Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 22, Issue 1, 2022
PRINT ISSN 2284-7995, E-ISSN 2285-3952

STUDY OF THE IMPACT OF CLIMATE RISKS ON THE DEVELOPMENT OF THE LIVESTOCK SUB-INDUSTRY IN RUSSIA

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Abstract

The purpose of the study is to identify the relationship between the main characteristics of animal husbandry in the regions of the Russian Federation and the most common types of hazardous weather phenomena that occur on their territories. Empirical data for 1991-2019 were obtained from the Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet) and the Federal Statistical Service of the Russian Federation. Using the methods of classification and mathematical-statistical analysis, five classification groups of regions of the Russian Federation with different livestock specialization were obtained and described. In each of the selected classification groups, the features of the manifestation of a whole spectrum of adverse weather phenomena of a hydrometeorological nature were studied. It has been determined that the most prone to weather risks are highly productive regions (the share of livestock products reaches from 4% to 8% in the Russian Federation) and regions with a low level of self-sufficiency in livestock products (less than 0.5%, respectively). In the course of the study, special attention was paid to small businesses, as the category of rural producers most vulnerable to climate risks. It has been established that large agricultural organizations are less affected by them. Over the past 30 years, heat waves, wind and floods have become the main damaging weather risks in the regions of livestock specialization over the past 30 years. Heat stress is the main climatic trigger for the decrease in the number of farm animals in farms of all categories. It is shown that the greatest influence of changes in the parameters of the climate system on the development of animal husbandry occurs through indirect links: the emergence of new pests and the emergence of diseases, new ways of their transmission; changes in the quality of forage crops and the availability of feed and water; reproductive and genetic variation. The impact is long-term and cumulative.

Key words: *climate change, weather risks, animal husbandry, temperature increase, damage, adaptation*

INTRODUCTION

The World Economic Forum annually publishes the Global Risks Report. It tracks the perception of global risks that humanity may face in the next 10 years. According to the data presented in the 2022 report, the first three lines of the most serious global risks are now occupied by environmental problems: failure to combat climate change, extreme weather conditions and loss of biodiversity [30]. A complex combination of social, climatic and environmental risks causes a threat of deviation from the vector of sustainable development of socio-economic systems, the transformation of established economic ties and chains, a decrease in the level of physical availability of food, and destabilization of the process of ensuring food security of countries [11]. All this creates problems for the life and livelihood of the population on the planet [10].

Under the influence of temperature shifts and changes in productivity, there are shifts in the structure of world agricultural production and a change in the global agri-food market. The depletion of natural resources exacerbates the tasks facing crop and animal husbandry. And if the bulk of scientific research is devoted to the problems of crop production in terms of adapting agriculture to the consequences of global climate change, then there is only a small part of them in animal husbandry.

Animal products provide up to 17% of the world's kilocalorie intake and 33% of the world's protein intake, so they are an important part of the global food system [24]. More than 800 million smallholder farmers and households live off subsistence farming,

and livestock rearing is a way for them to survive [34].

The share of small farms in the structure of producers in countries is different [19]. In the Russian Federation in 2020, 37.7% of peasant (farm) households (PFH) and households were engaged in animal husbandry, which in total produced products worth 1,068.5 billion rubles. Therefore, the study of factors that have a varying degree of influence on the dynamics of the development of the livestock sub-sector is of particular scientific and practical interest.

The impact of natural and climatic risks on the livestock sub-sector is difficult to assess, because it occurs mainly in an indirect form. These are the risks of impact on the quality of forage crops and feed, the availability of water, the emergence of new pests; diseases and methods of their transmission; reduced forage yields and changes in diet composition, genetic variability, etc.

According to the Food and Agriculture Organization of the United Nations (FAO), direct impacts are mainly caused by droughts, floods and hurricanes. But direct damage is also difficult to capture statistically. The methodological base of national statistical services in the field of climate change and their assessment is not well developed [27].

Without taking into account the dependence of livestock productivity on climate change, models for predicting food security will be unreliable. The scientific objective of this study is to determine the relationship between the main characteristics of animal husbandry in the regions of the Russian Federation and the most common types of hazardous weather phenomena occurring on their territory. This will help substantiate the directions of adaptation of the sub-sector to the consequences of global climate change.

