Climate change impact on economical efficiency of leguminous crops production and perspectives in Kazakhstan

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Abstract: *In this article, the authors consider the main aspects of climate change`s impact on economical efficiency of leguminous crops production and perspectives in Kazakhstan. It is worth noting that climate change has an impact on the instability of leguminous crops and leads to a decrease in the production efficiency. Ultimately, all of the above determines the relevance and significance of this topic.*
Keywords: CLIMATE CHANGE, ECONOMICAL EFFICIENCY, LEGUMINOUS CROPS, PRODUCTION, YIELD

1. Introduction

At the present stage of development, the main criterion for the food security of any country in the world, including Kazakhstan, is the stable provision of the population with quality food and, as a result, the effective development of agriculture. Agricultural production is a specific sector of the national economy to the efficiency which significantly affects natural and climatic risks. The impact of climate change risks primarily concerns the crop industry and is manifested not only in a decrease in crop yields, but also in the efficiency of production of leguminous crops. It should be noted that climate change has a negative impact on producers, which leads to significant instability in grain and legume crops and to a decrease in the efficiency of agricultural production in general. Also in Kazakhstan, leguminous crops are the main agricultural raw materials, because grain-based products are one of the main ones. Leguminous crops are both inexpensive and nutritious at the same time. All of the above determines the relevance and significance of the research topic.

The issues of increasing the efficiency of the functioning of the grain and legume subcomplex have been and remain in the focus of attention of scientists. At the same time, the “climax” of solving the problem of increasing the profitability of grain and legume production in order to ensure the possibility of expanded reproduction and sustainable development of the subcomplex as a whole has not been achieved. From these positions, there is an objective need to conduct scientific research in the context of substantiating the reserves and factors that ensure the effective development of the grain industry and take into account modern requirements and principles of the functioning of agriculture.

The most important factor determining the efficiency and sustainability of agro-food systems is the natural and climatic factor (Akmarov et al., 2014; Romanenko et al., 2016; Zhuchenko, 1990; Zhuchenko, 2009; Nikonov, 1979). Theoretical and methodological foundations for studying the influence of natural and climatic factors on the production of agricultural crops, its efficiency and sustainability are presented in Table 1 (Nikonov, 1979; Nikonov, 1975; Shashko, 1967; Siptits et al., 2018).

It is worth noting that the gross harvest of leguminous crops in Kazakhstan in 2021 is estimated at 16.6 million tons, which is the lowest figure since 2012 and is 18% lower than the previous season. The main reason for the reduction in production is the low average grain yield, which was formed in rather difficult agro-climatic conditions. The average yield for grains and legumes as a whole is estimated in 2021 at 10.4 c/ha, which is 19% lower than the previous season. The sown area of cereals and legumes in Kazakhstan was 16108 thousand hectares in 2021.

Table 1 *- Theoretical and methodological foundations for studying the influence of natural factors on the efficiency of crop production*

The name of the theoretical and methodological foundations	**The authors of the theoretical and methodological foundations**
Methodology and methods of zonal zoning of agricultural territories (agroclimatic and agroecological zoning)	Vasily Vasilyevich Dokuchaev, Nikolay Ivanovich Vavilov, Kliment Arkadyevich Timiryazev, Georgy Timofeevich Selyaninov
Biological law of unity "organism-environment"	Vasily Ivanovich Vernadsky
The law of return	Justus von Liebig
The law of "decreasing soil fertility"	Anne Robert Jacques Turgot Wassily
The law of indispensability and equivalence of plant life factors	Robertovich Williams
The Law of the Minimum and the Law of Tolerance	Justus von Liebig Victor Ernest Shelford
The law of the combined action of natural factors	Max Eilhard Alfred Mitscherlich, August Friedrich Thienemann, Bernhard Baule, Alexander Trofimovich Kirsanov
The concept of environmental sustainability of agricultural crops as an assessment of yield variability	Pavel Andreevich Kostychev, Vasily Vasilyevich Dokuchaev, Alexey Fedorovich Fortunatov, Vladimir Mikhailovich Obukhov

2 Materials and methods

The object of the study is the impact of climate change on the economic efficiency of the production of leguminous crops. The theoretical and methodological basis of the study are system-functional approaches to studying the impact of climate change on the economic efficiency of the production of leguminous crops, which requires the use of various methods of scientific analysis: comparative, abstract-logical, monographic, statistical, mathematical-economic and others.

