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THE İNFLUENCE OF CLIMATIC FACTORS ON AGRICULTURAL PRODUCTION IN DRYLAND AREAS OF AZERBAIJAN

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Abstract
Objectives: Agricultural production is realized through interaction with various natural-climatic factors and biological processes. The moist areas face more serious problems in this aspect. The purpose of the research is to determine the impact of climatic factors on agricultural production in such conditions to prepare proposals for reducing dependence on natural-climatic factors in moist lands.
Methods: Based on calculations in the moist areas of Azerbaijan., the dependence of production on agrotechnical measures and natural-climatic factors was determined quantitatively. Economic and statistical analyses, comparative analysis and forecasting methods are used in the investigation of the indicated issue. The tendency of yield changes depending on climate indicators was revealed with the help of the Exsell software package,. Additionally, with the help of the forecasting method, the linear dependence of productivity and the forecast for the next years were calculated. Empirical statistical data was taken from the State Statistics Committee of the Republic of Azerbaijan.
Findings: Since agricultural production interacts with various natural-climatic factors and biological processes, this sphere is considered a rather risky type of economic activity. Studying the impact of climatic factors on agricultural production, especially in dryland areas, is of particular importance in terms of production stability. In the article, the impact of climatic factors and, in parallel, agro-technical measures on the production of agricultural products and productivity is defined. The obtained results can be useful in terms of optimal evaluation of the current state of the agricultural area and creation of necessary conditions for the sustainable development of this sphere.
Novelty: The results obtained in the research enable to quantitatively evaluate the influence of natural-climatic factors on the production of agricultural products. At the same time, the used methodology provides a basis for the conclusion of the possibility of reducing dependence on natural-climatic factors, and allows predicting future changes in production.

Keywords: production, yield, climatic factors, temperature, precipitation

1. INTRODUCTION

In recent years, the problems of climate change have become more apparent. The global trend of climate change means a serious disturbance of the climate balance [1]. In this regard, predictions about the consequences of global warming are not encouraging. Especially since climate factors have a direct impact on the formation of agricultural production, the role played by this problem in the country's food supply and the demand for raw materials of food and some industries is extremely important. In addition, climate change covers various economic, social and environmental aspects of the country's development. The analysis of the dependence between climate factors and agrarian production gives reason to consider climate as a natural resource and risk factor. In the agricultural sector, uncertainty and risk factors have a significant impact on the outcome, so it is inevitable that there will be a conflict between the outcome and the risk factor [2].

It is known that the effect of long-term changes in temperature or precipitation on the agrarian products, in itself, leads to the disruption of the stability of the agrarian economy. The average annual temperature and the average annual amount of precipitation are extremely important, depending on the production characteristics of the products, especially in dry areas. Of course, depending on the type of product, i.e. temperature and precipitation according to the production period of each product are required.

According to the conclusions of the experts of the International Food Organization, it is estimated that after 2030, a global warming of 2°C could reduce agrarian production by 25%, with a decrease in the productivity of agrarian crops due to climate change all over the world [3].

It is clear from the above that agriculture is a field of activity accompanied by extensive use of natural resources [4], in this regard it is effective on land and water resources, and changes in natural resources have a serious impact on agricultural production. Due to these characteristics and its different structure compared to other sectors, agriculture is more affected by the effects of climate change [5].

Thus, the negative impact of changes in temperature and precipitation on agricultural production is expected to increase (especially due to the increase in temperature) [6]. The impact of climate change on agriculture may differ depending on the country, region and seasonal conditions . Therefore, it is necessary to develop and apply various mechanisms of adapting the economy to changing climate conditions [7].

Thus, the restructuring of agriculture as a wide-ranging area of the agrosphere is show itself as one of the complex issues [8].

In accordance with the above, it is necessary to carry out investigations in the directions of assessing the impact of natural-climatic factors and climate changes on agricultural production (change in productivity). The first direction in the research is important because, in addition to natural-climatic factors, agrotechnical works have a significant impact on productivity, ultimately on total production.