The methodological approach proposed by the author includes the sequential implementation of two stages of the study. At the first stage, based on the data of selective federal statistical observation on agricultural production, a typology of subjects of the Russian Federation was built according to the share of livestock products in the region in the total volume of livestock products in the country. The second stage includes the study of regional features of the manifestation of a whole range of adverse weather phenomena of a hydrometeorological nature, as well as an analysis of their direct and indirect impact on indicators characterizing the efficiency of the development of the livestock sub-sector in the obtained groups of regions.

The calculations carried out and the conclusions drawn on their basis will contribute to the optimization and harmonization of agricultural methods, the development of a differentiated strategy for the development of regional agrosystems in the direction of adaptation to the consequences of global climate change.

MATERIALS AND METHODS

Foreign and Russian researchers have established in detail the relationship between livestock productivity, temperature shifts and CO2 concentration in the atmosphere. The main block of scientific research is devoted to changing the yield of fodder crops, the quality of fodder and changes in the composition of the diet [3, 31]. A causal relationship with fluctuations in animal reproduction was established by A. Nardone, B. Ronchi, et al. [16], having established its slowdown with an increase in the average air temperature. Another block of researches includes works on infections, livestock diseases and genetic changes [4, 5, 7, 13, 18]. A number of authors pay attention to the problem of water availability, focusing on its shortage [8, 31], pollution and salinity [16]. A small number of studies are devoted to assessing the economic damage from the impact of weather risks on the livestock sub-sector [28].

The identified areas of research have been continued in the form of FAO models and information systems in the direction of the impact of climate on livestock. These are, for example, the system of independent and integrated assessment of the resilience of farmers and pastoralists to climate change [6], the domestic animal diversity information system (DAD-IS). Future animal habitats are modeled using “Hadley's Global Ecological Model #2”. The Global Livestock

Environmental Assessment Model (GLEAM) was developed by FAO to help assess scenarios for climate change adaptation and mitigation in the livestock sector. It allows calculation of livestock production, emissions and mitigation potential using the Tier 2 methodology of the Intergovernmental Panel on Climate Change (IPCC) [9].

Information systems and databases of the Russian Federation in this direction are characterized by significant fragmentation and a large time lag. In our study, we use data from the Federal State Statistics Service, as well as the Unified Interdepartmental Information and Statistical System (EMISS) on the development of agricultural production in the constituent entities of the Russian Federation. Operational information is presented in the reports of the Ministry of Agriculture of the Russian Federation and the Federal State Budgetary Institution "Federal Agency for State Support of the Agroindustrial Complex". Data on the number of hazardous weather events in the Russian Federation and other agrometeorological information were obtained using a specialized electronic platform of the World Agrometeorological Information Service (WAMIS), the Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet).

When working with statistical data sets, methods of economic and statistical analysis were used, which made it possible to get an idea of the dynamics of adverse hydrometeorological phenomena in the classification groups of the regions of the Russian Federation and correlate them with the main indicators of the livestock sub-sector.

RESULTS AND DISCUSSIONS

For the distribution of subjects of the Russian Federation into classification groups, the share of livestock products in the region in the total volume of livestock products in the Russian Federation was taken as a key feature. The analysis included regions, in each of which, as of January 1, 2020, this indicator exceeded 0.1%. The sample included 75 subjects of the Russian Federation. Excluded were: Chukotka, Nenets and Yamal-Nenets Autonomous Areas, Murmansk Region, Republic of Tuva, Jewish Autonomous Region, Magadan Region, and the Federal cities – Moscow, S.-Petersburg and Sevastopol. 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 (Table 1).

According to the distribution results, the first group included regions that are leaders in the share of livestock products in the total volume of livestock products in the country: Krasnodar Territory, Voronezh and Belgorod Regions, and the Republic of Tatarstan. In the first group, the average indicator of livestock production in actual prices exceeded the corresponding indicator for the country by 4 times. The second classification group included regions located mainly in the Central zone with a temperate climate. Livestock indicators exceed the average for the Russian Federation by 2 times. The third group included the regions of the Siberian and Northwestern Federal Districts with more severe natural and climatic conditions. At the same time, the average livestock production indicators for the group reach the average level of similar indicators for the country. The fourth and fifth groups included regions characterized by a cold or arid climate.

