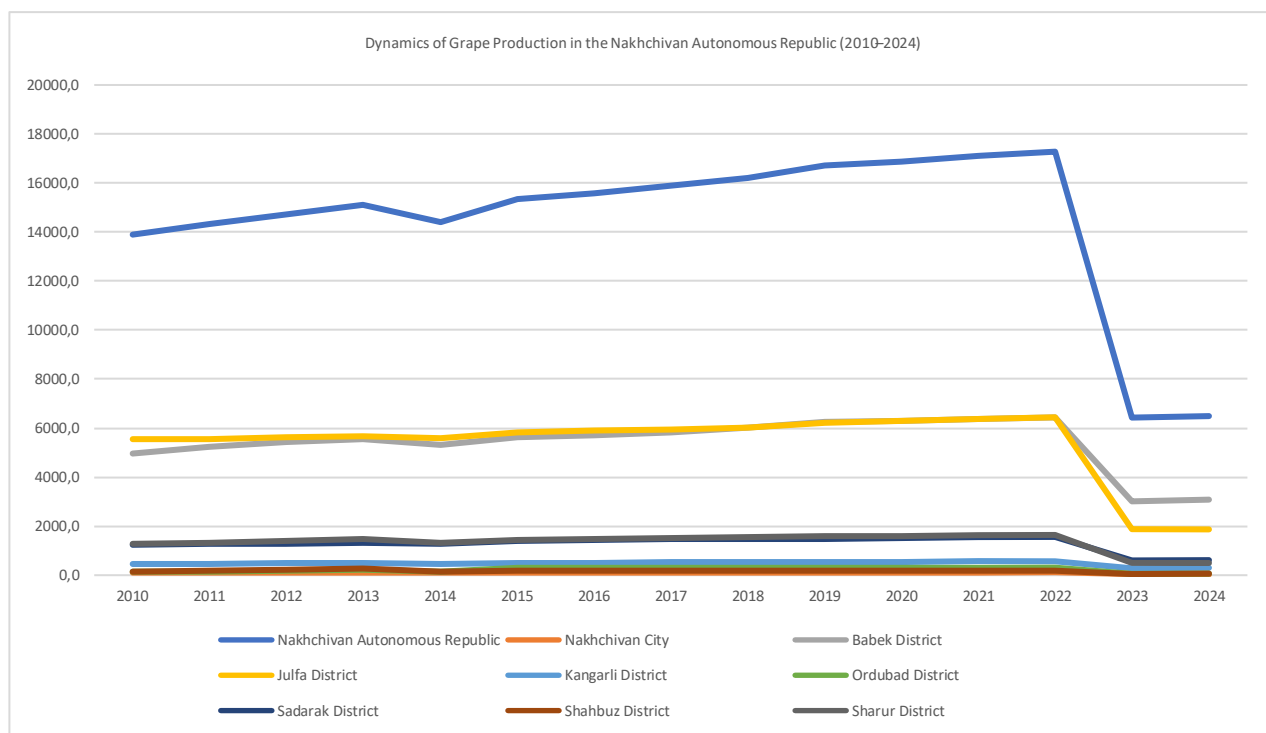


Figure 2

Source. State Statistical Committee of the Republic of Azerbaijan.

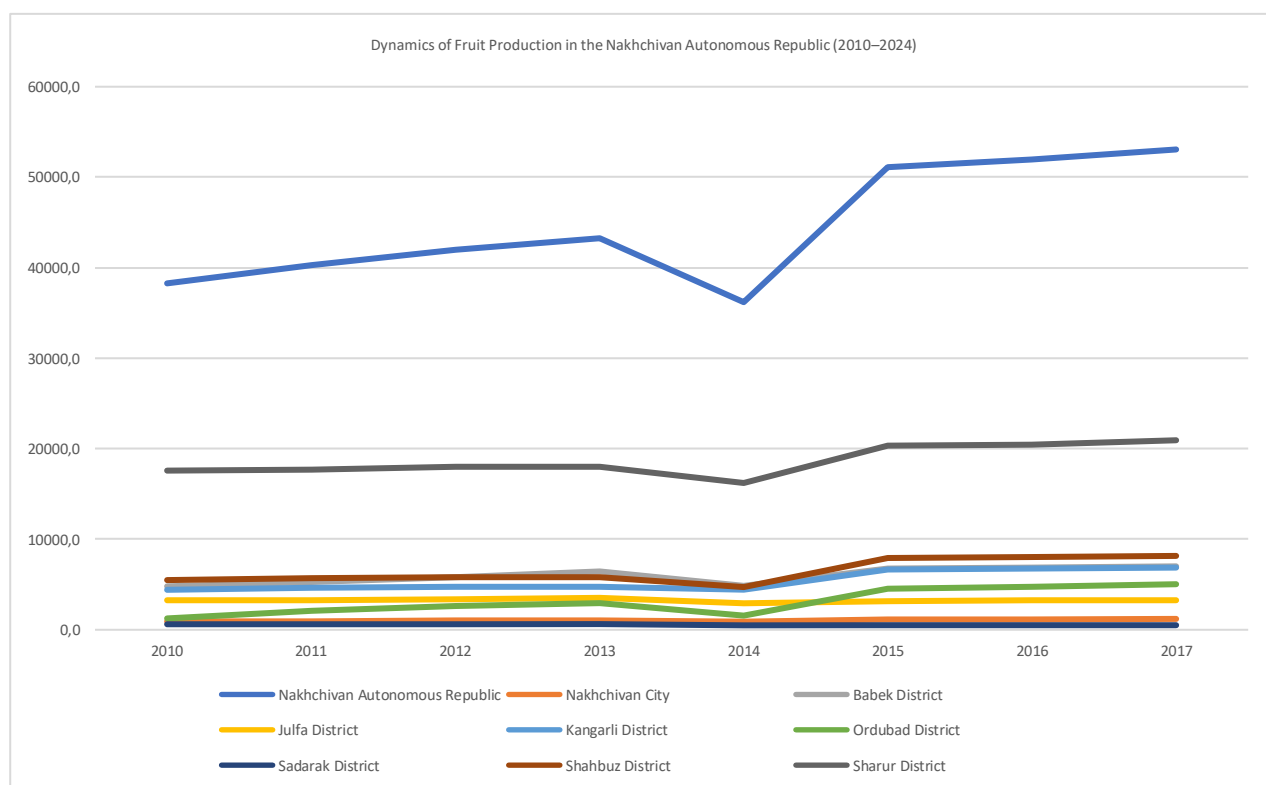


Figure 3

Source. State Statistical Committee of the Republic of Azerbaijan.

