FTAMP 06.71.63 DOI: https://doi.org/10.55871/2072-9847-2024-65-4-141-152

Yessirkepova A.M.*
d.e.s., professor
M. Auezov South Kazakhstan University
Shymkent, Kazakhstan
E-mail: essirkepova@mail.ru
ORCID: https://orcid.org/0000-0002-5028-238X

Niyazbekova R.K.
d.e.s., professor
M. Auezov South Kazakhstan University
Shymkent, Kazakhstan
E-mail: roza.niyazbekova@gmail.com
ORCID: https://orcid.org/0000-0001-6666-0456

Makhmud D.M.
m.e.s., PhD student
M. Auezov South Kazakhstan University
Shymkent, Kazakhstan
e-mail Dinara.Makhmud@auezov.edu.kz
ORCID: https://orcid.org/0009-0005-6737-903X

Zhumagulova A.M.
m.e.s., PhD student
M. Auezov South Kazakhstan University
Shymkent, Kazakhstan
E-mail: asel_1982@mail.ru
ORCID: https://orcid.org/0000-0002-9277-6759

ANALYSIS OF THE IMPACT OF CLIMATIC FACTORS ON THE DEVELOPMENT OF AGRICULTURE IN THE TURKESTAN REGION

Abstract: *This article presents an analysis of the impact of climatic factors on agriculture in the Turkestan region, within the context of the interconnection between global warming and the development of the agro-industrial sector. It describes changes in climate, such as temperature fluctuations, precipitation levels, and humidity, and their interaction with agricultural processes. A central focus of the article is the analysis of climate-related threats and the development of adaptation measures aimed at enhancing the resilience of the agricultural sector.*

Research findings indicate a direct correlation between global warming and agricultural productivity, revealing that the lower the effects of global warming in the region, the higher the likelihood of fluctuations in the yield of various crops. Additionally, a forecast for the gross output of agricultural, forestry, and fishery products (services) by districts, as well as the gross agricultural output by districts in the Turkestan region for 2026, has been conducted. The research is based on the analysis of data on the area of farmland, gross output and the number of workers in agriculture. It is shown that the productivity of land and labor use increased in 2022, which is associated with improved resource exploitation and more efficient farming methods. However, in 2023, there is a decrease in these indicators, which indicates the negative environmental impacts that have affected the excessive use of resources. At the same time, the article substantiates the need to use rational farming methods and the introduction of agrotechnologies that reduce the impact on climate change. It is expected that the implementation of these measures will lead to an increase in export potential, improvement of resource efficiency and reduction of risks associated with climate change. As a result, sustainable agriculture will ensure stable incomes and sustainability of the agricultural sector in the long term.

Keywords: *climate change, agricultural adaptation, precipitation variability, temperature fluctuations, labor productivity, Turkestan region***.**

Introduction

Relevance

Global warming and agriculture are two interconnected concepts. Changes in average temperature, precipitation levels, carbon dioxide, and ozone can significantly affect agriculture. Examples of negative impacts include the expansion of the range of agricultural pests, the potential intensification of drought in certain areas, and soil salinization due to rising sea levels. Positive impacts may include an extended growing season and the associated expansion of risk-free farming zones, potential increases in precipitation in some regions, and enhanced plant mass productivity due to elevated carbon dioxide levels in the atmosphere.

Agriculture also influences climate change. The primary cause of global warming often lies in greenhouse gas emissions, as well as the conversion of non-agricultural land, such as deforestation for agricultural purposes. Agriculture is a major contributor to the increase in methane and nitrous oxide levels in the Earth's atmosphere.

Despite technological advancements, such as the breeding of new plant species and the development of irrigation systems, weather remains the dominant factor in determining the quantity and quality of crop yields. Hence, agronomists believe that the assessment of yield loss or gain should be region-specific [1].

Scientific Significance

A study published in the journal 'Science' predicts that by 2030, Africa could lose more than 30% of its maize harvest, while losses of rice and millet in Asia may reach up to 10% of total production [2]. In this context, the present study analyzes the impact of global warming, particularly climate change, on agriculture in the Turkestan region. Special attention is given to trends in air temperature variation and their consequences for agricultural processes. This research is crucial for understanding the current and future challenges facing agriculture, not only in the region but also across the country.

Research Objective

The objective of this research is to conduct a comprehensive analysis of agricultural development in consideration of the climatic characteristics of various regions within the Turkestan region and to formulate recommendations for adapting agriculture to climate change. This work is aimed at enhancing the resilience of the agricultural sector to climate threats, with an emphasis on forecasting crop yields.

Main Body

Literature Review

Agriculture faces significant challenges due to climate change, both in Central Asia and globally. As global climatic conditions evolve, there is growing interest in international trade of agricultural commodities as a potential adaptation strategy. However, the impact of climate change on grain trade in Central Asia remains insufficiently studied. Specifically, an analysis conducted using the gravity model for Kazakhstan reveals that changes in precipitation and temperature can substantially affect grain trade flows. For instance, a 1-millimeter increase in rainfall during the wheat harvesting period (from May to August) could lead to a 0.7% increase in wheat exports and a 1.7% decrease in wheat imports. Meanwhile, a 1°C rise in temperature during the same period could boost wheat exports by 21.9% and reduce imports by 49.4%. Given Kazakhstan's pivotal role in global grain trade, such changes could have profound implications for global food security.

The uncertainty of future climate changes, coupled with socio-economic conditions and population growth, heightens the interest in systems linking water, energy, food, and ecology to analyze water resources. Modeling these interconnections aims to reduce multidimensional uncertainty and effectively measure complex linkages. In this context, the proposed methodological solution, which incorporates a Bayesian network for water resource analysis, allows for more precise consideration of climate factor interactions. The analysis indicates that in the short term, it is beneficial to increase the share of food crops, improve water use efficiency, and prevent drought damage. In the long term, the implementation of drip irrigation technologies, increasing usage from 50% to 80%, could significantly raise the annual water inflow to the Aral Sea by 6.4-9.6 km^3, helping to mitigate the environmental crisis in the region [3]

These changes also underscore the need for the development and implementation of innovative methods to enhance the resilience of agriculture. The paper «Striving for Preservation: Innovative Methods of Arid Land Reclamation in the Turkestan Region» emphasizes the necessity for new approaches to land reclamation focused on strengthening ecosystems and restoring natural resources. The researchers also highlight the importance of modern soil monitoring systems for more efficient resource management [4].