Analysis of the obtained groups of regions in the space of climatic features showed the following feature. The average number of adverse weather events in the regions included in the first and fifth classification groups exceeds the average number of such events recorded throughout the Russian Federation.

In the period from 1991 to 2019, an average of 14.2 units per year was recorded in the regions of the first group, of which the largest share was rain, extreme fire hazard, and wind. In the regions with low productivity, included in the fifth group, the most frequent climate risks were floods, heavy rains and a combination of adverse weather events.

Table 1. Grouping of subjects of the Russian Federation by the average value of the share of livestock products of the subject in the total volume of livestock products of the Russian Federation for 1991–2019

	Number of regions of the Russian Federation	Subjects of the Russian Federation	The share of livestock products in the region in its total volume in the Russian Federation, (%)	Average indicator of livestock production (in actual prices; million rubles)	Average number of climate risks per year, units
		Russian Federation	1.23	23,851.8	10.1
1	4	Belgorod Region, Krasnodar Territory, Republic of Tatarstan, Voronezh Region	5.04	97,560.55	14.2
2	14	Leningrad Region, Chelyabinsk Region, Kursk Region, Moscow Region, Penza Region, Republic of Bashkortostan, Tambov Region, Bryansk Region, Sverdlovsk Region, Republic of Mordovia, Stavropol Territory, Novosibirsk Region, Lipetsk Region, Udmurtian Republic	2.46	47,612.99	7.9
3	20	Altai Territory, Pskov Region, Nizhny Novgorod Region, Tula Region, Republic of Mari El, Tyumen Region, Krasnoyarsk Territory, Irkutsk Region, Kaluga Region, Omsk Region, Kirov Region, Tver Region, Ryazan Region, Perm Territory, Yaroslavl Region, Vologda Region, Orel Region, Rostov Region, Republic of Daghestan, Kaliningrad Region	1.42	27,455.59	7.8
4	13	Orenburg Region, Tomsk Region, Novgorod Region, Vladimir Region, Volgograd Region, Kemerovo Region, Samara Region, Saratov Region, Chuvash Republic, Kabardino-Balkarian Republic, Smolensk Region, Republic of Crimea, Republic of Sakha (Yakutia)	0.76	14,736.46	7.7
5	24	Ivanovo Region, Kostroma Region, Karachayevo-Circassian Republic, Primorye Territory, Astrakhan Region, Republic of Kalmykia, Komi Republic, Ulyanovsk Region, Amur Region, Sakhalin Region, Kurgan Region, Kamchatka Territory, Republic of Buryatia, Republic of Adygeya, Arkhangelsk Region, Khanty-Mansi Autonomous Area–Yugra, Republic of Altai, Republic of Ingushetia, Chechen Republic, Republic of North Ossetia–Alania, Republic of Khakassia, Trans-Baikal Territory, Khabarovsk Territory, Republic of Karelia	0.27	5,295.08	12.9

Source: own calculations based on data [21].

The maximum number of dangerous weather events occurred in the Belgorod region. The share of livestock products produced by the region in the Russian Federation in 2020 amounted to 8.45%. The structure of producers is dominated by agricultural

organizations (70.9%), the remaining 29.1% are small agricultural producers. In the Krasnodar Territory, 65.8% of farms are engaged in beef cattle breeding. More than half of the livestock production is produced by small farms in the Republic of Tatarstan and the Voronezh region. There is a high share of the private sector (up to 70%) in the structure of gross livestock production. There is a high level of self-sufficiency of personal subsidiary farms with pork and beef. A similar situation is typical for most regions with favorable natural and climatic conditions (Southern regions and regions of the Central Chernozem region). More northern regions are characterized by an increase in the share of PFHs and agricultural organizations in the structure of meat products producers (Fig. 1, Table 2).

