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RATIONALE OF CLIMATE RISK MANAGEMENT MECHANISMS IN THE REGIONS OF THE RUSSIAN FEDERATION WITH CROP SPECIALIZATION

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Abstract

The growing number of dangerous weather events, an increase in their duration and amplitude of action leads to sharp fluctuations in agricultural production, thereby creating risks for sustainable development and ensuring food security of the country. The aim of the study is to analyze the peculiarities of the manifestation of hazardous weather phenomena in the regions of the Russian Federation with crop specialization and to substantiate the actual mechanisms of adaptation of regional agrosystems to the consequences of the transformation of natural and climatic conditions. The use of the author's methodology for assessing the level of influence of climatic risks on agricultural production made it possible to establish that the increase in the number of unfavorable meteorological phenomena and the degree of their impact occurs more intensively in the most productive regions of crop specialization. The differentiated impact of climate risks necessitates the creation of regional and sectoral models of adaptation of regional agrosystems, taking into account the peculiarities of natural-resource potential, changes in crop productivity in response to changes in climatic variables, the structure of crop producers in the region. Mechanisms and tools for adapting agricultural systems to the consequences of climate change for the regions involved in the study are formulated.

Key words**:** *agri-food complex, climate change, crop production, climate risk, adaptation, strategy, mechanism*

INTRODUCTION

From the point of view of the world community, the risks driven by climate change, in terms of the probability of occurrence and the expected size of losses, are among the most significant risks threatening the world. Already in the short and medium term, a change in the conjuncture of the global agri-food market is expected due to shifts in the structure of world agricultural production under the influence of a shift in temperature regimes and changes in productivity.

A large number of studies have been devoted to analyzing the impact of climate change on agricultural production in recent years. Assessment reports of the Intergovernmental Panel on Climate Change (IPCC), the Food and Agriculture Organization of the United Nations (FAO) are published regularly. In the annual report of the World Economic Forum on global risks "Global Risks Report 2021" as one of the most important in the medium and long term, the problem of climate change is identified, leading to a spatial shift in agricultural production and the redistribution of resources [22]. A complex combination of social, climatic and environmental risks threatens to deviate from the vector of sustainable development of socio-economic systems, transform established economic ties and chains, reduce the level of physical availability of food, and destabilize the process of ensuring food security of countries. The results of a retrospective analysis indicate that the repetition of several lean years leads to fluctuations in yields and agricultural production volumes, disruption of food chains and a sharp reduction in carry-over stocks of agricultural products, destabilizing the provision of domestic food consumption [13].

Researchers from different countries note that the number of climatic anomalies and natural disasters at the macro level in recent decades has increased by 4 times - in terms of climatic disasters, and 6 times - in hydrological ones

[4]. At the same time, in the countries with the most productive agriculture, an increase in the number of negative weather events, their duration and intensity was observed.

The main conclusions made by Russian researchers can be boiled down to the fact that the impact of climate change on the prospects for the development of agriculture in Russia can be regarded as moderately negative [12, 20]. It is believed that the potential climatically conditioned increase in gross harvests of grain and other basic crops in the regions of the Central Non-Black Earth Region, the North-West and the Far East will positively affect the state of food security in macroregions. Taking into account natural and climatic risks in regional strategies of socio-economic development exists only in the form of a statement of the presence of such factors (risks) [19, 6]. At the same time, the unpredictability of the onset of unfavorable weather events, an increase in their number and intensity, will neutralize the softening of temperature regimes and the expected increase in productivity in crop production in more northern regions.

The current regulatory framework does not facilitate their mandatory analysis and quantitative accounting when developing or adjusting strategies, which is a violation of the principle of realistic strategic planning. The significance of the factor of hazardous weather phenomena in the system of strategic priorities is certainly underestimated. At the same time, the growing number of dangerous weather events, an increase in their frequency and amplitude of action, can create risks for the sustainable development of agriculture and food security of the country.

An integrated approach to climate risk management includes three sequential stages: collection and processing of information on climate threats and risk recipients; identification and assessment of risks, forecasting their changes; implementation of measures to adapt to climate risks, as well as monitoring the results of their implementation. Without complete information about the intensity and geography of hazardous phenomena, as well as the exposure of the economy and society to them, it is impossible to assess the scale and dynamics of climate risks. Without a quantitative assessment of risks, it is difficult to build a system of adaptation measures aimed at mitigating the consequences of their impact.