Wheat, as a key commodity for ensuring global food security, is especially important in the northern regions of the country. However, these regions, which rely on spring rainfed agriculture, are the most vulnerable to climate change and the scarcity of rainfall. To analyze the impact of climate change on wheat yield, researchers apply linear methods and drought indices, such as the Standardized Precipitation Index (SPI) and the Standardized Precipitation Evapotranspiration Index (SPEI). The results reveal significant internal variability in wheat yield and its correlation with three-month drought indicators in June and July over the period from 1950 to 2020. These data underscore the potential vulnerability of wheat in Kazakhstan to changes in precipitation patterns and the increasing frequency and intensity of droughts in the future [5].

Methods

In this study, the following methods were employed: data forecasting using linear extrapolation with Python for predicting data for 2026; data analysis, where input data were collected and structured using Python libraries (numpy and pandas) to ensure efficient data processing and analysis; average growth rate and forecasting, where the average growth rate was calculated for each region of the Turkestan region, followed by the forecasting of gross agricultural output (services) by districts, including irrigated lands for 2021-2023, with projections for 2025 and 2026, and values were rounded to simplify data interpretation.

Results

Kazakhstan's climate continues to warm. Since the 1960s, each subsequent decade has been warmer than the previous one. The average annual air temperature over the last decade (2013-2022) was +6.75°C, exceeding the climatic norm by 1.33°C, a record among positive decadal anomalies, with the previous warmest decade being 2003-2012 with an anomaly of +0.88°C. The last five-year period (2018-2022) was also the warmest, with an average annual air temperature of +6.79°C, exceeding the climatic norm by 1.36°C.

Nine of the ten warmest years have occurred in the 21st century. Similarly to the global scale, the highest average temperature in Kazakhstan was recorded in 2020, with an anomaly of 1.92°C, surpassing the previous record set in 2013 with an anomaly of 1.89°C. The year 2022, with an air temperature anomaly of 1.78°C, ranked third among the warmest years in Kazakhstan's history (Figure 1).

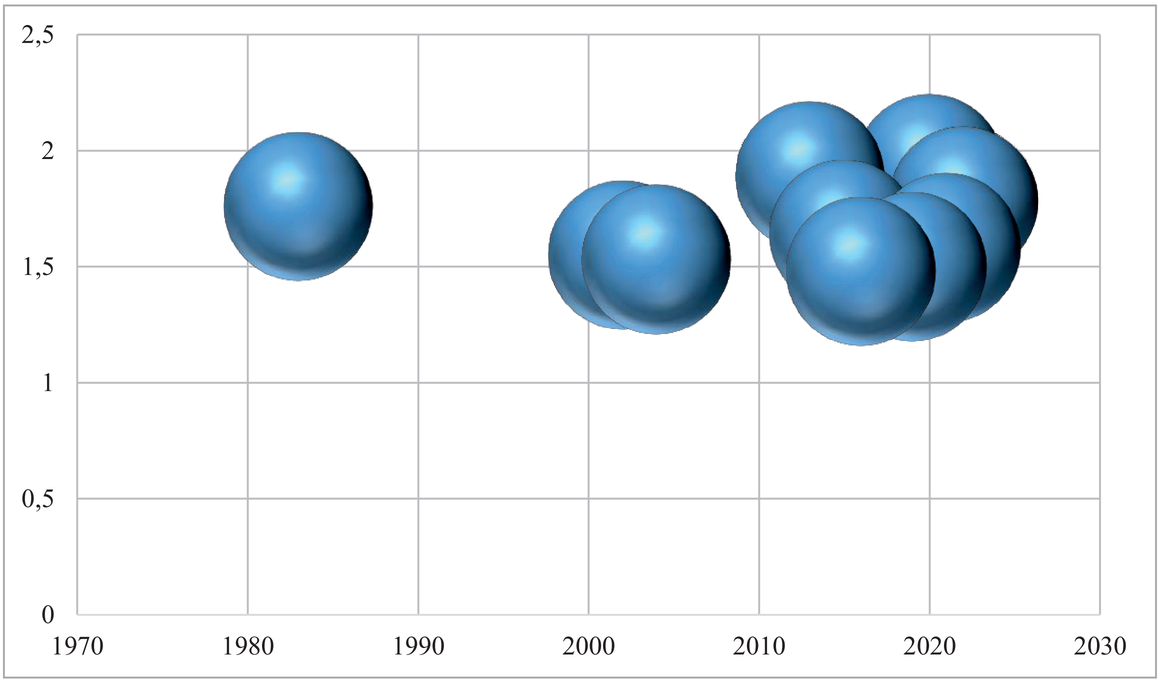

Figure 1. The warmest years in Kazakhstan's observational history from 1941 to 2022 and the corresponding anomalies of mean annual surface air temperature, averaged across Kazakhstan. Anomalies are calculated relative to the period 1961-1990

Extremely high annual temperatures were recorded at 75 meteorological stations, with anomalies ranging from 2.0 to 2.5°C in the southwestern, southern, and southeastern regions of the country. According to data from 29 meteorological stations in the southern, western, and eastern regions, the temperature anomaly reached up to 3.1°C. The year 2022 was the warmest year since 1941 in these regions, with record temperature anomalies ranging from +1.13 to +3.11°C in the Turkestan region (Table 1) [6].