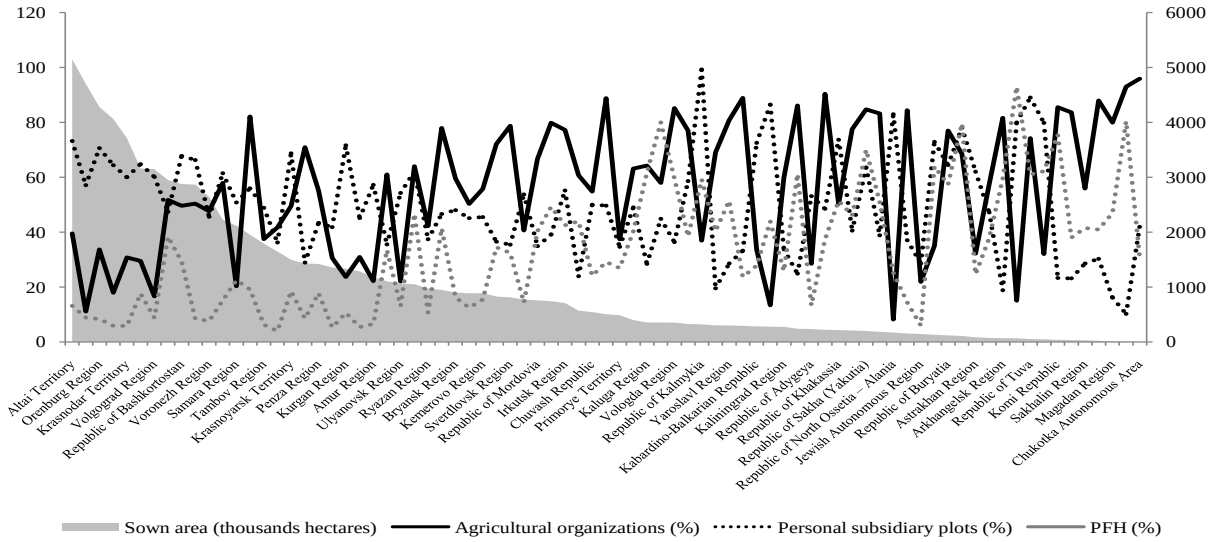

Fig. 1. The share of agricultural organizations, PFHs and households in the structure of livestock production
Source: Own calculations based on data [25].

Table 2. Top 20 subjects of the Russian Federation with the largest number of cattle as of 01/01/2021 (thousand heads)

The subject of the Russian Federation	Total	Agricultural organizations	PFHs	Households
Republic of Daghestan	462.6	42.9	69.2	350.6
Republic of Bashkortostan	386.8	114.5	67.5	204.8
Republic of Tatarstan	335.5	196.4	37.0	102.2
Rostov Region	302.1	37.7	79.8	184.6
Altai Territory	288,2	118.7	39.5	130.0
Republic of Kalmykia	258.3	28.5	134.6	95.2
Orenburg Region	239.9	72.5	48.2	119.2
Krasnodar Territory	212.2	128.2	22.1	61.9
Bryansk Region	205.6	187.1	8.1	10.0
Saratov Region	195.0	31.8	39.7	123.5
Novosibirsk Region	194.0	127.5	23.4	43.1
Trans-Baikal Territory	186.0	12.6	39.7	133.7
Voronezh Region	182.9	130.9	22.3	29.7
Volgograd Region	179.7	13.4	47.7	118.7
Astrakhan Region	156.4	5.3	55.1	96.0
Omsk Region	149.8	69.0	20.7	60.1
Stavropol Territory	142.5	34.3	31.3	76.9
Republic of Buryatia	140.3	19.8	22.8	97.8
Irkutsk Region	138.2	26.9	38.9	72.4
Krasnoyarsk Territory	135.5	72.3	17.0	46.2

Source: Compiled using data from [14].

Closed livestock systems in the form of large agricultural organizations and agricultural holdings better control the effects of climate risks, therefore they are less susceptible to their influence and more stable, unlike small agricultural producers. In this regard, it is advisable to consider the impact of weather anomalies on the dynamics of the production of the main types of farm animals by peasant (farm) households and household households (Fig. 2).