The aim of the study is to identify trends in the influence of hazardous weather events on the main indicators of crop production in the most productive regions of the Russian Federation and to substantiate the actual mechanisms of adaptation of regional agricultural systems to the consequences of global climate change. Achieving this goal involves solving the following tasks: studying the regional features of the manifestation of natural and climatic risks, assessing their impact on the productivity of basic agricultural sectors, justifying adaptation measures to mitigate the consequences of the negative impact of climatic factors. Regional differences create an objective basis for the development of sectoral and regional strategies for adaptation to the consequences of global climate change. The calculations performed and the conclusions made on their basis will allow substantiating the most relevant mechanisms for the sustainable development of the plant growing sub-industry to global climate changes, as well as contribute to the development of a differentiated strategy for the development of regional agrosystems.

MATERIALS AND METHODS

The research methodology is based on a set of conceptual provisions for sustainable development and climate-smart agriculture, developed by the Food and Agriculture Organization of the United Nations (UN FAO) [9]. The approaches to sustainable development described in the 2011 Human Development Report provide a clear justification for the presence of a synergistic component in the influence of factors that weaken or enhance the resilience of socio-economic systems [7, 8]. They are viewed in terms of nonlinear linkages and trade-offs between sustainability, ecology and equality of opportunity.

Today, the principle of dynamically balanced development of the economy-nature-society triad, when implemented, faces a number of problems and limitations. Existing approaches imply inconsistent, often isolated solutions to problems. Analysis by the United Nations Environment (UNEP DTU) indicates that most countries (72%) have adopted at least one national adaptation planning tool, and a number of countries (9%) are currently do not have such a tool, are in the process of developing it. According to the 2020 Adaptation Implementation Gap Report, huge gaps remain in implementation in developing countries and in bringing adaptation projects to the point where they provide real protection against climate impacts such as droughts, floods and sea-level rise [24]. The question of what policies, innovations and institutions are needed to eliminate or mitigate the negative side effects of climate change has become fundamental [23].

To develop strategies and measures for the adaptation of socio-economic systems, it is necessary to study the problem from different angles, determine the significance of the influence of various factors, study the institutional environment, the available resource potential, etc. The problems of the impact of climate change on agricultural production are reflected in a whole array of research works by Russian and foreign scientists. Andryushchenko S.A. [1, 2] in a number of his works systematizes climatic factors that have a direct and indirect impact on the competitiveness of the agri-food complex. The study of climate influence on structural changes in agricultural production and the associated change in the level of food security of the Russian Federation was carried out by M. Yu.Ksenofontov, D.A. Polzikov [12]. The authors provide an economic justification for the fact that in the long term, global climate change will not have such a negative impact on the development of agriculture in Russia.

The role of the climatic factor in the development of the Russian agri-food complex in the system of strategic priorities is reflected only in the form of an increase in the average temperature by 1.5°-2.2° and a uniform shift in the temperature gradient. At the same time, the differentiated impact of climatic risks is underestimated, which increasingly began to manifest themselves in the most fertile regions of the Russian Federation. Examples of scientific works devoted to a detailed consideration of the frequency of occurrence of various types of hazardous meteorological phenomena and their impact on the regional economy are the studies of A.N. Petina and M.V. Brykalova [16], P.V. Druzhinin [5], V.M. Katsov and others [3, 10]. Comprehensive study of the influence of unfavorable weather (agrometeorological) phenomena on the processes of growth, development and formation of productivity of cultivated crops, on the massive development of pests and diseases that cause serious damage to the formation of crop yields was carried out by Gringof I.G. and Kleshchenko A.D. [6]. Rusin I.N. summarized the approaches underlying the construction of modern methods of forecasting the impact of natural disasters [18].

The issue of assessing the impact of climate change on agricultural development is complex and interdisciplinary. To study it qualitatively, it is necessary to synthesize a systemic, institutional, logical and comparative scientific approach. Their consolidation, accompanied by spatio-temporal analysis, will make it possible to comprehensively approach the development of a strategy for adapting regional agrosystems.

The methodological approach proposed by the authors includes several stages of research. The study is based on the classification of the constituent entities of the Russian Federation by the specific weight of the region's crop production in the total volume of the country's crop production. The grouping of regions was carried out using the method of cluster analysis based on data from selective federal statistical observation on agricultural production. In each of the obtained classification groups of regions, an analysis of the dynamics of hazardous weather phenomena in the context of their types was carried out, as well as visualization of the

results of the analysis of the temporal variability of indicators of climatic risks. Using the methods of correlation and regression analysis, the relationship between production and climatic variables is determined.

The final stage of the study includes the substantiation of priority mechanisms for adapting regional agrosystems to climate change, taking into account the current state of the industry and its production potential.