Table 1. Temperature in the Turkestan region from 2015-2023, °C:

	2015	2016	2017	2018	2019	2020	2021	2022	2023
January	-2	2	0	-2	3	-1	-3	1	-4
February	4	4,5	-3	0	4	4	3	3	2,5
March	6	11,5	5,5	10	11	10	6	6	13
April	15	16	14	15	15	18	16	21	17
May	23	22	24	21	23	24	25	23	24
June	28	27,5	27,5	27	27	27	29	30	29,5
July	30	29	31,5	32	34	30	31	30	32
August	27	29,5	29	27	28	27	30	28	28
September	21	24	22	21	20	20	23	26	21
October	10	10	12,5	13	15	13	10	15	15
November	5	1	7,5	2	3	3	4	7,5	10
December	0	0	-3	3	2	-5	4	-2	0
Annual Average Temperature:	13,9	14,8	14,0	14,1	15,4	14,2	14,8	15,7	15,7
Note: The information on air temperature, humidity, and wind speed in Turkestan for 2015-2023 is based on data from World Weather statistics [7].									

Let us next examine specific weather data in the context of climate change for one of the key regions in the Turkestan region – the city of Turkestan. The hot season spans 3.8 months, from May 19 to September 13, with an average daily maximum temperature exceeding 28°C. July is the hottest month in Turkestan, with an average maximum temperature of 34°C and a minimum of 19°C (see Fig. 2).

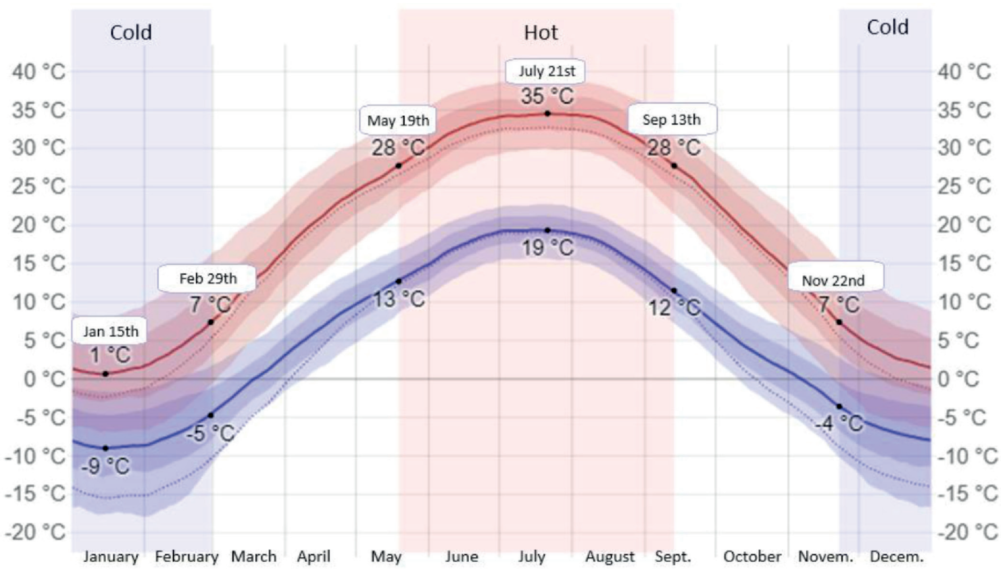

Figure 2. Average maximum and minimum temperatures in the city of Turkestan [8]

The cold season lasts 3.2 months, from November 22 to February 29, with an average daily minimum temperature below 7°C. January is the coldest month of the year in Turkestan, with an average maximum temperature of -9°C and a minimum of 1°C. Below is the graph depicting the average hourly temperature in Turkestan.

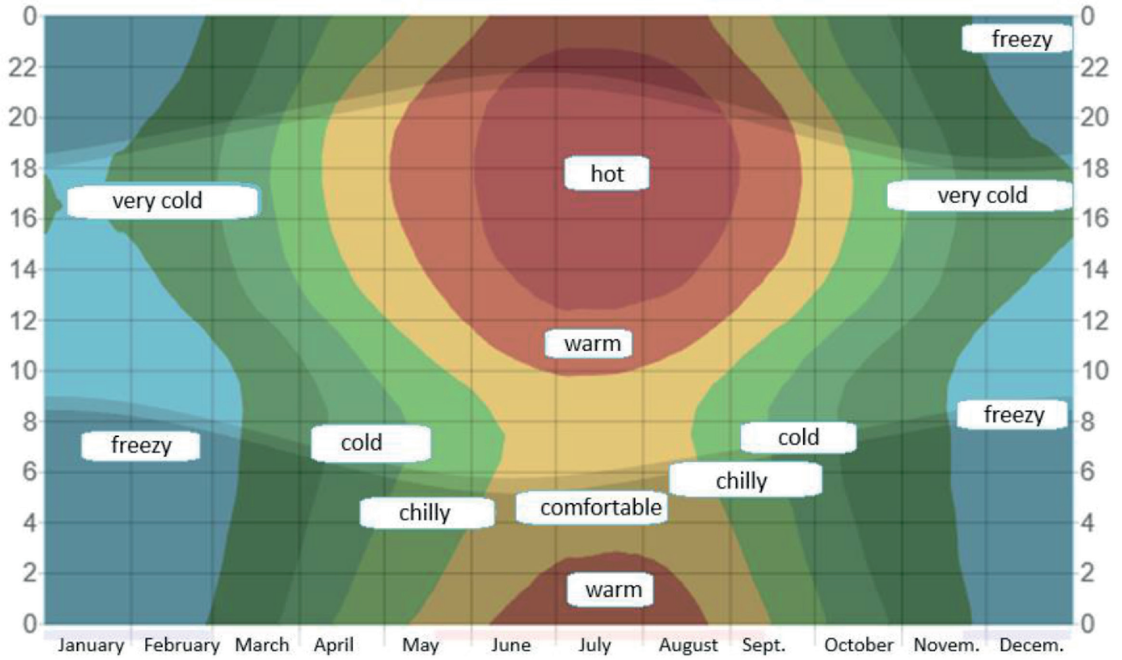

Figure 3. Average Hourly Temperature in Turkestan [8]

Definitions of the growing season vary worldwide; however, for the purposes of this description, we define it as the longest continuous period in the year during which temperatures exceed the freezing point (a calendar year in the Northern Hemisphere or *from July 1 to June 30* in the Southern Hemisphere). The growing season in Turkestan typically lasts 6.2 months (190 days), approximately from *April 7 to October 14*. It rarely begins before *March 19* or after *May 1* and seldom ends before *September 28* or after *November 1* (see Figures 3-4).