2. CONCEPT HEADINGS.

2.1.METHODOLOGY

The purpose of the study is to determine the role of temperature and precipitation, which are important natural and climatic factors for production in dryland regions, in agricultural production, as well as the impact of climate change on agricultural productivity.
The subject of the study is to determine the relationship between natural and climatic factors and agricultural production, including the production of cereals and potatoes, which are considered the main directions in meeting the need for food in the Ganja-Gazakh region of Azerbaijan. Natural and climatic factors, which are one of the important elements of the natural environment, have a decisive influence on production. In this regard, the main goal is to determine how climatic factors affecting the production of grains and potatoes in the Ganja-Gazakh region, including changes in temperature and rainfall, determine deviations in yield.
The researchs provide for the forecast of production based on the relevant study period, production and climate change using Microsoft Excel, a regression model and the dependence of production on natural and climatic factors and agrotechnical measures using appropriate methods.

2.2. LITERATURE SUMMARY

Considering agriculture as a risky sector of the economy, the main object of its production is land, plants and animals, which complement each other. It is important that the soil has enough water and temperature to provide the plant with nutrients normally. It is formed due to precipitation and sunlight, and production stops when optimal climatic factors are not present [9].

Although soil fertility increases due to agrotechnical activities carried out in agriculture, optimal temperature and sufficient light must be available for normal plant development. The mentioned shows that for the normal development of animal husbandry and crop production in a certain territory, it is important to have optimal climatic conditions suitable for that territory [10]. It is generally considered that in dryland areas with annual rainfall of less than 300 mm, unstable productivity is inevitable. A normal level of soil moisture is possible in dryland areas precisely due to precipitation. Therefore, it is important to pay special attention to keeping snow in the field, making snow furrows and strips, and laying forest strips in cold conditions [11].
In order to assess the impact of climate factors on agricultural production, the plant's response to heat, humidity, precipitation, etc. it is possible to determine how favorable the climatic conditions are by calculating the quantitative indicators of the demand. Various studies have been conducted on various aspects of the problems of assessing the impact of climate and climate changes on agriculture, and relevant methodologies have been developed. In recent years, with increasing interest in the problem of global warming, there has been an increase in the number of studies on the relationship between climate change and agriculture. Thus, the author's research on the impact of climate change on agriculture can be summarized as follows.
Akram. Panel Data Regression Analysis (seemingly uncorrelated regression-SUR method) An increase in precipitation has a positive effect on the share of the agricultural sector in GDP, and an increase in temperature has a negative effect [12].

Barnwal ve Kotani. Time Series Quantile Regression Analysis. Precipitation and temperature have a positive effect to the yield per hectare [13].
Brown and others. Panel Data Regression Analysis. An increase in precipitation has a positive effect on the share of the agricultural sector in GDP, and an increase in temperature has a negative effect [14].
Dasgupta. Panel Data Quantitative Regression Analysis. Climate change (precipitation and temperature) has a negative impact on production [15].
Dell and others. Panel Data Regression Analysis. The increase in temperature has a negative impact on agricultural production [16].
Deressa and others. Panel Data Regression Analysis. Temperature has a negative effect on production in winter and a positive effect in summer [17].
Jain. Horizontal Section Regression Analysis. An increase in temperature has a negative effect on the net income of agriculture, and an increase in precipitation has a positive effect [18].
Liu and others. Horizontal Section Regression Analysis. Climate change has a positive effect on agricultural income in spring and autumn. Climate change has a negative impact on agricultural incomes [19].
Van Passel and others. Horizontal Section Regression Analysis. Temperature has a negative effect on agricultural income in summer and winter, and a positive effect in spring and autumn. On the other hand, the impact of precipitation on agricultural income is in the opposite direction [20].
Taking into account the above, the research determines the dependence of agricultural production not only on climate changes, but also on natural-climatic factors.

2.3. MATERIAL AND METHOD

Researches show that the natural-climatic conditions determine the direction of agricultural production, determine the structure of the agricultural land, require a revision of the principles of land use and the policy of applying innovative resources to production. Productivity in agriculture varies depending on agrotechnical measures as well as soil and climate conditions. Therefore, adapting to climate change and approaching the production organization from a new perspective is one of the main problems of the agricultural sector. In this regard, let's determine to what extent the productivity of cereal crops and potatoes produced under different agro-ecological conditions depends on natural-climatic conditions and agrotechnical measures.