To solve the set tasks, an information base of the study was collected, which includes the values of indicators calculated using: materials of the Federal Statistical Observation on the development of the plant growing sub-industry in the regions of the Russian Federation, bulletins and annual reporting materials of the Ministry of Agriculture of the Russian Federation, summary information of the National Union of Agricultural Insurers on sales agricultural insurance programs in the regions, data from the Federal Agency for Support of State Support Programs for the Agro-Industrial Complex on the allocation of budgetary assignments for the development of subsidized agricultural insurance. The information array of weather characteristics in the context of the constituent entities of the Russian Federation was formed on the basis of data provided by the Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet). Using the methods of economic and statistical analysis, a set of statistical data was processed, the main climatic and production indicators were correlated. An idea of the differentiated impact of climatic risks in the regions of the Russian Federation with different levels of crop specialization was obtained.

RESULTS AND DISCUSSIONS

For the distribution of the regions of the Russian Federation into groups, the share of the region's crop production in the total volume of the country was taken as a classification indicator. The analysis included regions, in each of which it was in the period from 2009 to 2019 exceeded 1%.

The principle of constructing the classification is based on comparing data for the region with the average values of the corresponding indicator for the Russian Federation.

The selected groups of constituent entities of the Russian Federation are considered in the space of climatic factors (number, main types: abnormally cold and hot weather, wind, rainstorm, flood, sudden weather changes, extreme fire hazard, etc.) and the average gross harvest of grain and leguminous crops for last 10 years.

The first group includes the leading regions in terms of the share of crop production in the total volume of the Russian Federation: Krasnodar and Stavropol Territories, Voronezh and Rostov Regions, as well as the Republic of Tatarstan. Agriculture in these regions is the most productive due to favorable basic natural and climatic conditions, a developed level of infrastructure, and the presence of large export-oriented agro-food organizations. Despite the fact that the regions included in the first group have a smaller sown area, in contrast to most regions of the second group, they account for the bulk of the produced crop production (grain and leguminous crops, sunflower).

The specific weight of crop production produced in the Krasnodar Territory accounts for 10% of the total volume of crop production in the Russian Federation.

At the same time, the size of the sown area of the Krasnodar Territory is 3,727.22 thousand hectares. Similar indicators: Stavropol Territory 5% with a sown area of 2,937.41 thousand hectares, Rostov region 6.8% with a sown area of 4,747.95 thousand hectares, Voronezh region 3.9% with a sown area of 2,685.94 thousand hectares, and The Republic of Tatarstan 4.2% with a sown area of 2,870.62 thousand hectares (Table 1).

The plant growing sub-industry is of strategic importance for the implementation of the existing resource and natural-climatic potential of the listed regions.

On average, for this group, crop production accounts 70% of the total agricultural production. This sub-sector employs on average more than 63% of agricultural organizations and 84% of peasant (farmer)

households.

Analyzing the first group of regions in terms of climatic factors, it should be noted that the average number of dangerous weather events significantly exceeds the average value of this indicator in the Russian Federation.

Table 1. Grouping of regions of the Russian Federation according to the average value of the share of crop production of the region in the total volume of crop production of the Russian Federation for 2009–2019

Average share of crop production in the region in its total volume in the Russian Federation,%	The subject of the Russian Federation	Average gross harvest of grain and leguminous crops, thousand tons	Average number of dangerous weather events per year, units	Correlation coefficient
4.4	Voronezh region	3,990.7	6.36	-0.581
	Krasnodar region	12,337.8	57.45	-0.114
	Republic of Tatarstan	3,468.5	13.82	-0.240
	Rostov region	9,446.8	11.18	0.048
	Stavropol region	8,220.9	35.00	-0.589
1.9	Altai region	4,224.6	41.91	-0.114
	Belgorod region	2,950.1	4.91	-0.710
	Volgograd region	3,491.4	6.18	-0.236
	Kursk region	3,736.8	8.82	-0.692
	Lipetsk region	2,483.4	4.36	-0.291
	Orenburg region	2,338.9	7.27	-0.355
	Republic of Bashkortostan	2,633.3	9.45	-0.058
	The Republic of Dagestan	310.3	11.55	-0.513
	Samara Region	1,643.5	9.82	-0.878
	Saratov region	3,099.0	6.09	-0.574
	Tambov Region	2,845.5	4.27	-0.727
1.1	Amur Region	327.6	6.09	0.431
	Moscow region	305.9	5.09	0.018
	Novosibirsk region	2,246.6	24.09	-0.532
	Omsk region	3,016.5	6.64	-0.685
	Orel Region	2,680.5	4.00	-0.622
	Penza region	1,406.5	3.82	-0.408
	Tula region	1,419.2	1.91	-0.103
	Chelyabinsk region	1,535.1	12.18	-0.620

Source: own calculations.