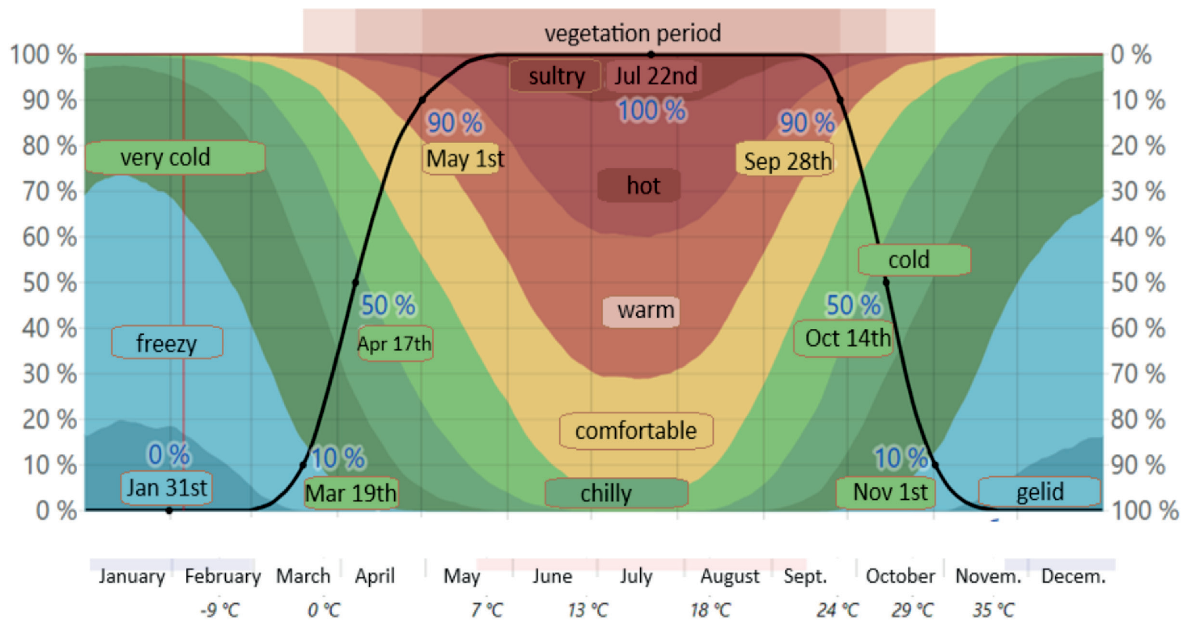

Figure 4. Time Spent in Various Temperature Ranges and Growing Season in Turkestan [8]

Our network includes only one weather station, Shymkent Airport, which is suitable as a proxy for historical temperature and dew point data for Turkestan. Located 144 kilometers from Turkestan, which is within our threshold of 150 kilometers, this station is considered close enough to be relied upon as a primary source of temperature and dew point data. The station's data have been adjusted for the altitude difference between the station and Turkestan according to the International Standard Atmosphere, as well as for relative changes in the MERRA-2 satellite-era reanalysis between the two locations [9].

Next, we will examine the impact of climate change on the agricultural sector as a whole. According to the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of Kazakhstan, the gross harvest of cereals and pulses in the country was estimated at 14.9 million tons in 2021, the lowest since 2012, and 18% lower than the previous season [10]. Data for 2022 show that with an average cereal yield of 13.0 c/ha, 20.1 million tons of grain were produced. In contrast, in 2021, with an average yield of 9.8 c/ha, 14.9 million tons were harvested, representing a 25.9% decrease compared to 2022. The most critical factors affecting the 2021 harvest were decreases in cereal yields in Akmolinskaya (25%), Kostanay (30%), and North Kazakhstan (20%) regions compared to 2020. The most remarkable yield reduction in 2021 was observed in the Aktobe region at 48%, while the most stable yield was reported in the Almaty region, where the average cereal yield remained unchanged from the previous year. Notably, the East Kazakhstan and Pavlodar regions experienced increases in yields of 27% and 37%, respectively, compared to the previous season, partially offsetting the overall decrease in the national average [49]. Meanwhile, wheat exports from Kazakhstan in 2021-2022 were estimated at 6 million tons, a 4% increase over the previous season. This increase is due to an expected reduction in domestic grain consumption to 7.9 million tons, an 11% decrease from the previous season, and a projected rise in wheat imports to 700,000 tons. It is important to note that even minor climate fluctuations are critical for the Turkestan region, which is traditionally oriented towards agriculture. More than 30% of the gross regional product is generated by the agricultural sector, creating a meaningful need to improve the efficiency of natural resource use and introduce new technologies.

Based on the data from 2021, 2022, and 2023, forecasts for 2025 and 2026 were generated using Python, employing linear extrapolation to estimate the Gross Output of Agricultural, Forestry, and Fisheries Production (Services) by districts (similar code with corresponding data for Gross Output of Agricultural Production (Services) by districts, including irrigated lands) (Tables 2 and 3).

Table 2. Gross Output of Agricultural, Forestry, and Fisheries Production (Services) by Districts for 2021-2023, with Forecasts for 2025 and 2026 [11-12].

Districts	2021	2022	2023	2025 (forecast)	2026 (forecast)
Turkestan region	637194,4	648470,7	637631,6	649934,2	55022,6
City of Turkestan	4951,0	5149,0	6041,0	6762,4	7104,2
City administration of Arys	10236,8	12673,2	11772,1	12436,8	12719,4
City administration of Kentau	6374,4	7062,8	7809,8	8784,1	9261,7
Baidibek district	14350,1	18439,9	15838,1	17182,6	17704,5
Zhetisay	84803,9	85651,9	77796,5	76919,5	75154,6
Keles	45967,7	47162,9	47145,7	49100,2	50077,6
Kazygurt	23258,6	24910,0	22288,3	21834,9	21608,2
Maktaaral	61740,7	64580,8	58844,4	57727,7	57119,4
Ordabasy	43669,4	44542,8	41295,2	40522,1	40135,5
Otyrar	22714,1	24803,8	23189,5	23634,9	23857,6
Sayram	53238,3	54835,5	55145,7	57324,8	58414,3
Saryagash	93837,7	80418,9	100861,7	106410,5	109686,9
Sauran	62895,2	64467,6	67262,7	70773,2	72528,4

Sozak	4837,6	5393,9	4990,2	5173,8	5265,6
Tolebi	24453,1	26825,0	24232,2	24497,4	24630,0
Tulkibas	29388,3	28477,3	27636,9	27272,4	27090,2
Shardara	51479,5	53075,4	45481,8	43576,9	42664,5

Table 3. Gross Output of Agricultural Production (Services) by Districts,
Including Irrigated Lands, for 2021-2023, with Forecasts for 2025 and 2026 [11-12].