The empirical base of the study consists of statistical data from the Bureau of National Statistics of the Agency for Strategic Planning

and Reforms of the Republic of Kazakhstan, data obtained from a survey among agricultural producers. organizations and their reports on a given research topic, publications of authoritative scientific publications and journals, professional publications.
Also, for a deeper analysis, the authors conducted a survey among agricultural producers of Akmola, Almaty, Abay, Aktobe, Atyrau, East Kazakhstan, Zhambyl and Zhetysu regions. During the survey, 31 agricultural producers were interviewed through a Google questionnaire. This study was carried out within the framework of state funding under the scientific project IRN No. AP13068128 "Study of the impact of climate change on the economic efficiency of leguminous crops of farms" under the budget program 102 grant funding for young scientists on scientific and (or) scientific and technical projects for 2022-2024, State institution "Committee of Science" of the Ministry of Education and Science of the Republic of Kazakhstan.

3 Results

In Kazakhstan chickpeas, peas, lentils, beans, and soybeans are cultivated for grain and green mass. The great interest in the cultivation of leguminous crops in Kazakhstan is due to the volatility of grain prices and the demand for leguminous crops in foreign markets. As is known, modern varieties of leguminous crops grow well both on fertile and poor soils with a pH of 5.0 to 7.5. In addition, it is a high-performance biofactory for air nitrogen fixation. Moreover, leguminous crops are also a biofactory for the production of high-quality protein. Leguminous crops are the most reliable and profitable component in mixed crops, due to their ability to actively fix nitrogen and excellent drought tolerance.
In total, 5050 companies are registered in the cultivation of grains and legumes in Kazakhstan, of which 2621 are statistically active. Total number of companies engaged in the cultivation of grains and legumes: large enterprises (with more than 250 employees) - 43; medium organizations (from 101 to 250 people) - 176; small enterprises (from 5 to 100 people) - 2581. Geography of agricultural companies growing grains and legumes in Kazakhstan. Most of the companies are registered in the South Kazakhstan region (717), North Kazakhstan region (560), and Akmola region (527). The least of all companies are located in the Kyzylorda region (5), in Astana (5), and the Mangistau region (1).
Leguminous are very important from both an ecological and agricultural point of view, as they are responsible for a significant portion of the global flux of nitrogen from the atmosphere into fixed form.
According to the Committee on Statistics of the Republic of Kazakhstan, in the country, the total area under of leguminous crops such as peas, chickpeas and lentils is 42.8 thousand hectares, and over the past 3 years, there has been an increase in the area under crops of lentils, chickpeas and peas. The main importers of Kazakh leguminous crops are Sweden, Turkey, China, Uzbekistan, Tajikistan, and Kyrgyzstan.
It should be noted that in assessing the impact of climate change on the economic efficiency of the production of leguminous crops, it is necessary to analyze the yield, which is directly affected by climate change. In this regard, the yield of grain and leguminous crops is of the greatest interest as the resulting indicator of agriculture and crop production, showing the efficiency of using the agro-climatic potential of a particular territory, the data of which are presented in
In Kazakhstan in 2021, compared to 2016, the yield of leguminous crops was 3.1 centners per hectare. This dynamics was primarily affected by climate change, which continues to have a negative impact on the yield of leguminous crops in Kazakhstan. As a consequence, there is a need to plan for the development of the industry in more severe arid conditions, with an emphasis on the development and distribution of drought-resistant crop varieties. According to meteorological and statistical data of some international organizations, have been forecasted and studied the impact of climate change on crop yields and productivity in Kazakhstan, which affected the country's economy (Agency for Strategic Planning and Reforms of the Republic of Kazakhstan Bureau of National Statistics, 2023; WMO, 2017; WB, 2005; WB, 2007; WB, 2009; WB, UN, 2012; Bolatova Z., Engindeniz S., 2020).