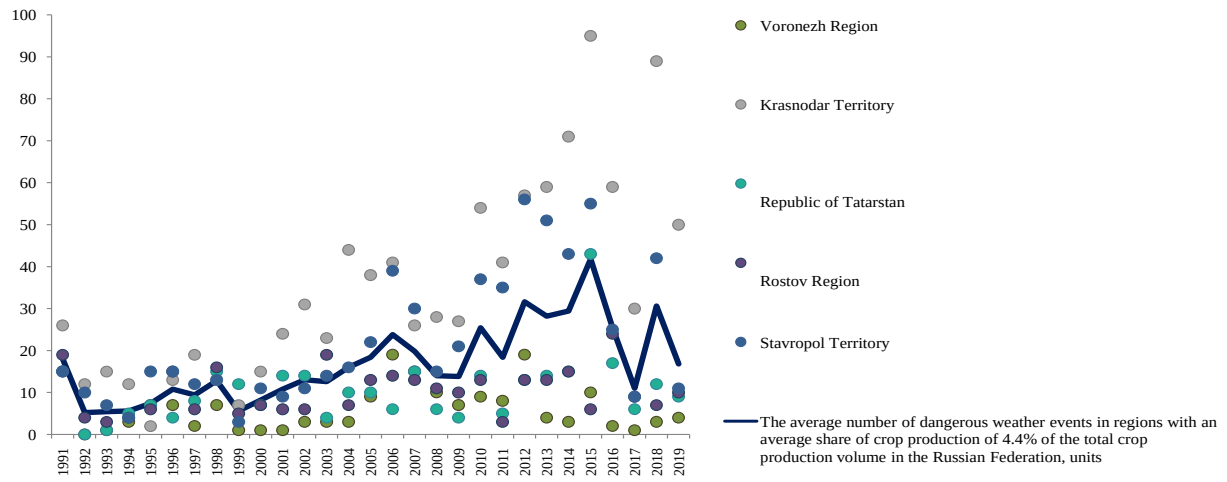

Fig. 1. The dynamics of unfavorable hydrometeorological phenomena recorded in the regions of the first classification group for 1991-2019.

Source: own calculations based on data from the Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet) [17].

Moreover, since 1999, on their territory, there has been a tendency to an increase in the number of climatic risks with an increasing amplitude of action (Figure 1): the equation of the trend line $y = 10^7\text{-}05x^2+0.782x+5.117$, with the determination coefficient $R^2 = 0.511$.

In the structure of climatic risks, the most typical for this group of regions are intense heat, wind, extreme fire hazard, hail, downpour, floods. During the period under consideration, weather anomalies had the greatest negative impact on the Stavropol Territory and the Voronezh Region. The correlation coefficient between the indicators of the gross harvest of grain and leguminous crops and climatic variables (the number of the most frequent unfavorable meteorological events) was -0.581 and -0.589, respectively. Despite the fact that the regions of the first classification group are experiencing the growing impact of dangerous weather events, the balanced financial result of agricultural organizations from year to year remains positive and is achieved due to the size of the cultivated areas, as well as the implementation of state support measures. However, the potential for sustainable development of crop production in these regions may decrease not only due to an increase in the number of climatic risks, but also an increase in their duration and amplitude of action. The most prolonged phenomena were such as extreme heat, wind and extreme fire hazard.

The regions of the second classification group are the undoubted leaders in terms of sown area in Russia: Altai Territory (5,175.85 thousand hectares), Orenburg region (4,285.6 thousand hectares), Saratov region (4,168.7 thousand hectares), Volgograd region (3,090.87 thousand hectares). But the productivity of the plant growing subsector is lower there, although it is close to the average for the Russian Federation - 2.1%.

The regions of this group are characterized by the temperate climate of the Central part of Russia and similar weather characteristics (Figure 2).