Districts	2021	2022	2023	2025 (forecast)	2026 (forecast)
Turkestan region	1 041 235,7	1 051 648,1	963 616,4	976 666,8	988 098,0
City of Turkestan	8 574,2	8 437,0	9 010,5	9 114,2	9 394,8
City administration of Arys	22 247,5	24 605,7	19 877,4	21 016,4	21 389,8
City administration of Kentau	11 495,1	12 150,3	11 531,2	11 578,3	11 668,5
Baidibek district	31 579,6	36 158,6	31 447,2	32 198,5	32 674,6
Zhetisay	106 124,0	106 973,0	93 656,7	94 297,8	95 507,6
Keles	71 673,1	71 816,4	66 501,4	66 701,8	67 202,5
Kazygurt	63 761,4	66 949,5	59 595,9	60 019,8	60 731,7
Maktaaral	77 613,4	80 562,7	68 797,8	69 343,4	70 509,2
Ordabasy	75 057,1	70 553,7	61 889,4	62 936,5	63 509,9
Otyrar	36 978,1	38 937,9	35 125,1	35 421,1	36 019,2
Sayram	121 367,9	124 523,5	116 787,4	118 597,5	120 002,5
Saryagash	123 727,5	112 220,8	123 654,6	126 329,8	127 919,0
Sauran	88 970,4	91 372,6	86 259,8	87 672,3	88 278,5
Sozak	19 733,8	20 365,3	19 002,2	19 342,5	19 432,6
Tolebi	63 342,7	64 926,3	54 169,7	54 761,8	55 263,8
Tulkibas	58 374,9	57 849,5	51 045,2	51 435,3	52 035,3
Shardara	61 883,9	63 245,3	55 265,1	55 899,8	56 498,5

Let's examine the code in detail:

```
# First, load the numpy and pandas libraries
import numpy as np
import pandas as pd
from sklearn.linear_model import LinearRegression
# Input data from the table
data = {
 "Region": ["Turkestan Region", "City of Turkestan", "Arys", "Kentau", "Baidipek District", "Zhetysay District", "Keles District", "Kazygurt District", "Maktaaral District", "Ordabasy District", "Otrar District", "Sayram District", "Saryagash District", "Sauran District", "Syzak District", "Tolebi District", "Tulkubas District", "Shardara District"],
 "2021": [637194,4, 4951,0, 10236,8, 6374,4, 14350,1, 84803,9, 45967,7, 23258,6, 61740,7, 43669,4, 22714,1, 53238,3, 93837,7, 62895,2, 4837,6, 24453,1, 29388,3, 51479,5],
 "2022": [648470,7, 5149,0, 12673,2, 7062,8, 18439,9, 85651,9, 47162,9, 24910,0, 64580,8, 44542,8, 24803,8, 54835,5, 80418,9, 64467,6, 5393,9, 26825,0, 28477,3, 53075,4],
 "2023": [637631,6, 6041,0, 11772,1, 7809,8, 15838,1, 77796,5, 47145,7, 22288,3, 58844,4, 41295,2, 23189,5, 55145,7, 100861,7, 67262,7, 4990,2, 24232,2, 27636,9, 45481,8 ]}
df = pd.DataFrame(data)
df.set_index('Region', inplace=True)
Model = LinearRegression()
# Calculate the average growth rate for each region
growth_rates = (df.loc[:, '2023'] / df.loc[:, '2022']) * (df.loc[:, '2022'] / df.loc[:, '2021'])
# Average growth (geometric mean)
```

```
mean_growth_rate = growth_rates.mean()
# Forecast for 2025
predictions_2025_df = pd.DataFrame(predictions_2025, index=[2025])
df_with_predictions = df.append(predictions_2025_df)
df_with_predictions.reset_index(drop=True, inplace=True)
# Forecast for 2026
for region in df.columns[1:]:
y = df[region]
model.fit(years, y)
predictions[region] = model.predict(np.array([[2026]]))[0]
```

Now let's build the dynamics of agricultural efficiency in the regions of the Turkestan region for the period from 2019 to 2023, using data on the area of farmland, gross output and the number of workers in agriculture (Figure 5).