3. DISCUSSION

Calculations based on preliminary data show that in 2011-2021, the influence of agrotechnical factors on productivity in grain growing is 7.96% (2.4/30.12*100=7.96%), and the influence of natural-climatic factors is 92.03% (100 -7.96=92.03%). Thus, it is possible to obtain the result by indicating the productivity by y, the number of years by n, and the number of rows by t.
In the calculation, productivity is indicated by y, number of years n, number of rows t, and the following results were obtained.

$$\sigma=\sqrt{\frac{\Sigma(\tilde{y}_t-\tilde{y})^2}{}}=\sqrt{\frac{63,5}{}}=\sqrt{5,77}=2,4 \qquad b=\frac{\Sigma yt}{\Sigma t^2}=\frac{83,8}{110}=0,76$$

$$\tilde{y}=29,36+0,76=30,12^{11}$$

$$a=\frac{\Sigma y}{n}=\frac{323}{11}=29,36$$

Table 1Factors of productivity change in grain growing in the Ganja-Kazakh economic region of the Republic of Azerbaijan

Years	ordinal number, n	Productivity, centner/hectare, y	y^2	t	t^2	y*t	$\tilde{y}_t$	$(\tilde{y}_t-\tilde{y})^2$
2011	1	25,4	645,16	-5	25	-127,0	26,32	14,44
2012	2	27,2	739,84	-4	16	-108,8	27,08	9,24
2013	3	27,5	756,25	-3	9	-82,5	27,84	5,19
2014	4	23,8	566,44	-2	4	-47,6	28,6	2,31
2015	5	31,2	973,44	-1	1	-31,2	29,36	0,57
2016	6	30,3	918,09	0	0	0	30,12	0
2017	7	29,8	888,04	1	1	29,8	30,88	0,57
2018	8	30,3	918,09	2	4	60,6	31,64	2,31
2019	9	32,7	1069,29	3	9	98,1	32,4	5,19
2020	10	31,6	998,56	4	16	126,4	33,16	9,24
2021	11	33,2	1102,24	5	25	166,0	33,92	14,44
Total	66	323	9575,44	30	110	83,8	366,0	63,5

Source: Official data of the State Statistics Committee of the Azerbaijan Republic [21].

Based on the preliminary data given in Table 2, when determining the influence of natural and agrotechnical factors on the change in productivity in potato farming, it is known that in 2011-2021, agrotechnical factors contributed to productivity by 7.71% (12.04/155.99*100=7.71%) , natural-climatic factors affected at the level of 92.28% (100-7.71=92.28%).

$$\sigma=\sqrt{\frac{\Sigma(\tilde{y}_t-\tilde{y})^2}{n}}=\sqrt{\frac{1596,72}{11}}=\sqrt{145,15}=12,04$$

$\tilde{y}$=152,18+3,81=155,99

$a=\frac{\sum y}{n}=\frac{1674}{11}=152,18$

$b=\frac{\sum yt}{\sum t^2}=\frac{420}{110}=3,81$

Table 2 Factors of productivity change in potato growing in the Ganja-Kazakh economic region of the Republic of Azerbaijan

Years	ordinal number, n	Productivity, centner/hectare, y	y^2	t	t^2	y*t	$\tilde{y}_t$	$(\tilde{y}_t-\tilde{y})^2$
2011	1	144	20736	-5	25	-720	136,94	362,9
2012	2	147	21609	-4	16	-588	140,75	232,25
2013	3	152	23104	-3	9	-456	144,56	130,64
2014	4	132	17424	-2	4	-264	148,37	58,06
2015	5	135	18225	-1	1	-135	152,18	14,51
2016	6	140	19600	0	0	0	155,99	0
2017	7	150	22500	1	1	150	159,8	14,51
2018	8	148	21904	2	4	296	163,61	58,06
2019	9	169	28561	3	9	507	167,42	130,64
2020	10	173	29929	4	16	692	171,23	232,25
2021	11	184	33856	5	25	920	175,04	362,9
Total	66	1674	257448	30	110	420	1715,89	1596,72

Source: Own calculations using the data of the State Statistics Committee of the Azerbaijan Republic and software MS Office Excel.