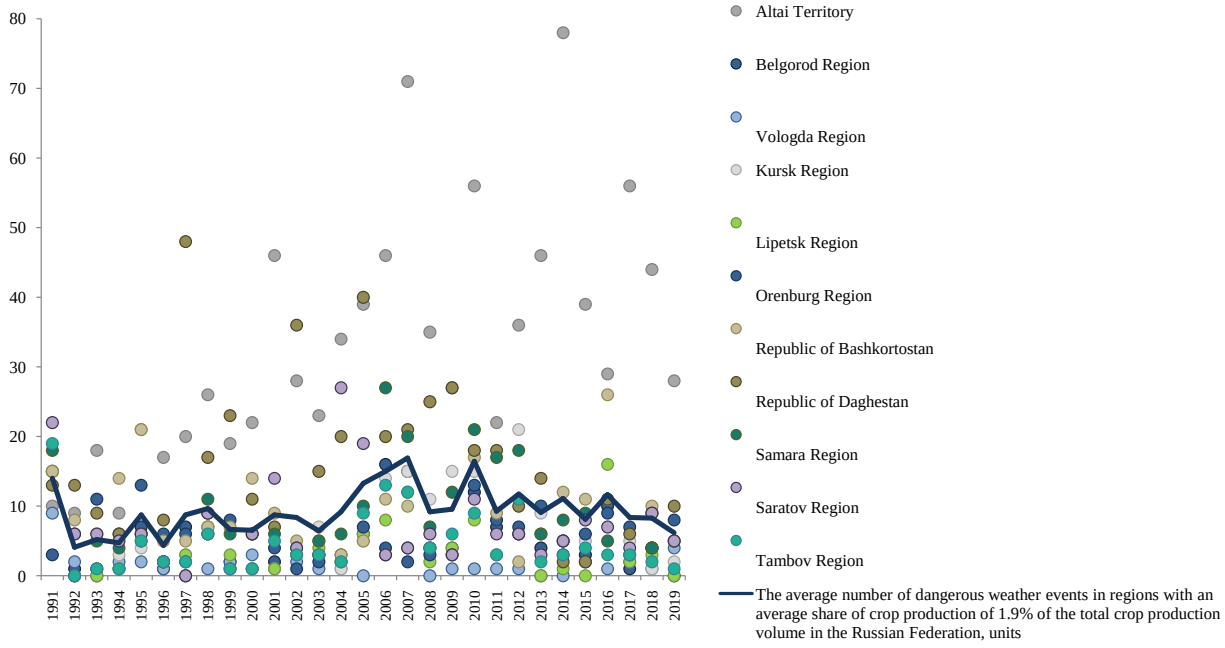

Fig. 2. The dynamics of unfavorable hydrometeorological phenomena recorded in the regions of the second classification group for 1991-2019.

Source: own calculations based on data from the Roshydromet [17].

Analysis of the dynamics of the gross harvest of grain and leguminous crops and the number of hazardous weather events in the regions of the second classification group showed their inverse relationship. A regularity is noted here - a greater number of hazardous weather events in the territories of regions with the

highest indicators of crop production and the available natural resource potential.

The type of climatic risk is of great importance. In the structure of unfavorable meteorological phenomena in the territories of the regions of the second classification group, wind, drought, intense heat and extreme fire hazard prevail. 2009 to 2019 The greatest destabilizing effect of weather anomalies was in Belgorod (-0.710), Kursk (-0.692), Samara (-0.878) and Tambov (-0.727) regions. This was reflected in the dynamics of the financial results of agricultural organizations with a delayed effect of one to two years [14]. Considering that in the regions of this classification group, half of the producers of crop production are small businesses, the share of unprofitable organizations increased in those years when the maximum number of dangerous weather events occurred.

A similar trend is typical for the regions included in the third classification group. The Moscow and Amur regions were exposed to the minimum impact of weather anomalies (on average 5 and 6 times a year). The maximum number of unfavorable weather events in the group occurred in the Novosibirsk region (on average, 24 times a year). The analysis of the time series showed that the regions of the second and third classification groups for the studied period of time on average accounted for the same number of dangerous weather events as the average for the Russian Federation (Figure 3).