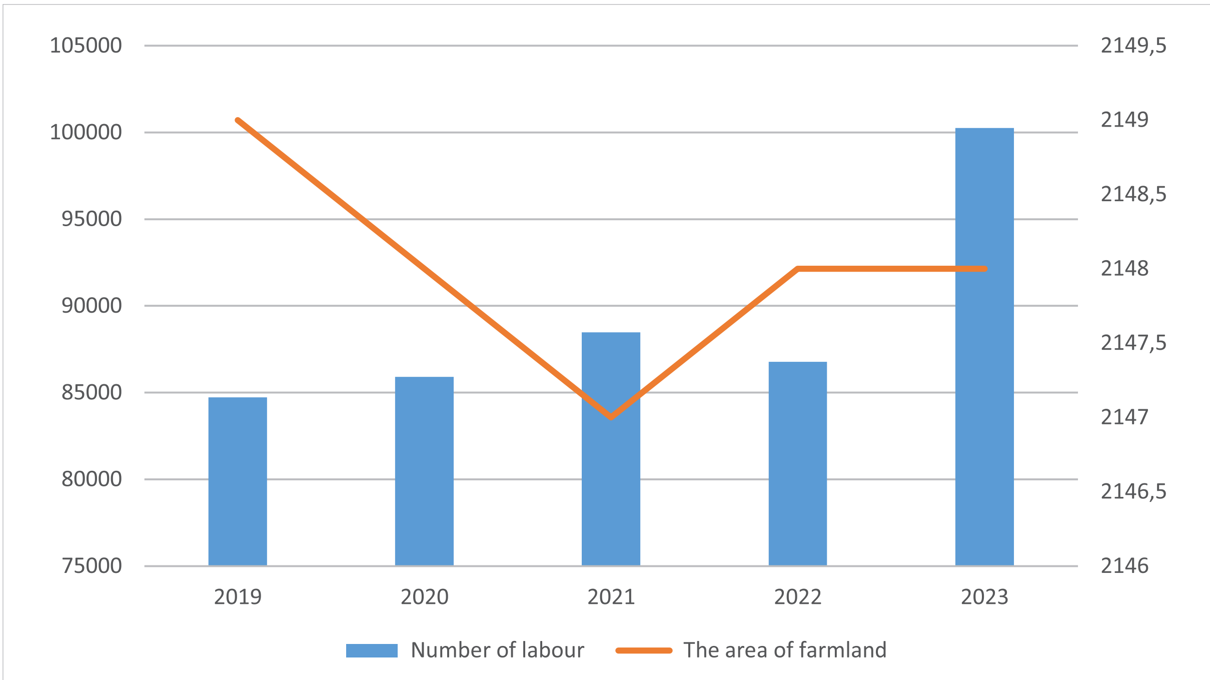

Figure 5. The area of farmland and the number of agricultural workers in the Turkestan region for 2019 to 2023.

Next, to calculate the dynamics of land use efficiency (productivity per hectare) and labor use efficiency (productivity per person), we need to use the formulas:

$$E_{land} = \frac{Gross\ Output}{Agricultural\ Land\ Area} \quad (1)$$

Where,

E_{land} is the land productivity (million Tenge per million hectares).Gross Output is the total agricultural production in million Tenge. Agricultural Land Area is the total land used for agriculture in million hectares.

$$E_{labor} = \frac{Gross\ Output}{Number\ of\ Workers} \quad (2)$$

The table below shows the calculation of productivity efficiency per hectare and per person (Table 4).

Table 4. Agricultural Effeciency Dynamic from 2019 to 2023

Year	Land Productivity (mln Tenge/ ha)	Labour Productivity (mln tenge/worker)
2019	274.54	0.696
2020	283.98	0.710
2021	296.78	0.720
2022	302.60	0.749
2023	296.17	0.634

The evolution of agricultural efficiency in the Turkestan region for 2019-2023, using indicators of land and labor productivity, is presented. The first phase indicated a gradual rise in land productivity – which peaked in 2022 and may have been a result of enhanced utilization of the resources, appropriate farming techniques, and probably favorable weather conditions. But in 2023, the world has seen a slight decrease which indicates that maybe land resources are stretched too far or there are other environmental issues.

The same positive trend is observable for labor productivity which increased steadily except for years 2020 and 2022 through enhanced training, better skills in farming, and possibly the application of better farming techniques and mechanical equipment. The total agricultural workforce in 2023 underwent a moderate incline while the applicative viewpoint in 2023 manifested a diminutive deterioration in labor productivity, presuming a declining return to labor or transitory misuse of the workforce.

In general, the data concerns the region's capacity to increase efficiency and shows that adaptation to new tasks to retain high productivity rates is becoming an issue.

High growth rates in some rural areas confirm the effectiveness of agricultural reforms and underscore the importance of agriculture for the economy. However, the disparity in performance between regions indicates a need for additional efforts to support areas facing slower growth. Targeted support in these regions may be necessary to address infrastructural and technological barriers, which could help balance development and improve economic conditions. An approach that considers these differences will aid in creating more uniform conditions across all regions.

Discussion and conclusion

In discussing the reduction of climate change impacts on agriculture in the Turkestan region, it is important to focus on rational and effective farming methods. These may include agroforestry, the implementation of advanced technologies, the development of industrial infrastructure, and the restoration of soil fertility through various biologically active substances, such as organic fertilizers, composts, and mycorrhiza inoculants. Each of these methods is effective in improving the efficiency of natural resource use, particularly soil, but we propose a comprehensive approach to this issue. Equally influential is the introduction of drought- and disease-resistant crops. Additionally, developing and implementing a drip irrigation system can minimize water consumption and enhance its efficiency. Furthermore, it is crucial to involve local communities in the development and implementation of land restoration programs.

Based on the data, it is possible to assess the economic effect of climate-adaptive methods in agriculture in the Turkestan region, which is associated with improved efficiency in the agricultural sector and resistance to climate change.

1. Export growth. With temperatures rising by 1°C, grain exports from the region can grow by 21.9%, which will reduce dependence on imports and support domestic consumption. With an estimated average price per ton of grain of $200, this increase will lead to a significant increase in export revenue.

2. Resource efficiency:

Water: The use of drip irrigation and other technologies will increase the efficiency of water consumption. Such technologies can save up to 20-50% of water and increase profitability by 15-20%. Due to the saving of water resources, the cost of irrigation is reduced, which has a positive effect on gross profit.

Labor and land: According to the article, labor and land productivity in the region have positive dynamics, but need further adaptations to stabilize yields. If the average labor productivity can reach 0.75 million tenge per employee, this will increase the overall productivity of agriculture and provide higher incomes to farmers.

3. Climate adaptation and risk reduction:

By introducing varieties resistant to drought and diseases, agricultural enterprises in the region will be able to minimize crop losses from climatic fluctuations, which stabilizes incomes and reduces insurance risks.

Such methods reduce the cost of insurance or subsidies for climate adaptation, which will further increase the economic efficiency of production.

4. Environmental awards and sustainable development. Products manufactured according to environmental standards are becoming more competitive in the global market. In particular, certificates and bonuses for sustainable production can add 10-15% to the price of products, especially for foreign markets, which will improve financial results for farmers and increase the export potential of the region.

In general, the expected economic effect of the introduction of climate-adaptive methods in agriculture in the Turkestan region will ensure a stable increase in income and profitability, as well as support for the long-term sustainability of the agricultural sector in the face of climate change.

