

ICEST 2021**II International Conference on Economic and Social Trends for Sustainability of Modern Society****CLIMATE CHANGE: IMPACTS AND ADAPTATION FOR
AGRICULTURE IN ALTAI TERRITORY**

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Abstract

The general stages of the adaptation process to the consequences of climate change make it possible to determine the vulnerability of regional agricultural producers. Altai Territory is considered as one of the typical agro-industrial regions of Russia. The importance of agriculture for the economy of the region under consideration and a significant degree of dependence of the sector on natural and climatic conditions have been substantiated. The territory of the region is responsive to the effects of global climate change; the average temperature has a long-term upward trend. Taking into account the existing trends, recommendations aimed at adapting regional agriculture to climate change seem to be relevant. The development of the basic recommendations is based on the period of their implementation. Within the framework of the short-term and long-term periods, the levels of implementation of specific measures for agricultural producers to the consequences of global climate change have been determined. The main directions of adaptation that require state support are also noted: insurance of risks with state participation, monitoring and assessment of agricultural adaptation, institutional measures, investments in research, international cooperation. It is assumed that the recommendations will allow agricultural producers to reduce the damage caused by the consequences of global climate change.

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1. Introduction

The effects of global climate change tend to manifest themselves in climate-sensitive sectors such as agriculture. Climate change in the long term can pose a serious problem for regions that specialize in food production. Research shows that without strategies to adapt to the impacts of climate change, agriculture can suffer significant economic damage. However, it is already possible to compensate the losses of the sector with various adaptation measures (Mendelsohn & Davis, 2001).

Currently, the following directions of the agricultural strategy to the consequences of climate change are distinguished:

- 1) directions of the micro level, such as diversification of crops and changes in the timing of technological operations (planting or crop rotation), an increase in the amount of fertilizers and pesticides;
- 2) income diversification;
- 3) institutional changes (government measures): subsidies, taxes, concessional lending;
- 4) technological developments: selection achievements; inventions related to crop cultivation, animal husbandry technologies, land reclamation (Deressa et al., 2009; Galkin, 2021; Mendelsohn & Davis, 2001).

The directions considered are universal and can be basic for strategies for adapting agriculture to climate change. However, the issues of determining need for adaptation of individual regions and the expediency of applying the considered directions to them remain relevant.

2. Problem Statement

Recently, there are more facts of vulnerability of agricultural producers to climate change (Cohn et al., 2017; Harvey et al., 2014, 2018), however, the development of specific adaptation measures is still hampered by the lack of information on the state, problems and needs of the sector in some regions. In addition, information about how vulnerable commodity producers are, depending on various farming systems and socio-economic conditions, is valuable. To adapt agriculture to the consequences of climate change at the level of specific regions, it is necessary to identify key directions in the short and long term.

3. Research Questions

The main directions of adaptation of regional agriculture to the consequences of global climate change are investigated. Particular attention is paid to identifying adaptation needs and developing a set of tactical and strategic measures for various adaptation options for the sector.

4. Purpose of the Study

The purpose of the study is to develop recommendations for ensuring the sustainability of agricultural development in a changing climate at the regional level.

5. Research Methods

The reliability of the results is ensured by the use of modern means and research methods. The theoretical and methodological basis of the study were the works of domestic and foreign scientists-economists dedicated to the development of strategies for adapting agriculture to the consequences of global climate change. The information base of the study was made up of data from the Federal State Statistics Service, the Federal Service for Hydrometeorology and Environmental Monitoring, and periodicals. Deduction, scientific abstraction, logical method, analysis, analogy method, statistical methods are applied.

6. Findings

Many adaptation measures are resource-intensive and often inaccessible to agricultural producers, and, therefore, require the attention of the state. National adaptation plans developed in different states differ significantly from each other depending on the level of development of countries, priorities of state policy in the field of climate change, the degree of susceptibility of the economy and the social sphere to weather and climate risks.

The report on the scientific and methodological foundations for the development of adaptation strategies to climate change in the Russian Federation highlighted the general stages of the adaptation process:

- 1) identification of adaptation needs;
- 2) determination of a set of measures for various adaptation options;
- 3) an economic assessment of these options;
- 4) planning and implementation of the selected adaptation measures at the federal level and at the level of the subjects of the federation;
- 5) monitoring and evaluating the progress of implementation and adaptation results, making the necessary adjustments to the measures being taken (Report on the scientific and methodological basis for the development of adaptation strategies to climate change in the Russian Federation, 2020).