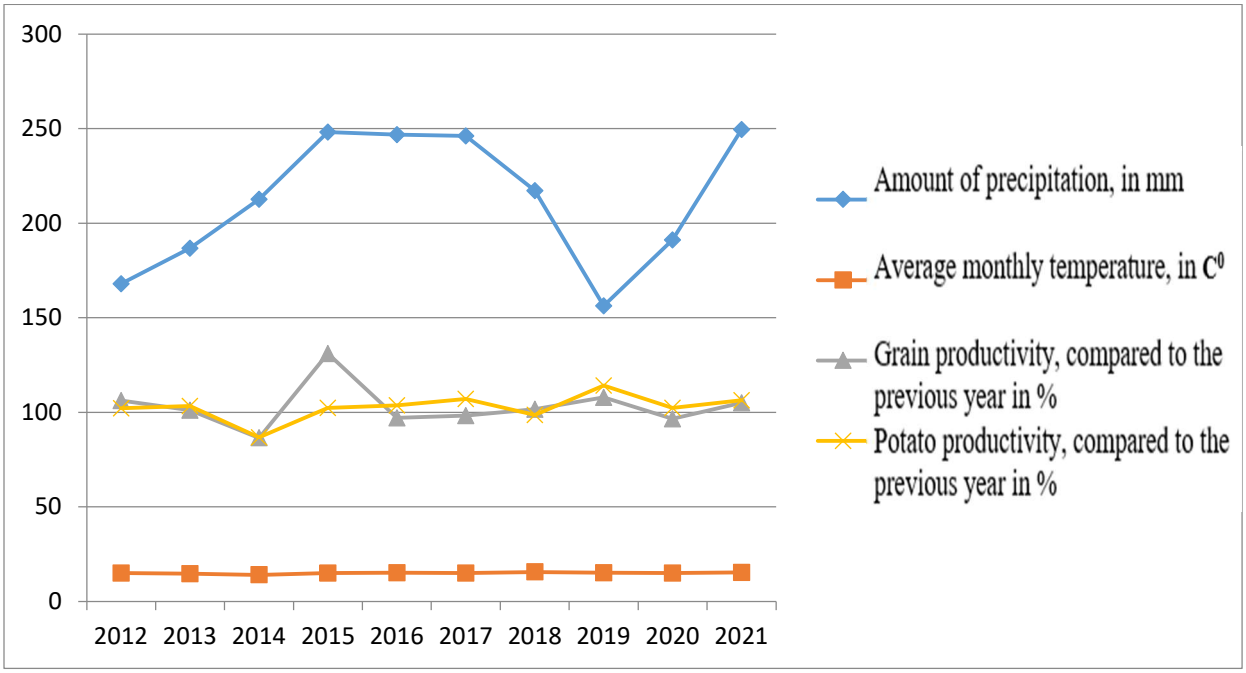
As it seen, natural-climatic factors are extremely important in the production of agricultural products in dryland areas. In this regard, it is necessary to mention the temperature and the amount of precipitation. Looking at the trend of changes in productivity, temperature, and precipitation, it is known that changes in the average monthly air temperature and precipitation in 2012-2021 also lead to changes in grain and potato productivity [table 3 and graph]. It should be noted that the temperature and precipitation level requirements, especially in dryland areas, differ from month to month depending on the production characteristics of the products. For example, in grain growing, the demand for rainwater increases in October-November, the demand for snow in December-February, the demand for rainwater in March-April, and the temperature increase in

May-July due to crop ripening and harvesting. In potato farming, there is a greater demand for rainwater in March-May.

Table 3Changes in climate indicators and productivity of the Ganja-Kazakh economic region of Azerbaijan, compared to the previous year, in %

Years	Amount of precipitation, in mm	Average monthly temperature, in C^0	Grain	Potato
2012	168,0	15.1	106.25	102.08
2013	186.8	14.7	101.10	103.40
2014	212,6	14,2	86.54	86.84
2015	248.1	15,0	131.09	102.27
2016	246,8	15,2	97.11	103.70
2017	246.1	15.1	98.34	107.14
2018	217.2	15.7	101.67	98.66
2019	156.3	15.2	107.92	114.18
2020	191.1	15.0	96.63	102.36
2021	249.5	15.4	105.06	106.35