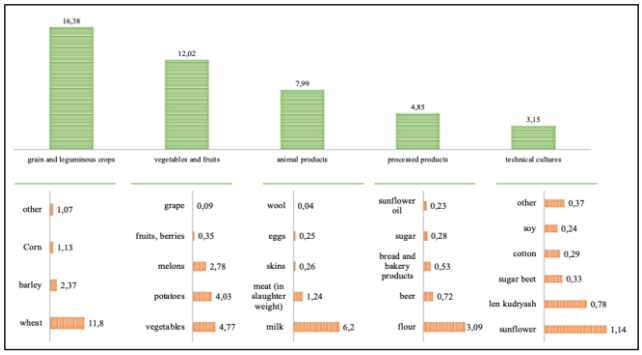

***Figure 1** - Production of the main types of agricultural products in kazakhstan in 2021, mln tonnes*

If we consider the production of the main types of agricultural products (Figure 1), then legumes occupy the 1st place - 16.38 million tons. According to Figure 1, in 2021, the first place in the production of the main types of agricultural products is occupied by leguminous crops - 16.38 million tonnes, where the leading position is given to wheat - 11.81 million tonnes, then barley - 2.37 million tonnes, corn - 1.13 million tonnes and other crops - 1.07 million tonnes (Agency for Strategic Planning and Reforms of the Republic of Kazakhstan Bureau of National Statistics, 2023).
The total volume of chickpea production in the Republic of Kazakhstan is 3.9 thousand tons per year. Crops are grown in the northern region, mainly more than 80% in the Kostanay and Karaganda regions. 325 tons annually produced by the western region - the West Kazakhstan region and 433 tons - by the southern region, where the South Kazakhstan and Almaty regions are in the lead. The Eastern region is not involved in the production of chickpeas.
A little more than 83 thousand tons of food peas are produced annually in Kazakhstan. The main volume of production - 88.4% falls in the northern region, where the leading positions are occupied by the Kostanay and North Kazakhstan regions. About 9.5 thousand tons of peas are annually produced in the eastern region of the republic. The Western region practically does not participate in the production (Bolatova Z., Engindeniz S. (2020); Bolatova Z., Engindeniz S. (2021)).

3.1 Production volumes of leguminous crops by regions of Kazakhstan

The annual production of leguminous in the republic is 486 tons. In the southern region - mainly more than 85% grown in the South Kazakhstan and Zhambyl regions. The Eastern region (mainly the East Kazakhstan region) produces 23 tons annually. Since 2017, the Aktobe region has started producing beans.
The gross harvest of lentils in 2017 amounted to more than 313 thousand tons. Almost all lentils - 98.9% - were produced in the northern region of the country, of which more than 221 thousand tons were in the North Kazakhstan region. A small contribution to the total production (about 3.5 thousand tons) is made by the eastern region. The annual soybean production in the republic is approximately 200-300 thousand tons per year. The main soybean growing area is the Almaty region. 15-20% of its crop is exported annually.
Also, as part of the study, a survey was conducted among agricultural producers, about 40 farmers were interviewed and another survey is underway. The bulk of respondents carry out agricultural activities in the following regions of Kazakhstan: Zhetysu region - 40% of respondents, Akmola region - 20% of respondents, Almaty region - 16.7%, Abay, Aktobe, Atyrau, East Kazakhstan, Zhambyl regions.

The Pulse Farm Questionnaire consists of 2 parts: 1) On the production and yield of leguminous crops, 2) The impact of climate change on the production of leguminous crops in Kazakhstan. The questionnaire was conducted in 2 languages (in Kazakh and Russian, as farmers of different nationalities) and in regions where more leguminous crops are grown for 2021-2024 (Figure 2).