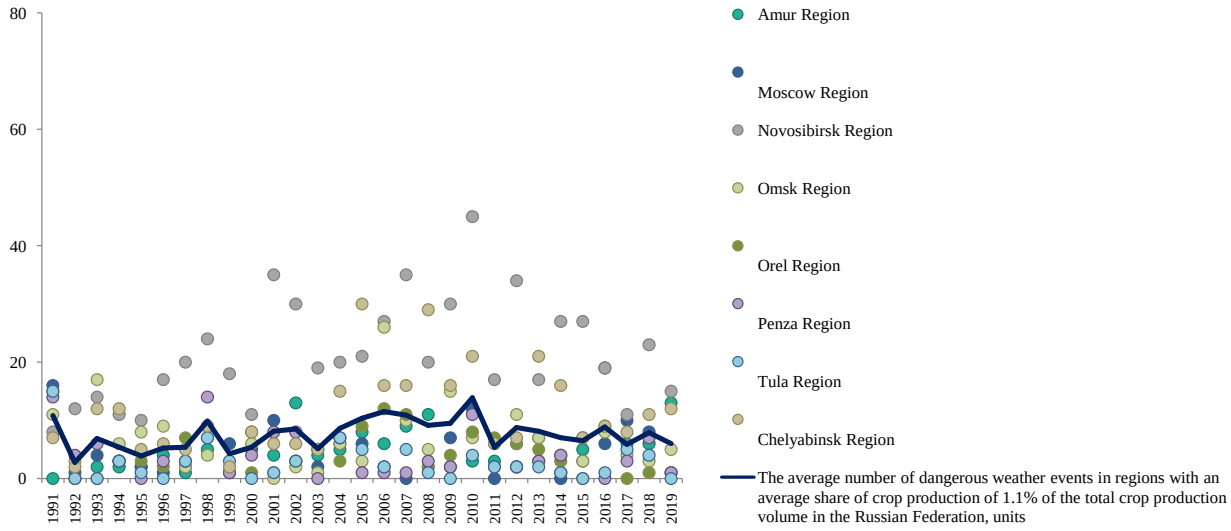

Fig. 3. The dynamics of unfavorable hydrometeorological phenomena recorded in the regions of the third classification group for 1991-2019.
Source: own calculations based on data from the Roshydromet [17].

Analysis of the spatial and temporal data obtained using the information arrays of the Roshydromet on hazardous weather phenomena, the regional satellite remote sensing system allows us to conclude that an increasing number of hazardous weather events in the territory of most constituent entities of the Russian Federation specializing in crop production. Correlation-regression analysis showed a strong inverse relationship between the increase in the number of dangerous weather events and the gross yield of basic crops [15, 11]. In addition, factors that have an indirect effect on the dynamics of the index of crop production are increasingly manifesting themselves: global structural transformations, changes in the world market situation, the development of digital technologies and the degree of their implementation, pricing policy, etc.

Fluctuations in the dynamics of yields in the most productive regions lead to an unstable volume of crop production, which poses a threat to sustainable food consumption by the population and ensuring the country's food security. The growing influence of unfavorable natural and climatic phenomena makes significant adjustments to medium- and

long-term development forecasts and the formation of an export-oriented model of the agro-industrial complex.

The strategic goal of state regulation of crop production is its sustainable dynamic development. Adaptation of agri-food systems is one of the areas of their sustainability. The architecture of the adaptation mechanism includes institutional, organizational and economic measures to reduce (mitigate) the consequences of climate risks.

The institutional basis of the state policy of adaptation of Russian agriculture to global climate change is made up of a number of normative legal documents at the national (federal) level and in the sectoral context [24]. (Table 2)

Table 2. Normative documents defining the Russian national agro-food policy in the field of climate change (all in Russian)

№	Denomination	Year/No.
1	Climate doctrine of the Russian Federation	Order of the President of the Russian Federation of December 17, 2009 No. 861-rp
2	Strategy for activities in the field of hydrometeorology and related fields for the period up to 2030 (taking into account aspects of climate change)	Order of the Government of the Russian Federation dated 03.09.2010 No. 1458-r
3	Comprehensive plan for the implementation of the Climate Doctrine for the period up to 2020	Order of the Government of the Russian Federation dated April 25, 2011 No. 730-r
4	State program for the development of agriculture and regulation of markets for agricultural products, raw materials and food for 2013-2020 (extended until 2025)	Government Decree of July 14, 2012 No. 717
5	Decree of the President of the Russian Federation "On the reduction of greenhouse gas emissions"	Decree of September 30, 2013 No. 752
6	Federal Scientific and Technical Program for the Development of Agriculture for 2017 - 2025	Resolution of August 25, 2017 No. 996
7	National action plan for the first stage of adaptation to climate change for the period up to 2022	Order of the Government of the Russian Federation of December 25, 2019 No. 3183-r

Source: compiled by the authors.

At the same time, an analysis of the content of the Federal Scientific and Technical Program for the Development of Agriculture for 2017 - 2025 showed the absence of a climate risk factor as the most important area of research. In addition, the problem of climate risks is still not properly reflected in the system of strategic priorities at the regional level.

Analyzing the dynamics of unfavorable hydrometeorological phenomena in the regions of crop production, it can be concluded that the consequences of climatic changes are differentiated from region to region. Therefore, we believe that the formation of regional climate strategies for the development of agro-food systems should become an effective measure of adaptation to climate change. Undoubtedly, regional climatic and resource characteristics will determine the specific content of adaptation strategies. Taking into account the classification of regions, we propose the most appropriate mechanisms for the selected groups of regions for adapting the crop production sub-industry to the consequences of global climate change (Figure 4).

Agricultural insurance is recognized as one of the main adaptation tools noted by the UN FAO in the framework of climate-smart farming. This is the most important mechanism of the stabilizing system, contributing to the formation of the prerequisites for the financial stability of agricultural producers in the event of risks.