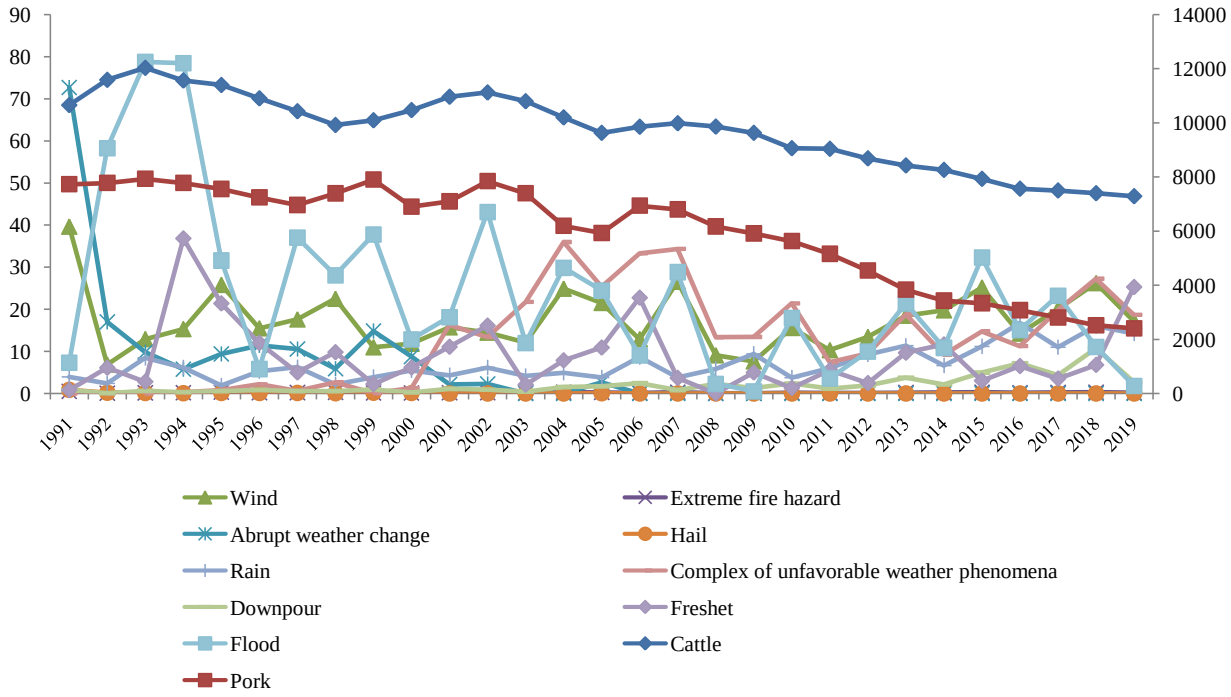

Fig. 2. The volume of the main types of livestock produced by small farms and the dynamics of adverse hydrometeorological phenomena recorded on the territory of the Russian Federation for 1991-2019.
Source: own calculations based on data from the Roshydromet [22].

There is an obvious general downward trend in the dynamics of the number of cattle and pigs raised by households and PFHs. It is due to a significant reduction in federal funding for the main measure of current support in crop production - unrelated support [26]. Most of the federal budget funds were redirected to provide preferential loans that provide for the transfer of compensation not to agricultural producers, but to credit organizations. Subsidies for dairy farming have also been reduced. Subsidies to increase productivity in dairy cattle breeding in the Russian Federation over the past three years have remained at the same level, which, taking into account inflation, has actually turned into a reduction in support. Unlike peasant (private) farms, subsidies for household farms are not available. For this category, separate support measures are provided only for keeping dairy cows, mares over 3 years old; construction of dairy mini-farms; acquisition of breeding stock of animals and birds. Against the background of general trends, one can note sharp fluctuations in the number of livestock in the years of maximum manifestation of weather anomalies.

The analysis showed that abnormally hot weather and extreme fire hazard have the greatest negative impact on the productivity of cattle and pigs. According to the classification proposed by the World Meteorological Organization, these categories include the value of the average daily air temperature above the climatic norm by 7 degrees or more in the period from April to September for 5 days or more. In accordance with the list of the main types of hazardous weather phenomena established by the World Agrometeorological Information Service,

weather temperature values exceeding 10,000°C according to the Nesterov formula are considered extreme fire hazards [29, 33].

Heat stress is an urgent problem for beef cattle breeding in most regions of the Russian Federation focused on this sub-sector. An increase in temperature leads not only to the direct death of livestock. According to experts, it is expected that water consumption by farm animals will increase by 3 times [16], the demand for agricultural land will increase due to the need to increase the production of crops for livestock feed [23].