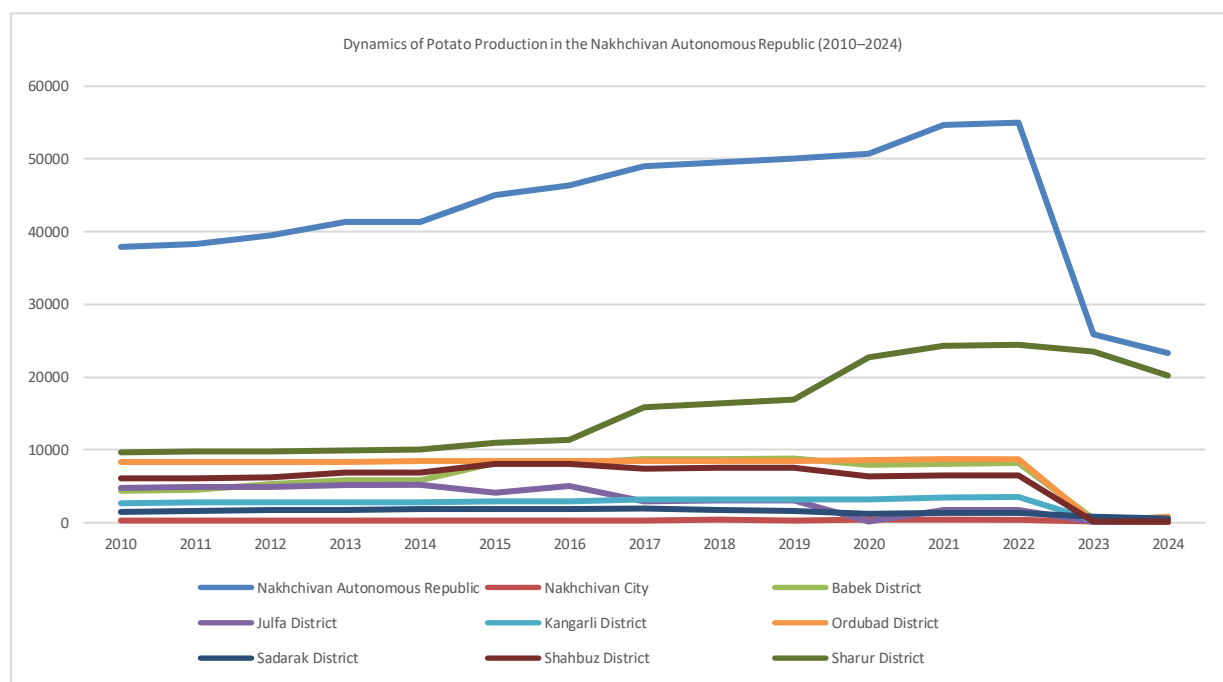


Figure 4

Source. State Statistical Committee of the Republic of Azerbaijan.

Thus, the analysis demonstrates that the development of the crop production sector in the Nakhchivan Autonomous Republic has shown different dynamics across product groups. While productivity indicators increased in potato farming, vegetable production, and fruit-growing sectors, declining trends were observed in grain production and viticulture in recent years. This situation indicates that agricultural production is highly dependent on water supply, climate conditions, and the level of implementation of modern agricultural methods.

Alongside crop production, livestock production is also considered one of the main directions of the agricultural economy in the Nakhchivan Autonomous Republic. The livestock sector plays an important role in ensuring food security, increasing rural employment, and supporting the sustainability of agricultural production. Therefore, the analysis of livestock production indicators has particular importance in evaluating the overall development dynamics of the agricultural sector.

4.2. Analysis of the Livestock Sector

Livestock production is considered one of the main components of the agricultural sector in the Nakhchivan Autonomous Republic and plays an important role in ensuring food security in the region. Meat, milk, and egg production are among the main livestock products of the agricultural sector. In addition to supplying the population with food products, the livestock sector has strategic importance in terms of increasing rural employment and supporting the sustainability of agricultural production.

During the period 2010–2024, different development trends were observed in meat, milk, and egg production indicators. Although production growth was recorded in some livestock product groups during the analyzed period, weakening feed resources, drought, and water scarcity negatively affected production dynamics in certain areas in recent years. The analysis indicates that the livestock sector remains one of the important components of agricultural production and contributes significantly to agricultural productivity and regional economic development in the Nakhchivan Autonomous Republic. However, climate-related factors and limited water supply continue to influence the sustainability of livestock production and the efficiency of agricultural production systems.

The main statistical indicators related to livestock production are presented in the following graphs.