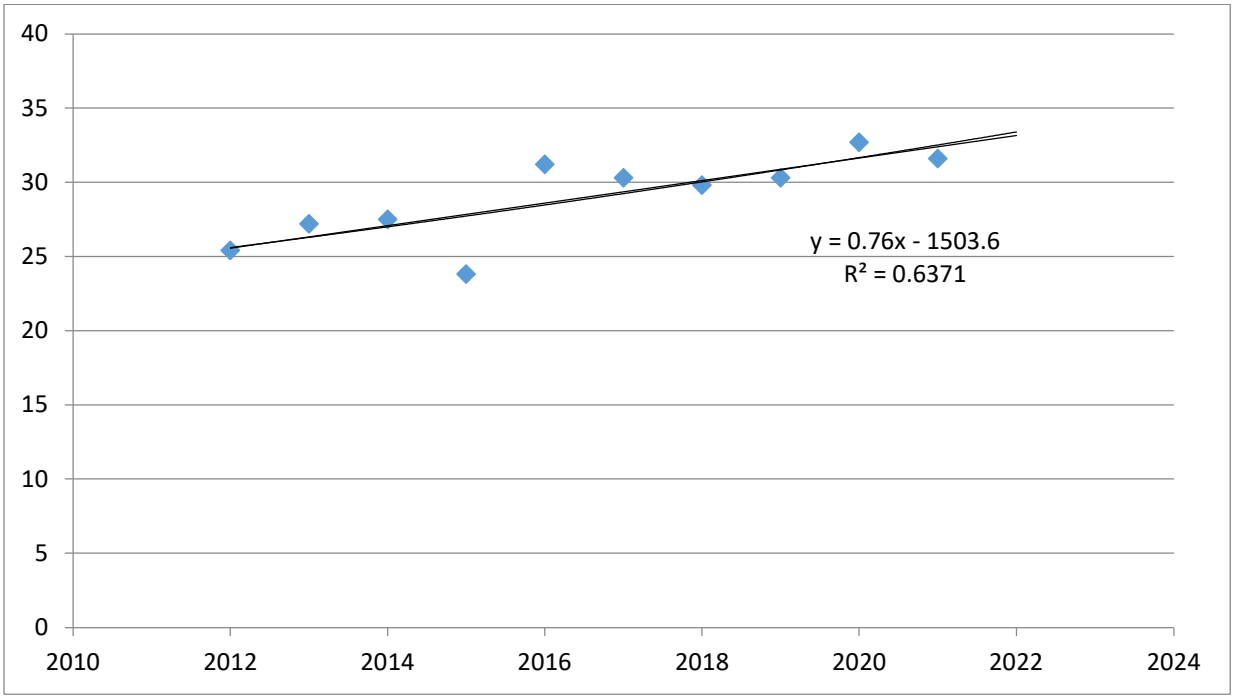
Source: Official data of the State Statistics Committee of the Azerbaijan Republic and Data of Ganja HMS [22].



Graph 1. Climatic indicators and productivity changes of the Ganja-Kazakh economic region of Azerbaijan.

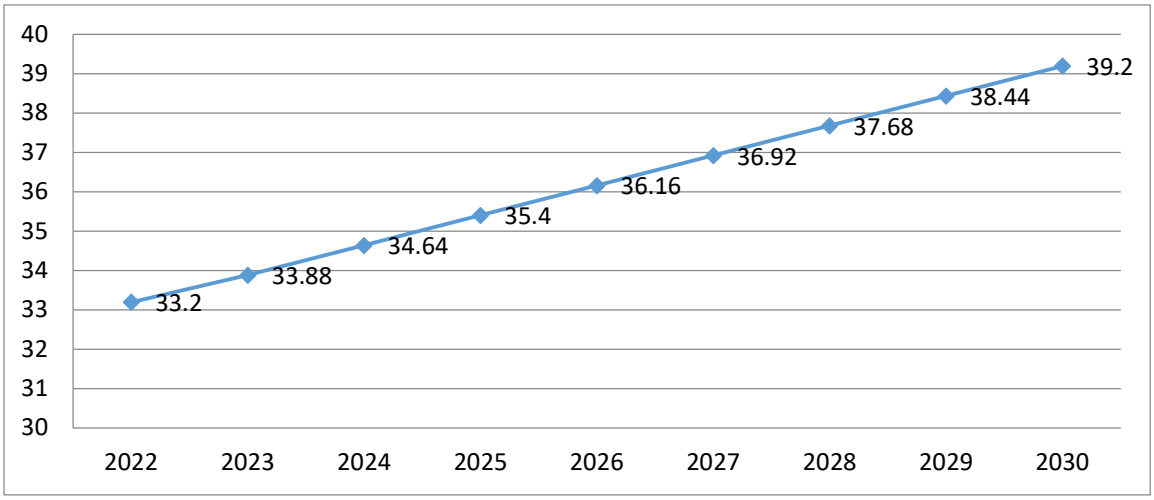
Now let's look at the graphical representation of the change in the yield of grain crops and potatoes using the trend line. The linear dependence of grain productivity on the observation period shows that the accuracy level of approximation is 64% (the higher the indicator, the more accurate the dependence): $R^2 = 0.6371$. The obtained equation allows to calculate the forecast for the following years:

$y = 0,76x - 1503,6$ [graph 2].