The most widespread in Russian conditions is voluntary agricultural insurance subsidized from the federal budget. However, the coverage of crop production with insurance

coverage based on government support remains insufficient. As a result of the institutional reforms carried out in recent years in the sector of subsidized agricultural insurance, the share of the sown area of insured crops decreased from 17.1% in 2014 to 2.3% in 2017 and 1.7% in 2018 [21]. This became one of the reasons for the insufficiently effective use of budget funds allocated for the development of agriculture, which did not allow achieving the required target indicators (balanced financial result, the proportion of unprofitable organizations, gross harvest of major agricultural crops) in crop production in certain regions.

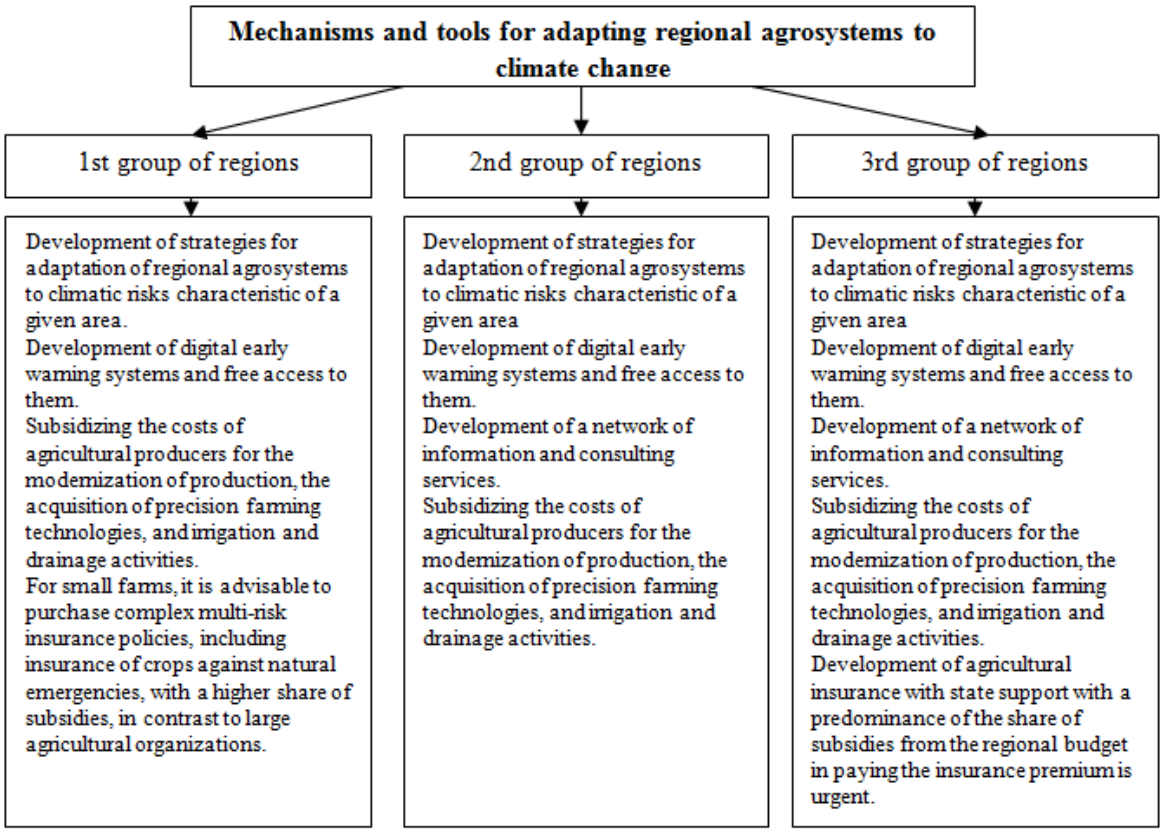

Fig. 4. Mechanisms and tools for adaptation of regional agrosystems 1, 2 and 3 groups to climate change.
Source: own developments

Since 2020, amendments have been made to federal legislation, the list of incentive measures for its development has been increased: the list of insurance risks has been expanded; the threshold level of loss (death) of the crop was canceled; the maximum deductible was increased from 30% to 50%; it became possible to insure certain risks, which is especially important for small farms.

The results obtained make it possible to formulate proposals for the development of agricultural risks insurance for the regions of each of the identified classification groups. For regions with small cultivated areas (Moscow and Amur regions), the development of agricultural insurance with state support with a high share of the regional budget in the allocated subsidies for paying the insurance premium is of the greatest relevance. This measure is also expedient for the constituent entities of the Russian Federation, the territories of which belong to territories that are unfavorable for the production of agricultural products. Among the regions included in the study are the Volgograd Region and the Republic of Dagestan. In the regions with the largest cultivated areas (Krasnodar, Stavropol and Altai Territories, Novosibirsk and Chelyabinsk Regions, the Republic of Tatarstan), an increase in the number of unfavorable natural and climatic phenomena

is noted. At the same time, a characteristic feature is the predominance of small business entities in the structure of crop producers. In this regard, it seems most expedient to purchase complex multi-risk insurance policies, including insurance of crops against natural emergencies, with a higher share of subsidies, in contrast to agricultural organizations.