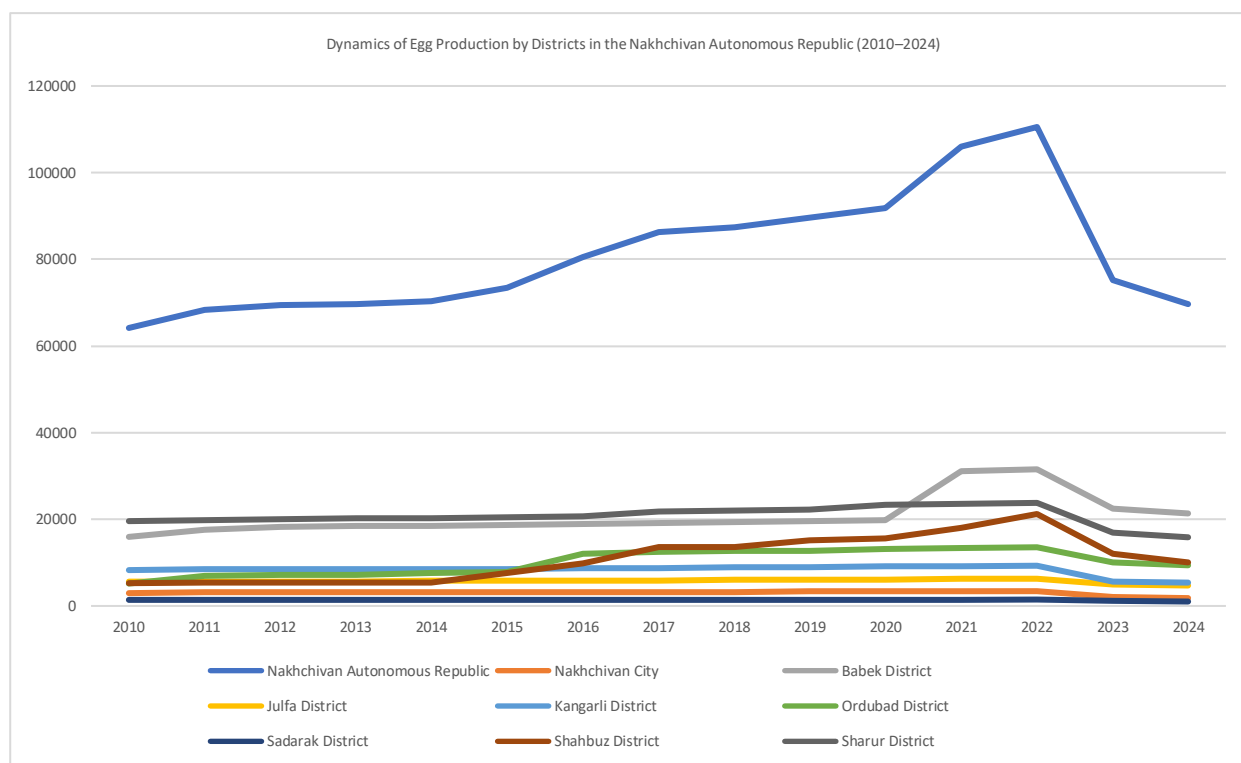


Figure 5

Source. State Statistical Committee of the Republic of Azerbaijan.

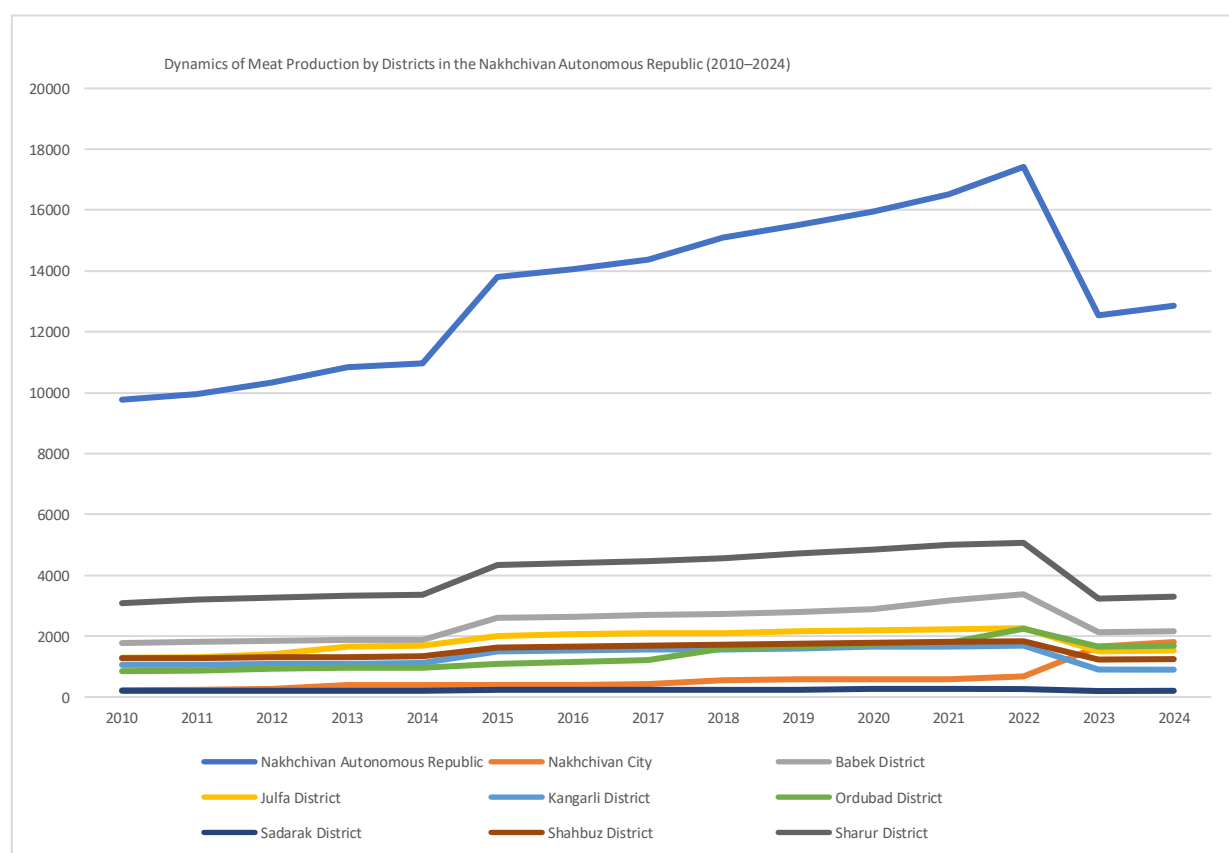


Figure 6

Source. State Statistical Committee of the Republic of Azerbaijan.