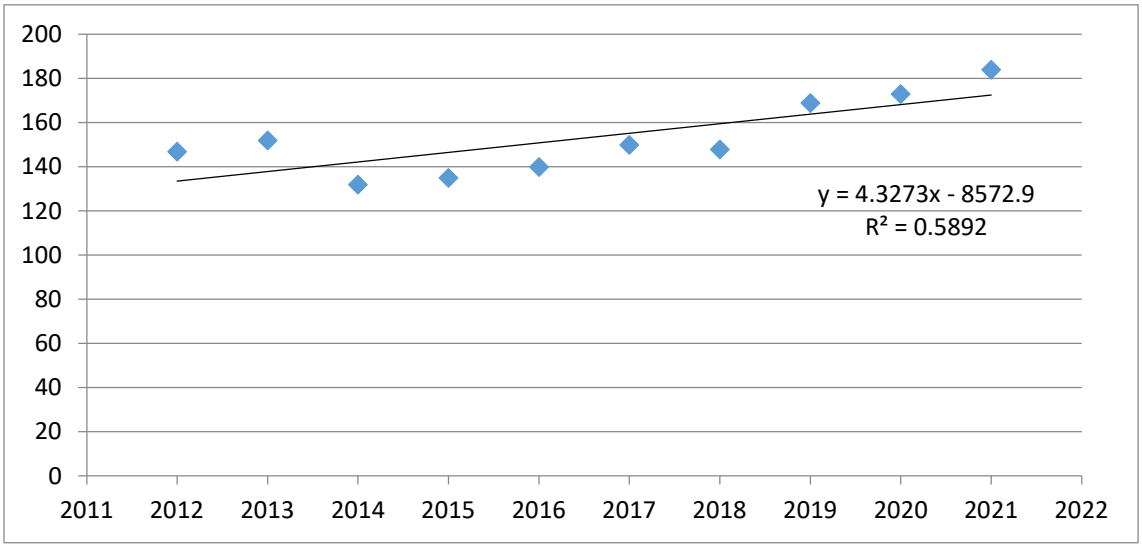
Graph 2. Linear dependence of productivity in grain growing by years.

Using the equation, let's predict the productivity in grain growing for 2022-2030.

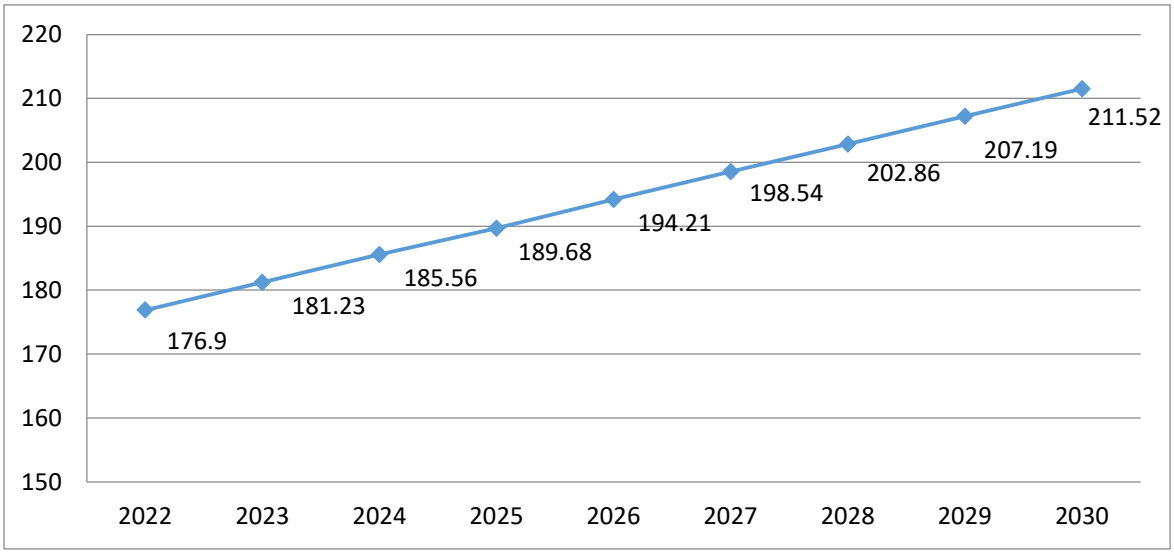


Graph 3. Forecast indicator of productivity in grain growing.

With same rule we can determine the linear dependence and forecast of productivity in potato farming.