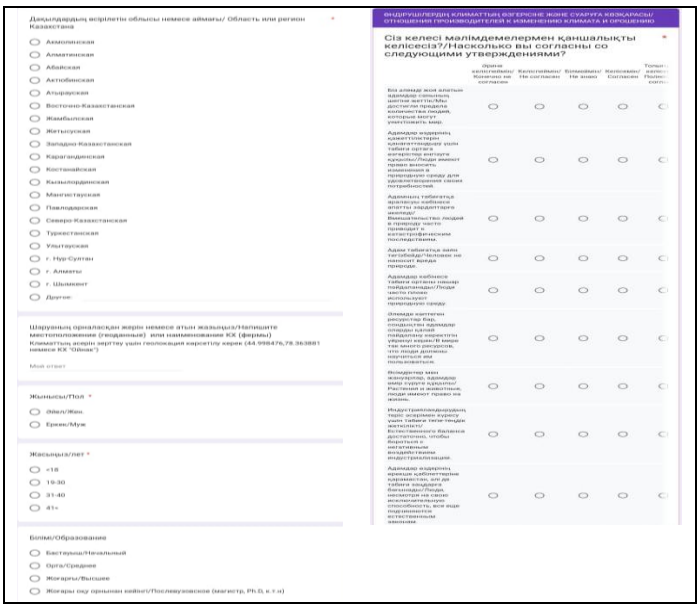

Figure 2 *- Type of questionnaire (google questionnaire).*

It should be noted that among the interviewed farmers - 80% of men and only 20% of women. Also, the age category of agricultural entrepreneurs: over 41 years old - 50% of respondents, from 31 to 40 years old - 26.7% of respondents and 19-31 years old - 26.7%. That is, we can conclude that the majority of farmers are over 41 years old, there are fewer young people. It should be noted that among the respondents 70% have higher education, postgraduate - 6.7% and only secondary education - 23.3%. Now let's consider in more detail the area and yield of farmers' leguminous crops, the data of which are presented in Figure 3.

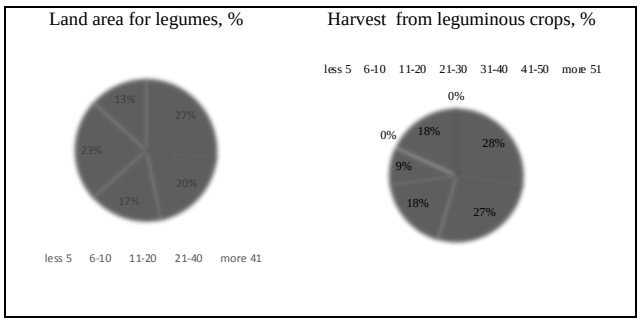

Figure 3 *- Area and yield of leguminous crops according to the results of the survey, %*

According to Figure 3, it can be noted that among the interviewed farmers, legumes are allocated for cultivation: less than 5 hectares - 27%, from 6 to 10 hectares - 20%, from 11 to 20 hectares - 17%, from 21 to 40 hectares - 23 % and more than 41 hectares - 13%. As for the yield of leguminous crops, the highest yields are from 41 to 50 hectares - 28% and from 6 to 10 hectares - 27%. It is worth noting that favorable conditions in 2022 made it possible to carry out most of the harvesting campaign without outage. If we consider the context of the country, then in the end, 15.4 million hectares of grain and leguminous crops or 96.3% of the total harvested area were harvested in Kazakhstan. With an average yield of 13.0 c/ha, 20.1 million tonnes of grain were threshed. It should be noted that in 2021, with an average yield of 9.8 centners per hectare, 14.9 million tonnes were harvested, or 25.9% less. But at the same time, there is a tendency that agricultural producers are actively expanding the sowing of oilseeds, vegetables and melons. The growth in areas under these crops since 2012 has been 67%, 14% and 35%, respectively. Yields are also growing in these segments of crop production as opposed to legumes.