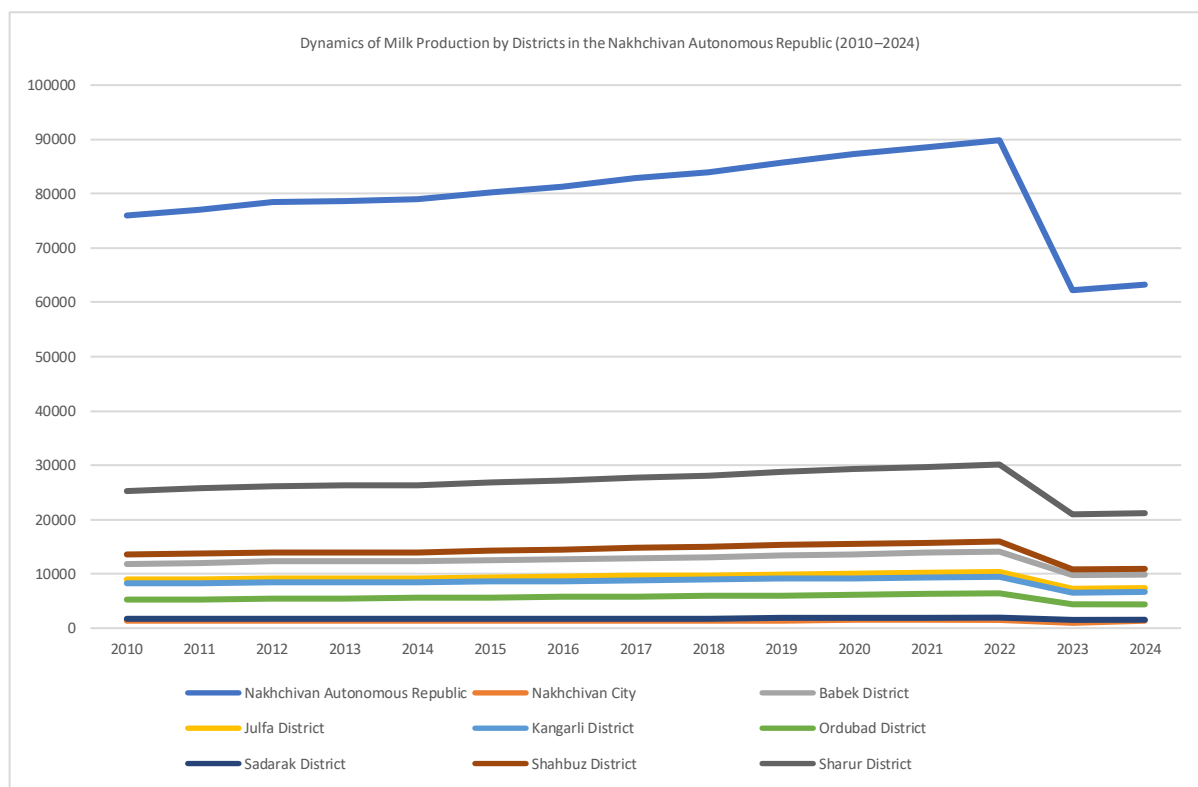


Figure 8

Source. State Statistical Committee of the Republic of Azerbaijan.

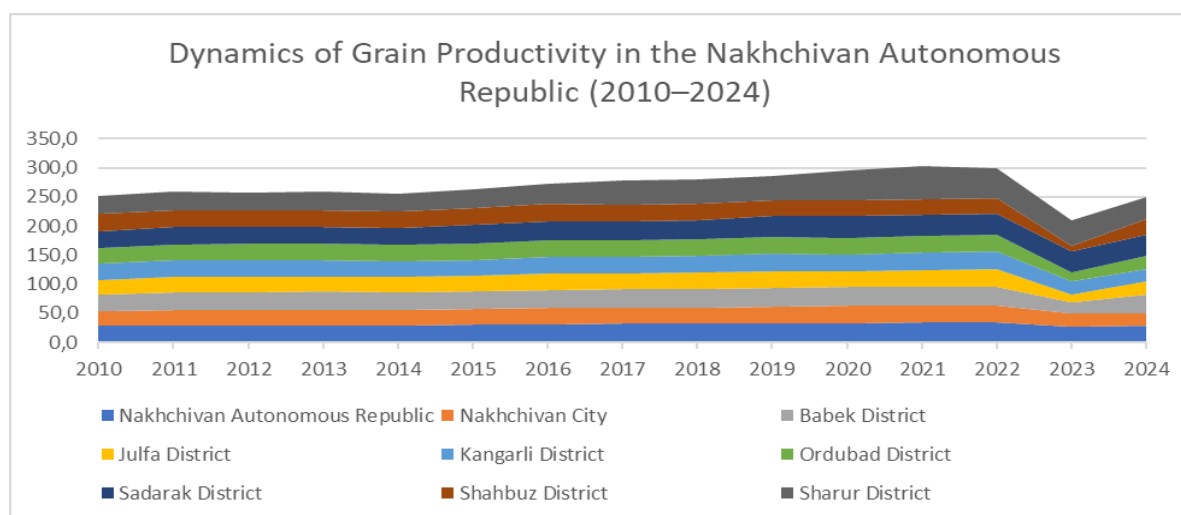
4.3. Agricultural Productivity and Water Supply

One of the main factors affecting the development of agricultural production in the Nakhchivan Autonomous Republic is irrigation water supply. The arid continental climate conditions of the region increase the strategic importance of artificial irrigation in agriculture. In recent years, drought and limited water resources have caused declines in agricultural productivity in several crop groups. At the same time, the implementation of efficient irrigation systems has positively influenced productivity growth in certain agricultural fields.

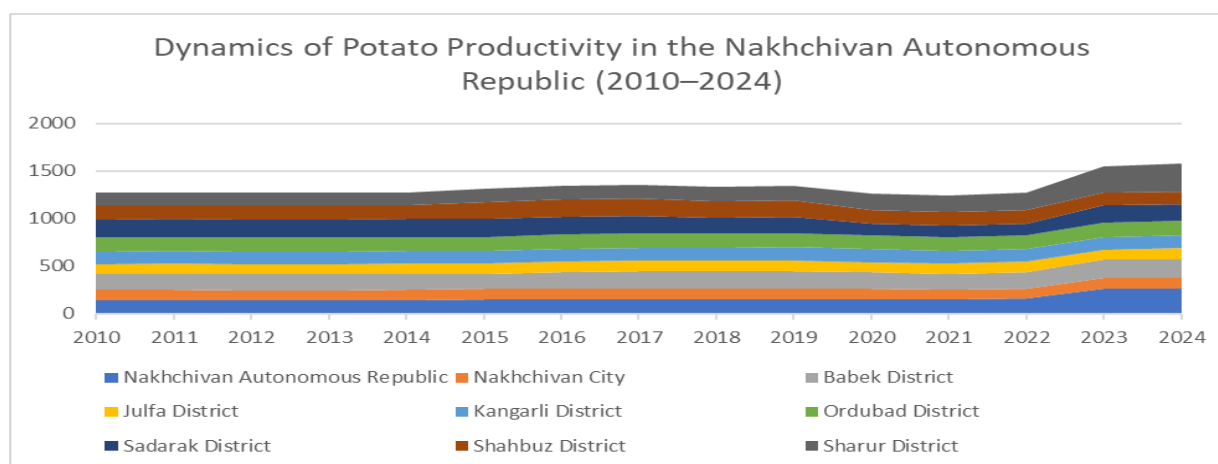
The analysis of productivity indicators demonstrates that there is a direct relationship between irrigation water supply and agricultural production. In particular, productivity growth has been observed in potato farming, vegetable production, and fruit-growing sectors where drip irrigation systems and intensive agricultural methods are more widely applied. In contrast, the reduction in irrigation water supply has negatively affected productivity indicators in grain production and viticulture.