Graph 4. Linear dependence productivity of potato farming year by year.



Graph 5. Forecast indicator of productivity in potato farming.

As mentioned early, agrotechnical factors affected 7.96% and natural-climatic factors at the level of 92.03%. In potato farming, these indicators are at the level of 7.71% and 92.28% (100-7.71=92.28%), respectively. Taking into account the above, let's calculate the forecast indicators for the years 2022-2030 based on the data of 2012-2021 for both types of products. For this, the possible production level depending on the temperature and rainfall in grain growing and the forecast for the next years can be calculated using the following equation based on the regression model:

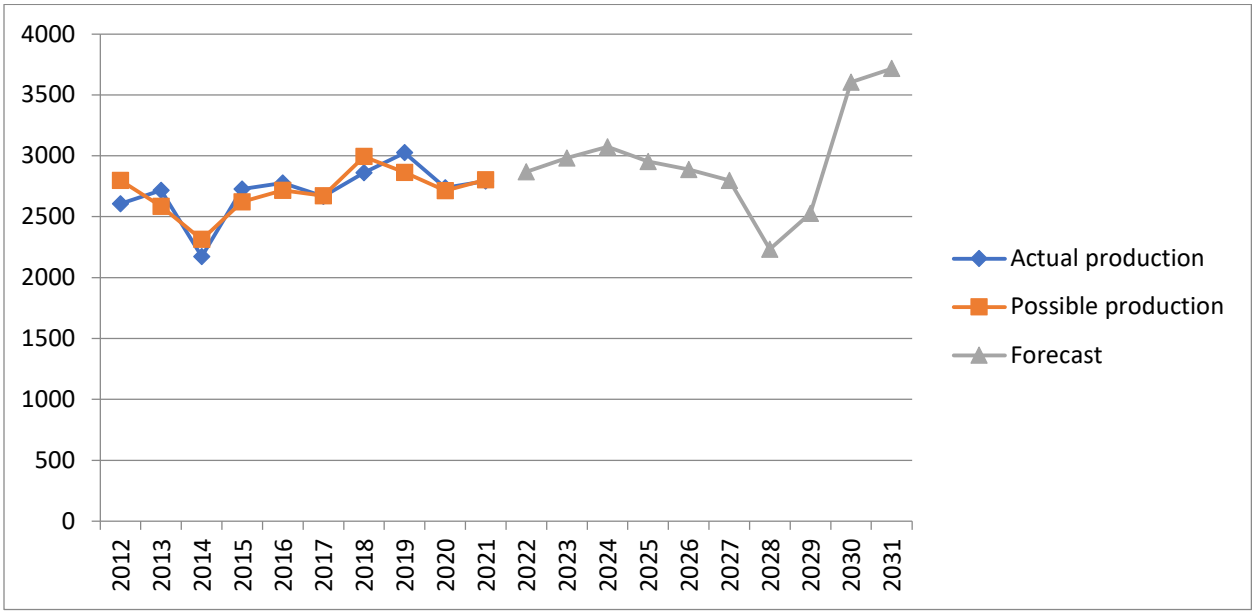
Y=-3853.419588-1.619979129X1+458.5232509X2

It should be noted that the main issue of regression analysis is to determine the form of dependence between variables [23].

Table 3 Possible grain production and predicted indicators, based on the regression model

Years	Actual production, thousand tons	Possible production, thousand tons	Years	Forecasting production, thousand tons
2012	2606.8	2798,1	**2022**	2867.463
2013	2715.4	2584.3	**2023**	2982.154
2014	2173.7	2313.2	**2024**	3072.659
2015	2726.6	2622.5	**2025**	2952.296
2016	2777.1	2716.3	**2026**	2887.200
2017	2665.1	2671.6	**2027**	2797.646
2018	2861.9	2993.5	**2028**	2233.675
2019	3025.4	2862.9	**2029**	2527.064
2020	2737.8	2714.8	**2030**	3602.876
2021	2791.2	2803.6	**2031**	3716.700

Source: Official data of the State Statistics Committee of the Azerbaijan Republic and own calculations using the software MS Office Excel.



Graph 6. Forecast indicator of production in grain growing.