Altai Territory is one of the typical agro-industrial regions. To determine the need for adaptation of agriculture, it is advisable to determine the significance of this sector for the regional economy and its susceptibility to climatic conditions, the main climatic impacts on the sector and their consequences. The Altai Territory has a significant area of agricultural land, but unfavorable climatic conditions limit the possibilities for successful farming (Galkin & Pospelova, 2021). The population of the region is 2341.4 thousand people, the share of the urban population is 56.6%, the rural population is 43.4%. The economic significance of agriculture, taking into account its share in the GRP of the Altai Territory, is quite high - 13.4% versus 4.3% in Russia (2018). The sector's contribution to the region's GRP is higher than in Siberia and Russia as a whole, while the dynamics of the sector's share is decreasing (for the period 2004-2018 it decreased from 23.3% to 13.4%) (Federal State Statistic Service, 2021), which may be due to with a disparity in prices and low growth rates of agricultural production.

The Agriculture sector is highly exposed to climatic conditions. The example of the dependence of agriculture on drought is 2012 – the hottest year in the Altai Territory over the past 10 years. The highest average annual temperatures were observed in the summer months (June and July – 22.1⁰C) with the lowest average monthly precipitation in June 2012 – 10 mm. The yield for grains and legumes in all categories of farms amounted to 8.4 centner/ha, while in 2013 the value of the indicator increased by 69% and amounted to 14.2 centner/ha. At the end of 2012, the decrease in grain harvest in the region was 36%. The increase in prices for grain in the Altai Territory in 2012 amounted to 80.9%.

Research of climate information shows that agriculture in different regions will be affected by the nature of climate change. Climate models predict further temperature increases, more irregular precipitation, and a possible increase in the intensity and / or frequency of extreme weather events (Imbach et al., 2017). Research shows that Russia and the Altai Territory are affected by the effects of global climate change. The data of the report on the features of climate change in Russia indicate that 2019 was one of the warmest years since 1936. Warming is observed throughout the territory of Russia, the rate of growth of the average annual temperature was 0.47⁰ C in ten years, which is 2.5 times higher than the rate of increase in global temperature (Report on the peculiarities of the climate in the territory of the Russian Federation for 2019, 2020). Altai Territory is also affected by climate change, for the period 1838-2020 there is a warming, the highest growth rate of the average annual temperature is observed from 1960 to the present (Figure 1), which may be associated with the development of scientific and technological progress, with the increase of greenhouse gas emissions in energy and industry.

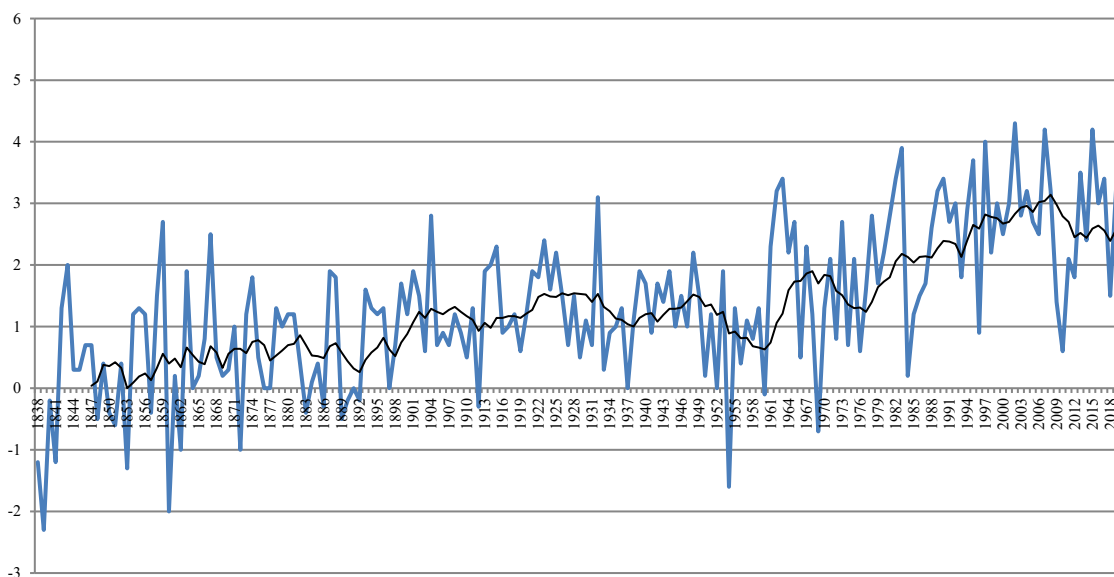


Figure 1. Dynamics of the average annual temperature in the Altai Territory for 1838-2020

The energy sector dominates in the structure of CO₂-equivalent emissions in Russia in 2018, its share in the total emissions was 78.94%, the contribution to the total emissions of the industrial sector is 10.95%. By transforming Figure 1 by the method of enlarging the intervals, one can observe the cyclical nature of climatic changes since 1838 and the greatest amplitude of fluctuations since 1960 (Figure 2). The trend can be set by a power-law function showing high confidence. Thus, the territory of the Altai Territory

is responsive to the consequences of global climate change, the average annual temperature has a long-term upward trend.