Funding. The article was carried out within the framework of the funded project: IRN AP23487689 «Development of economic-mathematical model of increasing efficiency of natural resources utilization in agriculture of Turkestan region preventing climatic changes».

REFERENCES:

1. Annex I NC (October 24, 2014), 6th National Communications (NC6) from Parties Included in Annex I to the Convention, Including Those That Are Also Parties to the Kyoto Protocol, United Nations Framework Convention on Climate Change. Archived from the original on August 2, 2014.
2. Battisti, David; Naylor (2009), «Historical Warnings of Future Food Insecurity with Unprecedented Seasonal Heat,» Science, 323 (5911): 240-244, doi:10.1126/science.1164363, PMID 19131626. Accessed April 13, 2012.
3. Yu X. et al. Climate Change and Agricultural Trade in Central Asia: Evidence from Kazakhstan. Ecosystem Health and Sustainability. 2020. Vol. 6, No. 1, p. 1766380.
4. Jumakhanov B., Ultanbekova G., Mukhtaev K. Stremlenie k sohraneniyu: Innovacionnye metody rekul'tivacii zasushlivyh zemel' v Turkestanskom regione. Nauka i innovacii. 2024. Vol. 3, Special Issue 39, pp. 20-26.
5. Karatayev M. et al. Monitoring izmeneniya klimata, uslovij zasuhi i proizvodstva pshenicy v Evrazii: na primere Kazahstana. Heliyon. 2022. Vol. 8, No. 1.
6. Kazhydromet. (2023). Otchet o klimaticheskih harakteristikah Kazahstana za 2022 god. Almaty: Kazhydromet.
7. World Weather. (2023). Informaciya o temperature vozduha, vlazhnosti i skorosti vetra v Turkestane na 2015-2023 gody. Perejdite po ssylke: https://world-weather.ru/pogoda/kazakhstan/turkistan/2023/
8. Weather Spark. (2023). Istoricheskie dannye o klimate goroda Turkestan.
9. Global Modeling and Assimilation Office (GMAO). (2023). MERRA-2: Modern-Era Retrospective Analysis for Research and Applications, Version 2. Following the link:
10. Smagulova Sh.A., Ermakhanbetova A.E., Zhakupova S.T. Informacionno-kommunikacionnye tekhnologii v agrarnom sektore. Problemy agrorynka. 2022. No. 2, pp. 26-37.
11. Byuro nacional'noj statistiki Respubliki Kazahstan. Nacional'nyj statisticheskij sbornik za 2022 god. Astana, 2022.
12. Byuro nacional'noj statistiki Respubliki Kazahstan. Nacional'nyj statisticheskij sbornik za 2023 god. Astana, 2023.

СПИСОК ИСПОЛЬЗОВАННЫХ ИСТОЧНИКОВ:

1. Annex I NC (October 24, 2014), 6th National Communications (NC6) from Parties Included in Annex I to the Convention, Including Those That Are Also Parties to the Kyoto Protocol, United Nations Framework Convention on Climate Change. Archived from the original on August 2, 2014.
2. Battisti, David; Naylor (2009), «Historical Warnings of Future Food Insecurity with Unprecedented Seasonal Heat,» Science, 323 (5911): 240-244, doi:10.1126/science.1164363, PMID 19131626. Accessed April 13, 2012.

3. Yu X. et al. Climate Change and Agricultural Trade in Central Asia: Evidence from Kazakhstan. Ecosystem Health and Sustainability. 2020. Vol. 6, No. 1, p. 1766380.
4. Джумаханов Б., Ултанбекова Г., Мухтаев К. Стремление к сохранению: инновационные методы рекультивации засушливых земель в Туркестанском регионе. Наука и инновации. 2024. Том 3, Специальный выпуск 39, стр. 20-26.
5. Каратаев М. и др. Мониторинг изменения климата, условий засухи и производства пшеницы в Евразии: на примере Казахстана. Гелий. 2022. Том 8, № 1.
6. Казгидромет. (2023). Отчет о климатических характеристиках Казахстана за 2022 год. Алматы: Казгидромет.
7. World Weather. (2023). Информация о температуре воздуха, влажности и скорости ветра в Туркестане на 2015-2023 годы. Перейдите по ссылке: https://world-weather.ru/pogoda/kazakhstan/turkistan/2023/
8. Weather Spark. (2023). Исторические данные о климате города Туркестан.
9. Global Modeling and Assimilation Office (GMAO). (2023). MERRA-2: Modern-Era Retrospective Analysis for Research and Applications, Version 2. Following the link: https://ru.weatherspark.com/y/106714/%D0%9E%D0%B1%D1%8B%D1%87%D0%BD%D0%B0
10. Смагулова Ш.А., Ермаханбетова А.Е., Жакупова С.Т. Информационно-коммуникационные технологии в аграрном секторе. Проблемы агрорынка. 2022. № 2. с. 26-37.
11. Бюро национальной статистики Республики Казахстан. Национальный статистический сборник за 2022 год. Астана, 2022.
12. Бюро национальной статистики Республики Казахстан. Национальный статистический сборник за 2023 год. Астана, 2023.

АНАЛИЗ ВЛИЯНИЯ КЛИМАТИЧЕСКИХ ФАКТОРОВ НА РАЗВИТИЕ СЕЛЬСКОГО ХОЗЯЙСТВА В ТУРКЕСТАНСКОМ РЕГИОНЕ

Есиркепова А.М.*
д.э.н., профессор
Южно-Казахстанский университет им. М. Ауэзова
Шымкент, Казахстан
E-mail: essirkepova@mail.ru

Ниязбекова Р.К.
д.э.н., профессор
Южно-Казахстанский университет им. М. Ауэзова
Шымкент, Казахстан
E-mail: roza.niyazbekova@gmail.com

Махмуд Д.М.
м.э.н., докторант PhD
Южно-Казахстанский университет им. М. Ауэзова
Шымкент, Казахстан
E-mail: Dinara.Makhmud@auezov.edu.kz