It should be noted that the climate has a significant impact on the economic efficiency of the production of leguminous crops. In 2022, despite favorable weather conditions in 2022, the survey revealed that over the past 5 years, many farmers have been affected by drought - 81%, which had an impact on the cultivation of pulses. And to the question regarding: “Have there been habits / floods in your region over the past five years?”, 71% of respondents answered NO.

The survey revealed that 48.4% of farmers felt that the drought had a strong impact on leguminous crops, while 35.5% of respondents had a very strong impact on the growth of crops. At the same time, 41.93% of respondents answered the question: “What were the changes in legumes after drought or cold?” answered - strongly, 25.8% of respondents - very strongly and 22.% influenced, but slightly. Also, many farmers believe that the area of production of pulses during drought, cold or floods suffered very much - 22.5% of respondents answered, 29.0% of respondents said that it was severe and 29.0% of farmers answered that the level was below average.

And if we turn to the question “Did drought, cold or floods (habits) affect the use of fertilizers and pesticides”, then the opinion is as follows:

- 22.5% of the respondents answered that the influence of drought, cold or flood (habits) on the use of fertilizers and pesticides is very strong;
- 32.25% of respondents answered - significantly;
- 22.5% of farmers noted that they had an impact, but below the average.

And to the question: “Did the drought, cold or floods (habits) affect the price of legumes?” the following answers were received: very strongly influenced - 32.3% of respondents, strongly influenced - 38.7% of respondents, below average - 19.4% of respondents, slightly influenced - 3.2% of farmers and practically had no effect - 6.2 %.

If we consider the effect of drought, cold or flood (habits) on the yield of leguminous crops, we can see:

- 35.5% of farmers believe that drought, cold or floods (habits) have greatly affected the yield of leguminous crops;
- 32.3% of respondents answered that it was just a strong influence;
- 25.8% of respondents are inclined to believe that these natural phenomena have affected the yield of leguminous crops below the average.

The question was also asked to agricultural producers: “Did the drought, cold or floods (habits) affect the quality of the grain?” and received the following responses:

- 25.8% of farmers believe that drought, cold or floods (habits) have greatly affected the quality of grain;
- 29% of respondents answered that it was just a strong influence;
- 38.7% of respondents are inclined to believe that these natural phenomena have affected the quality of grain crops below average.

Also, during the survey, it was revealed that against drought, most of the farmers use irrigation - 9.7, the other part - a small number of agricultural producers (3.1-3.2%) use starting from moisture-saving technologies to nothing.

It is worth noting that despite the not always good weather conditions, many farmers did not take out a loan and insurance for growing leguminous crops - 70% of respondents (Figure 4).

However, the production of leguminous crops in Kazakhstan has a number of problems. With a delay in its development, the lack of awareness of agricultural producers about crop production technologies, the lack or economic unavailability of seed material,

the underdevelopment of confidentiality of storage, as well as the instability of relations with sales markets. In the field of processing, technical and technological re-equipment of production remains relevant, leguminous cereals produced at industrial enterprises have significant production volumes of higher grades, and agricultural cereal workshops do not require significant sizes for finished products. In the field of regulatory and methodological regulation, it should be noted that there are no updated regulations for the production of a wide range of leguminous cereal products.

However, the production of leguminous crops in Kazakhstan has several problems. Its development is hindered by the lack of awareness of agricultural producers about the technology of crop production, the lack of economic inaccessibility of seed material, the underdeveloped storage infrastructure, as well as the instability of relations with sales markets. In the field of processing, technical and technological re-equipment of production remains relevant, leguminous cereals produced at industrial enterprises have insignificant production volumes of higher grades, and agricultural cereal workshops do not meet the requirements of existing standards for finished products. In the field of regulatory and methodological support, it should be noted that there are no updated regulations for the production of a wide range of leguminous cereal products.

4 Conclusion

Thus, based on the analysis carried out, it can be concluded that the effectiveness of the development of agricultural production is influenced not only by natural and climatic risk factors. Only by taking into account all external and internal risk factors, it is possible to reliably assess the actual state of the industry and develop prospects for its development.