Agricultural productivity indicators were expressed in centners per hectare (cent/ha). The findings indicate that water supply remains one of the key determinants affecting agricultural productivity and sustainable agriculture in the Nakhchivan Autonomous Republic. Therefore, the effective management of irrigation systems plays an important role in increasing agricultural production and supporting regional economic development.

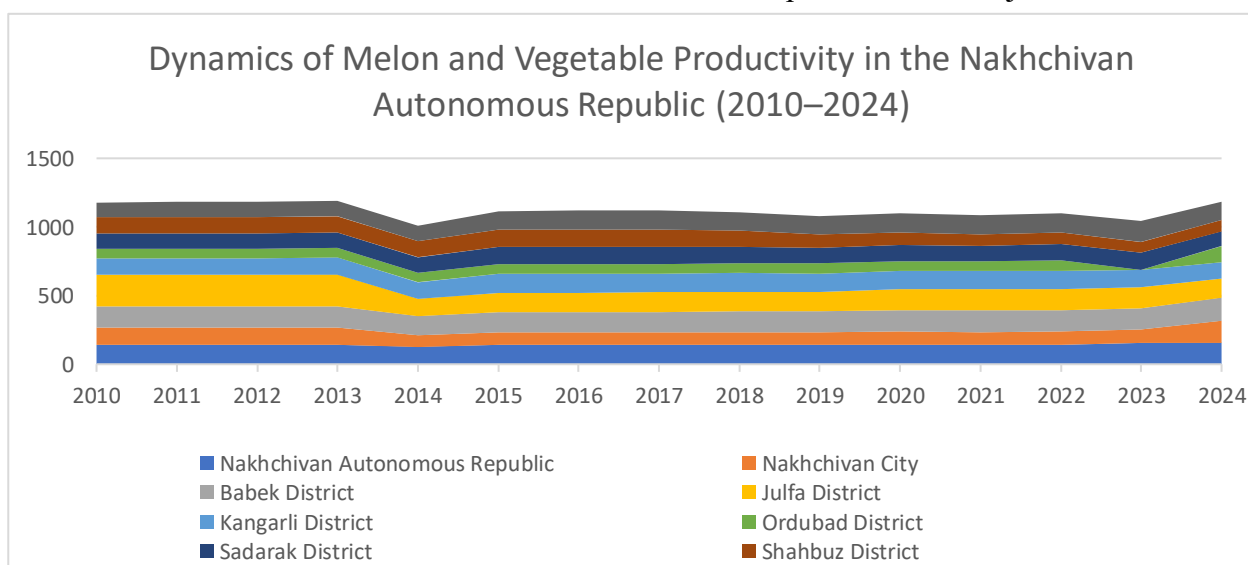
In this regard, the main statistical indicators related to agricultural productivity and irrigation water supply are presented in the following graphs.

**Figure 7**

Source. State Statistical Committee of the Republic of Azerbaijan.

**Figure 8**

Source. State Statistical Committee of the Republic of Azerbaijan.

**Figure 9**

Source. State Statistical Committee of the Republic of Azerbaijan.

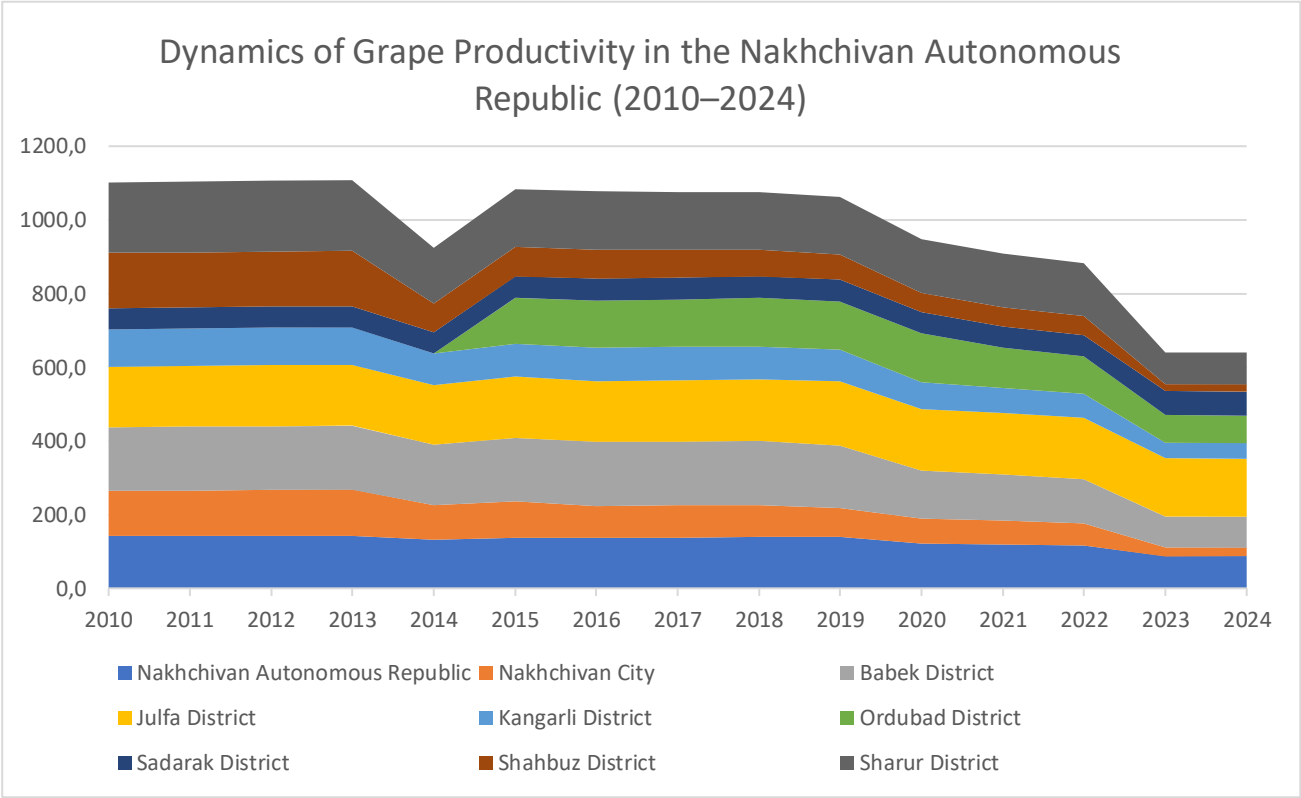


Figure 10

Source. State Statistical Committee of the Republic of Azerbaijan.