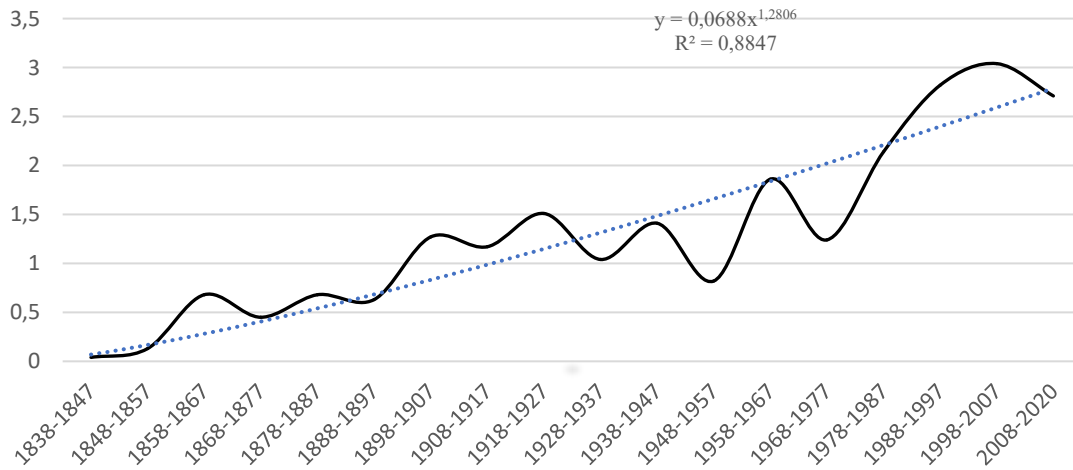


Figure 2. Dynamics of the average annual temperature by the method of enlarging the intervals in the Altai Territory for 1838-2020

The goals of the concepts of adaptation of agriculture to the consequences of global climate change, as a rule, are to increase the industry's resilience to climate change, as well as to reduce greenhouse gas emissions. The Climate Smart Agriculture concept, presented by FAO in 2010, is based on the principles of sustainable agriculture and improved resource efficiency. The considered concepts (Lipper et al., 2017; Paptsov et al., 2015; United Nations Framework Convention on Climate Change, 1992) make it possible to determine the basis of the strategy and tactics of adaptation of food producers of the Altai Territory to the consequences of global climate change based on the implementation period (Table 1).

Table 1. Tactics and strategy of adaptation of agricultural producers to the consequences of global climate change

Implementation period	Implementation level	Type of tactics (short term) \ strategy (long term)	Measures of specific tactics / strategies
Short term	Micro level	<i>Crop management</i>	Diversification of crops, crop rotation, use of organic and mineral fertilizers, sowing of drought-resistant and / or early maturing varieties, irrigation of crops
		Risk insurance Monitoring and assessment of agricultural adaptation	Insurance of the cultivated area, livestock of farm animals Real-time assessment, exchange of experience
	Region level	Institutional arrangements	Transfers, tax breaks, government-owned insurance
Long term	Macro level	<i>Migration</i>	Labor migration (food production in other regions), rural-to-city migration
	Micro level	<i>Diversification of income</i> Organic farming	Work outside the sector (trade, tourism) Build up soil organic matter, increase water retention capacity, reduce vulnerability to drought
	Macro level	The international cooperation	Exchange of experience, systematic updating of sector development programs
		Investment in research	Inventions, utility models and selection achievements related to the cultivation of agricultural crops, animal husbandry technologies, breeding

The types of strategies are determined based on the periods and levels of implementation. Three levels of strategy implementation are assumed: micro level (private sector of the economy), region level (regional government) and macro level (federal government). Within each level, a choice of basic tactics in the short-term and strategies in the long-term periods is offered, while their combination is possible. The application of specific measures depends on the intensity and frequency of hazardous hydrometeorological events.

The impacts of a changing climate indicate significant obstacles to the adaptation of the sector in the long term. Overcoming them requires significant government support. As areas requiring state support, the following should be highlighted:

- In the short term: risk insurance, monitoring and assessment of agricultural adaptation to the consequences of climate change, institutional measures;
- In the long term: investment in research, international cooperation.

7. Conclusion

Taking into account the impact of the consequences of global climate change on agriculture in Russia, it is necessary to determine the needs for adaptation for specific regions, taking into account their specialization.

The region considered in the article, the Altai Territory, is responsive to the consequences of global climate change; the average annual temperature has a long-term upward trend that has intensified since 1960. In this regard, it is advisable to focus efforts on recommendations regarding the adaptation of agriculture in the region to the consequences of global climate change.

The main strategies and tactics of adaptation of agriculture in the region under consideration can be grouped based on the short- and long-term periods, the level of implementation. The areas requiring the attention of the state include: insurance of risks with state participation, monitoring and assessment of the adaptation of agriculture to the consequences of climate change, institutional measures, investments in research, international cooperation.

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