At the same time, weather risks turn out to be key for agriculture, since there is a dependence of crop production volumes on weather conditions, which in turn directly affects the livestock industry. Under unfavorable weather conditions, there is a shortage of fodder, which leads to a decrease in the productivity of livestock, a decrease in its livestock. This affects the increase in production costs, a decrease in the profitability of products and labor productivity.

The following are proposed as the main methods for adapting agricultural enterprises to the impact of weather risks:

- conducting a comprehensive study to assess the impact of weather risks on agricultural production in the Akmola region;
- optimization of the sowing structure of winter and spring crops, taking into account changes in the weather in the autumn-winter period;
- increase in crops of stubble and hay crops;
- intensification of the development of the agricultural sector of the region.

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References

1. Akmarov P.B., Knyazeva O.P., Suetina N.A. (2014). Some Aspects of the Influence of Climatic Factors on the Efficiency of Agriculture, *Bulletin of NSAU (Novosibirsk State Agrarian University)*, 4 (33): 178-185.

2. Romanenko I.A, Siptits S. O., Evdokimova N. E. (2016). Methodology for the development of strategic directions for the placement of crop production, *Encyclopedia of Russian villages*, 246.

3. Zhuchenko, A.A., (1990). Adaptive crop production (ecological and genetic foundations) - Kishinev: Shtiinca.

4. Zhuchenko, A.A., (2009). Ensuring Russia's food security in the XXI CENTURY based on an adaptive strategy for the sustainable development of the agro-industrial complex: (theory and practice). Russia, Kirov: Research Institute of Agriculture of the North-East.

5. Nikonov A.A., (1979). About regional systems of agriculture in modern conditions, *Agricultural Economics*, 8: 24-30.

6. Nikonov A.A. (1975). Economic foundations of the agricultural system. Stavropol: Stavropol book publishing house.

7. Shashko D.I. (1967). Agro-climatic zoning of the USSR, Moscow: Kolos.

8. Siptits S.O., Romanenko I.A., Evdokimova N.E. (2018). The influence of the natural and climatic factor on the sustainability of agricultural production, *International Agricultural Journal*, 4: 15-19.

9. Agency for Strategic Planning and Reforms of the Republic of Kazakhstan Bureau of National Statistics, 2023. Productivity of the main agricultural crops, report.

10. World Meteorological Organization (WMO) (2017). WMO Statement on the state of the global climate in 2017. Retrieved from http://ane4bf-datap1.s3-eu-west-1.amazonaws.com/wmocms/s3fspublic/ckeditor/files/2017_provisional_statement_text_-_updated_04Nov2017_1.pdf?7rBjqhMTRJkQbvuYMNAmetvBgFeyS_vQ

11. World Bank (WB) (2005). A better investment climate for everyone. Retrieved from http://siteresources.worldbank.org/INTWDR2005/Resources/complete_report.pdf

12. World Bank (WB) (2007). The impact of sea level rise on developing countries: A comparative analysis. Retrieved from http://documents.worldbank.org/curated/en/156401468136816684/pdf/wps4136.pdf

13. World Bank (WB), (2009). Climate change strategy for the South Asia region. Retrieved from http://go.worldbank.org/DEOKW48F50

14. World Bank (WB) and The United Nations (UN) (2012). Natural hazards, unnatural disasters the economics of effective prevention. Retrieved from https://www.gfdrr.org/sites/default/files/publication/natural-hazards-unnatural-disasters-2012-ru.pdf

15. Bolatova Z., Engindeniz S. (2020). The Economics of Climate Change in Agriculture: A Review on Kazakhstan and Turkey. *Sustainable Food Chains and Ecosystems*, Springer Nature Switzerland AG, Switzerland: Cham.

16. Bolatova Z., Engindeniz S. (2021). The economics of climate change in agriculture in Kazakhstan. *Economy and ecology of territorial formations*, Vol. 5 (2): 25-35, ISSN 2413-1474.