Summarizing the goals and objectives of the normative documents listed in Table 2 that define the Russian national agri-food policy in the field of climate change, analyzing a number of measures laid down for their implementation, it should be noted such shortcomings as inconsistency and fragmentation of coverage. An integrated approach to climate risk management should consistently include three stages: collection and processing of information on climate risks; their identification and assessment, forecasting changes; implementation of measures to adapt to climate threats and risks, monitoring of the results of the implementation of the measures taken.

Without complete information about the intensity and geography of hazardous phenomena, as well as the exposure of the economy and society to them, it is impossible to assess the scale and dynamics of climate risks. Without a quantitative assessment of risks, it is difficult to build a system of adaptation measures aimed at mitigating them. Therefore, when developing state programs, strategies for socio-economic and sectoral development, we consider it necessary to include in the methodological base the requirements for the presentation of quantitative characteristics of risk factors with the fixation of the limit values of these characteristics, exceeding which requires prompt action up to adjusting the state program or strategy. In this aspect, the development of digital early warning systems and free access to them are essential.

The adaptive potential of regional agrosystems also includes the introduction of digitalization means in the production and management of the agri-food complex. The digital infrastructure is represented by a large number of Russian and foreign organizations that develop and implement both separate software and comprehensive services for the entire cycle of agrotechnical activities. The digital solutions tool opens up opportunities for the structural and technological adaptation of agricultural producers themselves to the negative consequences of climate change. The most accessible and popular are precision farming technologies (differentiated irrigation and fertilization, etc.). This necessitates the development of information and consulting services of the agro-industrial complex, both at the regional and municipal levels.

Since 2019, in the pilot regions of the country, the formation and implementation of regional strategies for adaptation to the consequences of climate change has been taking place. These regions are Altai Territory, the Komi Republic, Saratov and Murmansk Regions, St. Petersburg. The implementation of pilot projects will largely contribute to the creation of examples of the formation of adaptation plans - from methods for collecting and processing information on climate risks to planning and implementing specific measures to mitigate them, with the aim of further spreading them to other regions of Russia facing similar problems.

CONCLUSIONS

Methodological approaches to the study of the relationship between climate change and agricultural production are implemented on the example of regions of crop specialization. An analysis of the dependence of the yield of the grain industry on the growing number of hazardous weather events, an increase in their amplitude and frequency, indicates a significant negative impact of climatic anomalies on the sustainable development of agriculture.

According to the results of the study, a more intensive increase in the number of unfavorable meteorological phenomena and the degree of their influence in the most productive regions - included in the first classification group - was established. For the second and third classification groups, a similar pattern remains: a greater number of hazardous weather events in regions with

increased rates of crop production and natural resource potential.

Regional differences create an objective basis for the development of sectoral and regional strategies for the development of agricultural systems. Therefore, along with the classical form of strategic planning, a differentiated approach should be used, taking into account the regional characteristics of the natural resource potential, the change in the productivity of agricultural crops in response to changes in climatic variables, the structure of crop producers in the region.

The author's approach made it possible to formulate mechanisms of adaptation to the consequences of global climate change for each selected group of regions with crop production. Based on the results of the study, it is recommended: development of strategies for adapting regional agrosystems to climatic risks characteristic of a given area; development of digital early warning systems and free access to them; development of a network of regional and municipal information and consulting services; subsidizing the costs of agricultural producers for the modernization of production, the acquisition of precision farming technologies, carrying out irrigation and drainage activities; development of an up-to-date range of agricultural risks insurance tariffs for a given area. For regions of the first classification group with a large share of small farms in the structure of crop producers, it is advisable to use complex multi-risk insurance policies, including insurance of crops against natural emergencies. Moreover, for small agricultural producers there should be a higher share of subsidies for complex insurance policies, in contrast to large agricultural organizations. For the regions included in the third group, the development of agricultural insurance with state support with a predominance of the share of subsidies from the regional budget in paying the insurance premium is relevant.

The obtained practical results and the conclusions drawn on their basis expand the possibilities for setting the tasks of optimal planning and management of the plant growing sub-sector of the most productive regions of the Russian Federation in the context of the probable onset of natural and climatic risks.

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