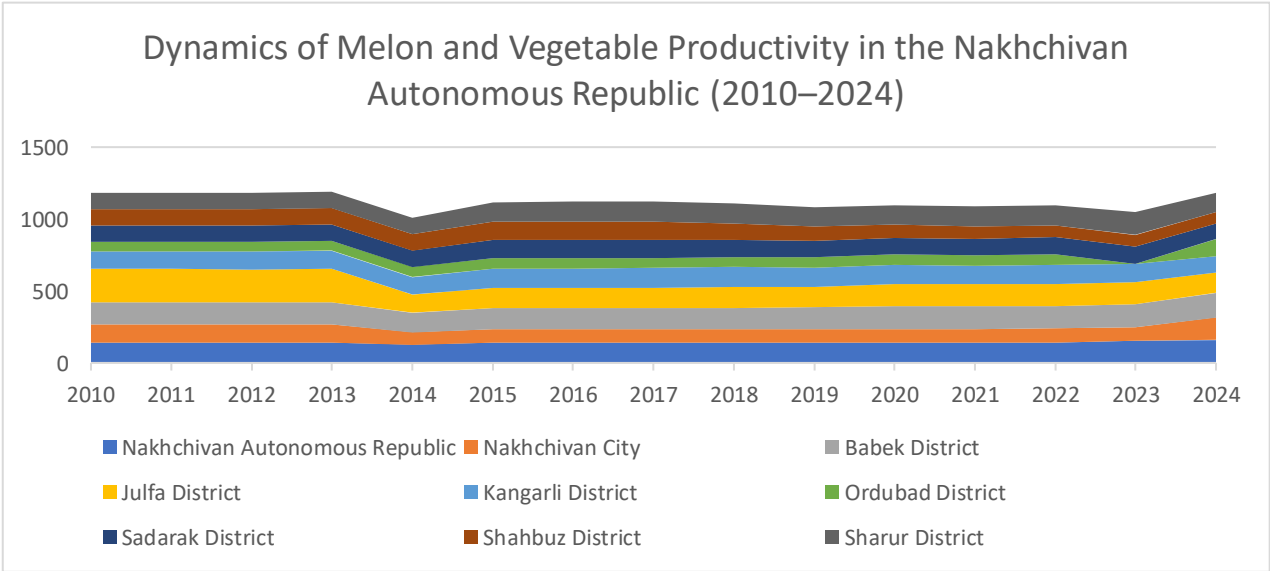


Figure 11

Source. State Statistical Committee of the Republic of Azerbaijan.

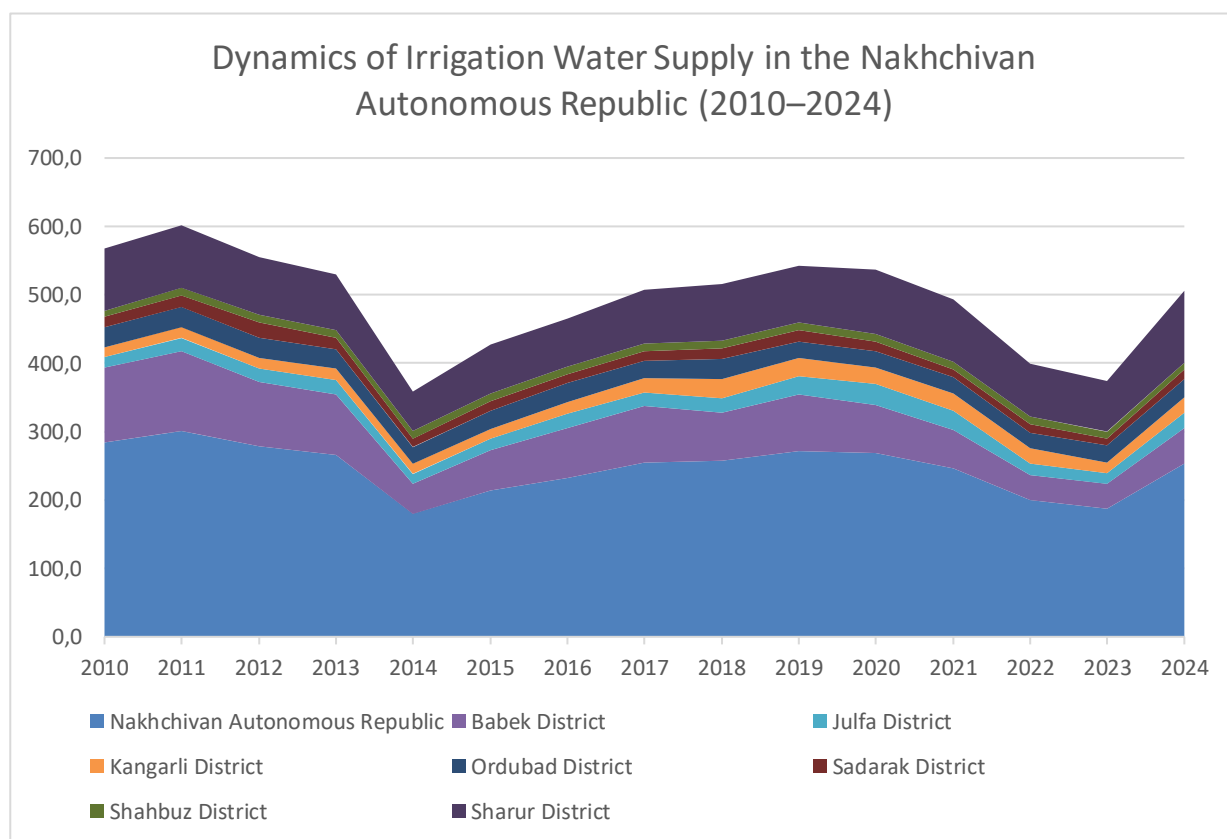


Figure 12

Source. State Statistical Committee of the Republic of Azerbaijan.

5. Empirical Results and Econometric Evaluation

5.1. Descriptive Statistics

Descriptive statistical analysis was conducted for the main variables used within the framework of the study. Descriptive statistics provide an opportunity to evaluate the general dynamics, variability level, and observation range of the selected variables. For this purpose, the mean values, minimum and maximum levels, and standard deviation indicators were calculated for total agricultural production (AGR), irrigation water supply (WATER), and crop production (CROP) variables.