Жумагулова А.М.
м.э.н., докторант PhD
Южно-Казахстанский университет им. М. Ауэзова
Шымкент, Казахстан
E-mail: asel_1982@mail.ru

Аннотация. *В данной статье представлен анализ влияния климатических факторов на сельское хозяйство в Туркестанском регионе в контексте взаимосвязи между глобальным потеплением и развитием агропромышленного сектора. В ней описываются изменения климата, такие как колебания температуры, уровня осадков и влажности, а также их взаимодействие с сельскохозяйственными процессами. Основное внимание в статье уделяется анализу угроз, связанных с климатом, и разработке адаптационных мер, направленных на повышение устойчивости сельскохозяйственного сектора.*

Результаты исследований указывают на прямую корреляцию между глобальным потеплением и продуктивностью сельского хозяйства, показывая, что чем слабее последствия глобального потепления в регионе, тем выше вероятность колебаний урожайности различных культур. Кроме того, был составлен прогноз валового производства сельскохозяйственной, лесной и рыбной продукции (услуг) по районам, а также валового производства сельскохозяйственной продукции по районам Туркестанской области на 2026 год. Исследование базируется на анализе данных о площади сельхозугодий, валовой продукции и количестве работников в сельском хозяйстве. Показано, что продуктивность использования земли и труда возросла в 2022 году, что связано с улучшением эксплуатации ресурсов и более эффективными методами ведения хозяйства. Однако в 2023 году наблюдается снижение этих показателей, что свидетельствует о негативных воздействиях окружающей среды, повлиявших на чрезмерное использование ресурсов. Вместе с тем, в статье обосновывается необходимость использования рациональных методов земледелия и внедрения агротехнологий, снижающих влияние на изменение климата. Ожидается, что внедрение данных мер приведет к увеличению экспортного потенциала, улучшению ресурсной эффективности и снижению рисков, свя-

занных с климатическими изменениями. В результате устойчивое сельское хозяйство обеспечит стабильные доходы и устойчивость аграрного сектора в долгосрочной перспективе.

Ключевые слова: *изменение климата, адаптация сельского хозяйства, изменчивость осадков, колебания температуры, производительность труда, Туркестанская область.*

ТҮРКІСТАН ӨҢІРІНДЕГІ АУЫЛ ШАРУАШЫЛЫҒЫНЫҢ ДАМУЫНА КЛИМАТТЫҚ ФАКТОРЛАРДЫҢ ӘСЕРІН ТАЛДАУ

Есиркепова А.М.*
э.ғ.д., профессор
М. Әуезов атындағы
Оңтүстік Қазақстан университеті
Шымкент, Қазақстан
E-mail: essirkepova@mail.ru

Ниязбекова Р.К.
э.ғ.д., профессор
М. Әуезов атындағы
Оңтүстік Қазақстан университеті
Шымкент, Қазақстан
E-mail: roza.niyazbekova@gmail.com

Махмуд Д.М.
э.ғ.м., PhD докторант
М. Әуезов атындағы
Оңтүстік Қазақстан университеті
Шымкент, Қазақстан
E-mail: Dinara.Makhmud@auezov.edu.kz

Жумагулова А.М.
э.ғ.м., PhD докторант
М. Әуезов атындағы
Оңтүстік Қазақстан университеті
Шымкент, Қазақстан
E-mail: asel_1982@mail.ru

Аңдатпа. *Бұл мақалада жаһандық жылыну мен агроөнеркәсіптік сектордың дамуы арасындағы байланыс контекстінде Түркістан өңіріндегі ауыл шаруашылығына климаттық факторлардың әсерін талдау ұсынылған. Ол температураның, жауын-шашын мен ылғалдылықтың ауытқуы және олардың ауылшаруашылық процестерімен өзара әрекеттесуі сияқты климаттың өзгеруін сипаттайды. Мақалада климатқа байланысты қауіптерді талдауға және ауыл шаруашылығы секторының тұрақтылығын арттыруға бағытталған бейімделу шараларын әзірлеуге баса назар аударылады.*

Зерттеу нәтижелері жаһандық жылыну мен ауыл шаруашылығы өнімділігі арасындағы тікелей корреляцияны көрсетеді, бұл аймақтағы жаһандық жылынудың әсері неғұрлым әлсіз болса, әртүрлі дақылдардың өнімділігінің ауытқу ықтималдығы соғұрлым жоғары болатынын көрсетеді. Бұдан басқа, аудандар бойынша ауыл шаруашылығы, орман және балық өнімдерінің (қызметтерінің) жалпы өндірісінің, сондай-ақ Түркістан облысының аудандары бойынша ауыл шаруашылығы өнімдерінің жалпы өндірісінің 2026 жылға арналған болжамы жасалды. Зерттеу ауылшаруашылық алқаптарының ауданы, жалпы өнім және ауыл шаруашылығындағы жұмысшылардың саны туралы деректерді талдауға негізделген. Жер мен еңбекті пайдаланудың өнімділігі 2022 жылы артқаны көрсетілген, бұл ресурстарды пайдаланудың жақсаруымен және шаруашылық жүргізудің тиімді әдістерімен байланысты. Алайда, 2023 жылы бұл көрсеткіштердің төмендеуі қоршаған ортаның жағымсыз әсерлерінен ресурстарды шамадан тыс пайдалануға әсер еткенін көрсетеді. Сонымен қатар, мақалада егіншіліктің ұтымды әдістерін қолдану және климаттың өзгеруіне әсерін төмендететін агротехнологияларды енгізу қажеттілігі негізделеді. Бұл шараларды енгізу экспорттық әлеуеттің артуына, ресурстық тиімділіктің жақсаруына және климаттық өзгерістерге байланысты тәуекелдердің төмендеуіне әкеледі деп күтілуде. Нәтижесінде тұрақты Ауыл шаруашылығы ұзақ мерзімді перспективада тұрақты кірістер мен аграрлық сектордың тұрақтылығын қамтамасыз етеді.

Түйін сөздер: *климаттың өзгеруі, ауыл шаруашылығының бейімделуі, жауын-шашынның өзгергіштігі, температураның ауытқуы, еңбек өнімділігі, Түркістан облысы.*