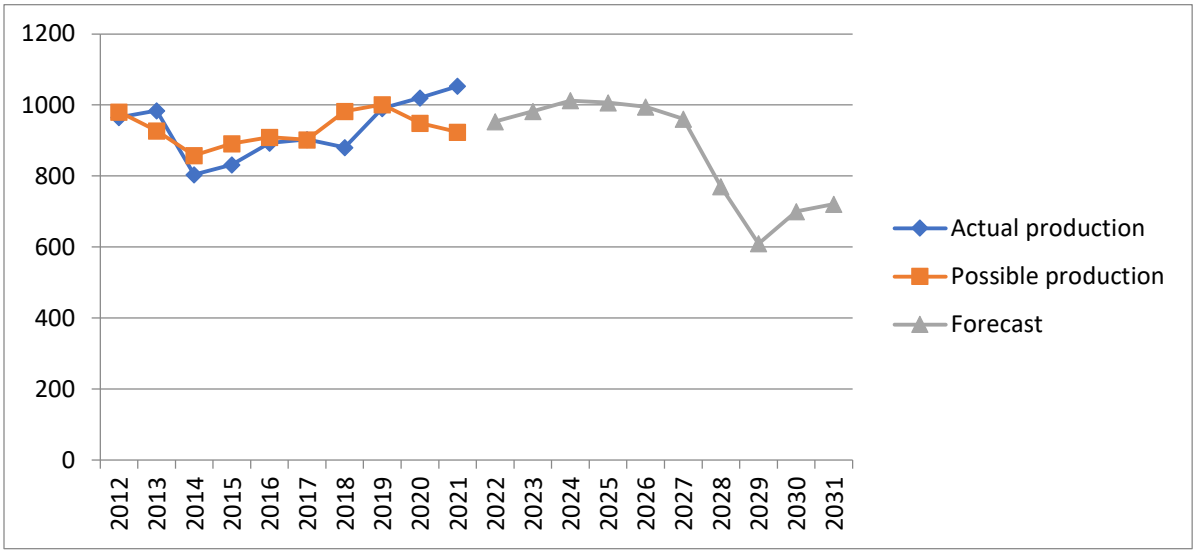
Depending on the temperature and amount of precipitation in potato farming, the possible production level and the forecast indicator for the next years can be calculated using the following equation obtained on the basis of the regression model:

Y=-146.316731034972-1.014366822X1+85.94396342X2

Table 3 Possible potatoes production and predicted indicators, based on the regression model

Years	Actual production, thousand tons	Possible production, thousand tons	Years	Forecasting production, thousand tons
2012	964.9	981.0	**2022**	953.362
2013	984.0	927.6	**2023**	982.485
2014	804.1	858.4	**2024**	1012.829
2015	832.1	891.2	**2025**	1006.433
2016	893.0	909.7	**2026**	994.650
2017	903.2	901.8	**2027**	960.607
2018	880.8	982.7	**2028**	770.415
2019	990.9	1001.5	**2029**	610.130
2020	1020.6	948.9	**2030**	700.383
2021	1053.4	924.1	**2031**	721.435

Source: Official data of the State Statistics Committee of the Azerbaijan Republic and own calculations using the software MS Office Excel.



Graph 7. Forecast indicator of production in potato farming.

Thus, the calculation of the forecast indicators of both productivity and production during the period of observation and research shows that grain products produced in dryland areas and potatoes in the period when the required level of natural-climatic factors for production cannot be observed seriously decrease. On the contrary, under normal natural-climatic conditions, an increase in production is recorded and expected. Based on the above, it can be concluded that dependence on natural and climatic factors will have a serious impact on production in the coming years.

4. CONCLUSION

Based on the research, it is possible to make a number of generalizations. First of all, it should be noted that the calculations lead to the conclusion that the use of agrotechnical measures in dry areas has less impact on productivity than natural-climatic factors. From this point of view, it is enough to say that the productivity indicator in grain growing varies in the range of 23.8-33.2 sen/ha in 2012-2021. In potato cultivation, this indicator fluctuates between 132-184 sen/ha. Actually, such a level of productivity is quite low.Considering that the average monthly temperature of the research object does not change drastically and the amount of precipitation does not change significantly, it can be concluded that the dependence on natural-climatic factors can be reduced to some extent. For this, it is necessary to use a number of measures - modeling of production due to the application of new technologies related to adaptation to climate change, expanding the use of drought-resistant and productive seeds, preventing the timing of pests and diseases. In terms of response to climate change, preparing strategies for adaptation to different climate scenarios, information on climate changes timely distribution and delivery to manufacturers, pre-determination of changes that may occur due to the preparation of reasonable forecasts, etc. can be considered appropriate.

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