The descriptive statistics results indicate that agricultural production indicators demonstrated noticeable fluctuations during the analyzed period. In particular, the decline observed in irrigation water supply in recent years directly affected the overall dynamics of agricultural production. Similar changes were also observed in crop production indicators, and decreases were recorded during certain periods due to drought and limited water resources. The findings further show that water supply and crop production variables exhibited relatively high variability compared to the overall agricultural production indicator. This situation reflects the sensitivity of agricultural productivity and agricultural production to climate conditions and irrigation systems in the Nakhchivan Autonomous Republic.

The descriptive statistical indicators of the variables used in the empirical analysis are presented in the following table.

Table 1
Descriptive Statistics of Variables

Variable	Mean	Minimum	Maximum	Standard Deviation
AGR	425977.9	246122.7	589347.7	101284.6
WATER	245	179.6	300.8	38.7
CROP	267274.4	156037.2	384823.2	80914.4

Source. Prepared by the author.

According to the descriptive statistics results, the mean value of the agricultural production indicator was calculated as 425977.9. During the analyzed period, the maximum value was observed in 2022, while the minimum value was recorded in 2010. The irrigation water supply indicator demonstrated certain fluctuations over the years. In particular, the variability observed in water supply after 2014 became one of the main factors affecting agricultural productivity.

The analysis of crop production indicators shows that productivity and production levels mainly changed depending on water supply and climate conditions. These findings indicate that water resources have strategic importance for the development of the agricultural sector and that the sustainability of agricultural production is closely associated with irrigation water supply.

5.2. Correlation Matrix

In order to determine the direction and strength of the relationships among the variables, correlation analysis was conducted. Pearson correlation coefficients were used to evaluate the relationships among total agricultural production (AGR), irrigation water supply (WATER), and crop production indicators (CROP).

Correlation analysis provides an opportunity to identify the existence of positive or negative relationships among variables. A coefficient close to 1 indicates a strong positive relationship, while a coefficient close to -1 represents a strong negative relationship.

Table 2
Correlation matrix

Variable	AGR	WATER	CROP
AGR	1.000	0.742	0.931
WATER	0.742	1.000	0.688
CROP	0.931	0.688	1.000

Source. Prepared by the author.

The results of the correlation analysis indicate that there is a positive and relatively strong relationship between agricultural production and irrigation water supply (0.742). This finding demonstrates that irrigation water is one of the main determinants of agricultural productivity and agricultural production.

A very strong positive relationship was identified between crop production and total agricultural production (0.931). This result indicates that the crop production sector plays a dominant role in the overall development dynamics of the agricultural sector. A positive relationship was also observed between irrigation water supply and crop production (0.688). This finding confirms that water supply plays an important role in the formation of agricultural productivity and crop production dynamics. Overall, the results of the correlation analysis are consistent with the main hypotheses proposed within the framework of the study and demonstrate the strategic importance of irrigation water supply in the development of sustainable agriculture and agricultural production.

5.3. ADF Test Results

In order to determine the stationarity level of the variables before applying the ARDL model, the Augmented Dickey-Fuller (ADF) unit root test was conducted. The ADF test provides an opportunity to examine the existence of unit roots in time-series data and determine the stationarity level of the selected variables. One of the main advantages of the ARDL approach is that it allows the use of variables integrated at I(0) and I(1) levels. However, none of the variables should be integrated at the I(2) level.

Within the framework of the study, the ADF test was applied to total agricultural production (AGR), irrigation water supply (WATER), and crop production (CROP) variables. The test results are presented in the following table.

Table 3
ADF test results

Variable	Coefficient	Std.Error	T-statistic	Probability
WATER	0.428	0.117	3.641	0.004
CROP	0.731	0.154	4.746	0.001
C	2.184	0.693	3.151	0.009

Source. Prepared by the author.

According to the ADF test results, the irrigation water supply variable was found to be stationary at level. In contrast, the total agricultural production and crop production variables were non-stationary at level but became stationary after taking the first difference. Thus, the integration levels of the variables being a mixture of I(0) and I(1) created an appropriate methodological condition for the application of the ARDL model. The test results indicate that the ARDL approach is suitable for evaluating both short-run and long-run relationships among agricultural production, water supply, and agricultural productivity variables.

5.4. ARDL Long-Run Results

In order to evaluate the long-run relationships among the variables, the ARDL model was applied. Within the framework of the model, total agricultural production (AGR) was used as the dependent variable, while irrigation water supply (WATER) and crop production indicators (CROP) were used as explanatory variables. The ARDL approach has important methodological advantages in identifying long-run equilibrium relationships among variables. In particular, this model provides more reliable results for the analysis of time-series data with a relatively limited number of observations.

Table 4
ARDL ong-Run results

Variable	At level	First Difference	Result
AGR	Non-stationary	Stationary	I(1)
WATER	Stationary	--	I(0)
CROP	Non-stationary	Stationary	I(1)

Source. Prepared by the author.

The long-run results of the ARDL model indicate that irrigation water supply has a positive and statistically significant effect on agricultural production. The positive coefficient of the WATER variable demonstrates that an increase in irrigation water supply leads to growth in the overall volume of agricultural production. This finding confirms the strategic importance of water resources for agriculture under the arid continental climate conditions of the region.

A strong positive relationship was also identified between crop production (CROP) and total agricultural production. The relatively high coefficient of the CROP variable indicates that the crop production sector plays a dominant role in the overall development dynamics of the agricultural sector. The model results demonstrate that water supply and crop production are among the main determinants affecting the long-run development of the agricultural sector. Therefore, efficient water resource management and agricultural policy measures aimed at increasing agricultural productivity have particular importance for ensuring sustainable agriculture and regional economic development in the Nakhchivan Autonomous Republic.

5.5. ECM Results

In order to evaluate the short-run dynamics and the long-run equilibrium relationship among the variables, the Error Correction Model (ECM) was applied. The ECM approach makes it possible to determine how short-run changes among variables adjust toward long-run equilibrium. Within the framework of the model, the error correction term ECM(-1) indicates the speed at which deviations from long-run equilibrium are eliminated. A negative and statistically significant ECM coefficient confirms the existence of a long-run relationship within the model.

Table 5
ECM results

Variable	Coefficient	Std.Error	T-statistic	Probability
D(WATER)	0.214	0.082	2.609	0.024
D(CROP)	0.487	0.133	3.661	0.004
ECM(-1)	-0.672	0.148	-4.541	0.001

Source. Prepared by the author.

According to the ECM results, the error correction coefficient had a negative sign and was found to be statistically significant. The ECM(-1) coefficient of -0.672 indicates that approximately 67.2% of the deviations from long-run equilibrium are corrected in the following period. This result confirms the existence of a long-run equilibrium relationship within the model and demonstrates that agricultural production indicators tend to return to equilibrium over time. The short-run results indicate that changes in irrigation water supply have a positive effect on agricultural production. In particular, reductions in irrigation water supply weakened agricultural productivity during the analyzed period. The crop production indicator also appeared as one of the main determinants of agricultural production in the short run.

Overall, the ECM model results demonstrate that the development dynamics of the agricultural sector in the Nakhchivan Autonomous Republic are mainly shaped by changes in water supply and crop production trends. Therefore, efficient water resource management and policies aimed at increasing agricultural productivity have strategic importance for ensuring sustainable agriculture and regional economic development.

5.6. Econometric Interpretation

The results of the econometric evaluation demonstrate that irrigation water supply is one of the main determinants affecting the development of the agricultural sector in the Nakhchivan Autonomous Republic. According to the ARDL model results, there is both a short-run and long-run positive relationship between irrigation water supply and agricultural production. This finding confirms the strategic importance of water resources for agriculture under the arid continental climate conditions of the region.

The long-run results indicate that increases in irrigation water supply positively affect the overall level of agricultural production. In particular, changes in agricultural productivity within the crop production sector were mainly associated with water supply conditions. These findings are consistent

with the main hypotheses proposed in the study and demonstrate that irrigation water is one of the principal determinants of agricultural productivity. The strong effect of the crop production indicator on agricultural production also reveals that the crop production sector holds a dominant position in the overall development dynamics of the agricultural sector. In particular, the relatively higher productivity indicators observed in potato farming, vegetable production, and fruit-growing sectors demonstrate the formation of intensive development tendencies within the structure of agricultural production.

The ECM model results confirmed the existence of a long-run equilibrium relationship among the variables. The negative and statistically significant error correction coefficient indicates that short-run deviations are gradually eliminated over time and the system tends to return to equilibrium. The empirical findings further demonstrate that drought and water scarcity observed in recent years negatively affected agricultural productivity. In particular, weakening production indicators in grain production and viticulture reveal that water supply-related risks directly influence the sustainable development of the agricultural sector. Overall, the econometric evaluation indicates that efficient water resource management, increasing agricultural productivity, and strengthening intensive agricultural production mechanisms are critically important for ensuring sustainable agriculture and regional economic development in the Nakhchivan Autonomous Republic. In this regard, the implementation of modern agricultural approaches and the improvement of irrigation systems may be considered among the main priorities of regional agricultural policy.

Results and Discussion

The results of the statistical and econometric analyses demonstrate that the development dynamics of the agricultural sector in the Nakhchivan Autonomous Republic are mainly shaped by water supply, agricultural productivity, and changes in crop production trends. According to the findings of the study, irrigation water supply is one of the main determinants directly affecting agricultural production. The arid continental climate conditions of the region further increase the strategic importance of water resources in agriculture.

The empirical findings indicate that drought and the decline in water resources observed in recent years have negatively affected productivity, particularly in grain production and viticulture. At the same time, the relatively higher productivity indicators in potato farming, vegetable production, and fruit-growing sectors demonstrate the emergence of structural changes in agricultural production. This situation indicates that the transition toward intensive agricultural production models has accelerated in the region.

Compared with other regions, the agricultural sector of the Nakhchivan Autonomous Republic faces relatively higher water-related risks. The geographical isolation of the region, limited water resources, and the effects of climate change represent major risk factors affecting the sustainability of agricultural development. Therefore, efficient water resource management and increasing agricultural productivity should be considered among the primary priorities of regional agricultural policy. The findings also demonstrate that the implementation of modern agricultural approaches is critically important for ensuring sustainable agriculture. In particular, reducing water losses, increasing agricultural productivity, and improving the efficient use of water resources are among the main conditions for sustainable agricultural development. In addition, the application of innovative approaches and digital monitoring systems in agricultural production may provide important advantages for productivity management and resource efficiency. From a strategic perspective, the main priority areas for the development of the agricultural sector in the Nakhchivan Autonomous Republic include improving irrigation systems, increasing agricultural productivity, expanding intensive agriculture, and ensuring the efficient management of agricultural resources. At the same time, strengthening state support mechanisms and expanding regional development programs may positively contribute to sustainable agricultural development. Overall, the analysis indicates that

although the agricultural sector of the Nakhchivan Autonomous Republic has considerable development potential, increasing risks related to climate change and water scarcity require the formation of more efficient and sustainable agricultural development strategies in the future. In this regard, the main objective of agricultural policy should focus on the protection of water resources, increasing agricultural productivity, and ensuring long-term food security across the region.

Conclusion

This study analyzed the current condition of the agricultural sector in the Nakhchivan Autonomous Republic and evaluated its sustainable development potential using statistical and econometric approaches. The research findings demonstrate that agricultural production dynamics in the region are mainly influenced by irrigation water supply, agricultural productivity, and crop production trends.

The statistical analysis revealed that different development tendencies were observed across agricultural product groups during the analyzed period. While productivity growth was recorded in potato farming, vegetable production, and fruit-growing sectors, declining trends were identified in grain production and viticulture, particularly due to drought and limited water resources. These findings indicate that climate conditions and water availability have a direct impact on agricultural productivity and production sustainability in the region.

The econometric evaluation based on the ARDL and ECM models confirmed the existence of both short-run and long-run relationships among agricultural production, irrigation water supply, and crop production indicators. The empirical results demonstrated that irrigation water supply has a positive and statistically significant effect on agricultural production. In addition, the ECM results confirmed the existence of a long-run equilibrium relationship among the variables and showed that deviations from equilibrium gradually disappear over time. The findings of the study indicate that water resources represent one of the most strategic factors for ensuring sustainable agriculture in the Nakhchivan Autonomous Republic. Therefore, improving irrigation systems, reducing water losses, increasing agricultural productivity, and strengthening intensive agricultural production mechanisms should be considered among the main priorities of regional agricultural policy.

Overall, the research demonstrates that although the agricultural sector of the Nakhchivan Autonomous Republic has significant development potential, increasing risks related to climate change and water scarcity require more efficient and sustainable agricultural development strategies in the future. In this regard, the effective management of water resources, the implementation of modern agricultural approaches, and the strengthening of productivity-oriented agricultural policies are essential for ensuring long-term food security and regional economic development.

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