Changes in temperature regimes lead to a shift in natural zones, a change in the growing season, a change in the species diversity of cultivated crops, etc. [20]. An indirect impact on the cultivation of farm animals is a decrease in the quality of feed and its consumption, which leads to a negative energy balance and a decrease in livestock weight gain. An example is the prolonged abnormal heat in 2021 on the territory of the Republic of Bashkortostan. Due to the drought, about 200 thousand hectares of grain crops perished. To date, the Ministry of Agriculture of the Russian Federation has not worked out such an important adaptation mechanism as the "fodder" mutual assistance of farms in the conditions of the current shortage. Farmers faced limitations such as the poor quality of hay, fodder and feed grains. In general, in the Russian Federation, a combination of general economic trends and the impact of the climate factor led to a decrease in the number of cattle in 2021 by 1.5-2%.

Indirect effects are associated with changes in ecosystem parameters and their impact on microbial communities (pathogens or parasites), the spread of vector-borne diseases, and foodborne diseases [12]. For example, White et al. modeled the impact of climate change on livestock using the example of Australian regions and found that as a result of increased tick infestation, livestock lost up to 18% of their weight [32]. In the northern regions of the Russian Federation (Arkhangelsk and Vologda regions), with an increase in the average ambient temperature, an increase in eye and mouth diseases in deer and other ungulates was recorded. Studies show that changes in temperature regimes and relative humidity adversely affect the health of cattle and their reproductive function [1, 2, 15].

Livestock production may also be limited by a number of other factors related to climate variability. Such unfavorable weather phenomena of a hydrometeorological nature as floods and floods cause direct damage to the development of animal husbandry. In the regions of the Russian Federation with a high probability of such a risk, during the years of peak activity, the damage reached 30% of the number of cattle. In addition, floods affect the shape and structure of plant roots, change the rate of leaf growth. This is the reason for the decrease in yield and lack of feed. Hurricane winds (when the speed reaches 33 m/s or more) and tornadoes also cause direct damage to animal husbandry.

The most important task of state regulation of the development of the national agro-food complex is the formation of conditions for the financial stability of agricultural producers. This is a factor in the rational use of the available resource potential and, in particular, the sustainable development of the livestock sub-sector of agriculture.

In the system of mechanisms for adapting agricultural systems to the consequences of climate change, the most effective and popular in the Russian Federation is agricultural risk insurance with state support. As part of the implementation of measures to improve the efficiency of the livestock sub-sector in 2020, 66 out of 85 constituent entities of the Russian Federation took part in the implementation of subsidized agricultural insurance programs. During the campaign, 8,103.4 thousand conditional heads were insured. The insured livestock accounted for 28.0% of the total livestock of farm animals in the constituent entities of the Russian Federation [17]. The leader in 2020 was the Tambov region, in which up to 96% of the available livestock were covered by insurance policies, which was the maximum indicator among all subjects of the Russian Federation.

CONCLUSIONS

Summarizing, we can conclude that changes in the parameters of the climate system have the greatest impact on the development of animal husbandry through indirect relationships. For example, reduced crop yields and lack of fodder, problems with access to water resources, etc.

The main climatic trigger for livestock reduction is heat stress, which results in a complex of such negative consequences as a decrease in animal reproduction, the emergence of new pests, diseases and methods of their transmission, genetic variability, etc. Such extreme weather events as hurricane winds, tornadoes, and floods have a direct impact on animal husbandry.

Using the classification method, groups of regions of different livestock specialization were identified. An analysis of the obtained groups in the context of climatic features showed that the regions included in the first and fifth classification groups are the most exposed to weather risks. The most vulnerable category of producers in the livestock sub-sector are small farms.

The concept of sustainable development of the Russian agro-food complex should take into account the current climate trend, which requires the development of differentiated strategies for the development of industries within the framework of regional strategic planning documents. An analysis of the dynamics of adverse hydrometeorological phenomena in the context of the regions of the Russian Federation in the livestock specialty made it possible to conclude that the consequences of climate change have different effects on different regions. It is expected that in the future this may make adjustments to the strategic planning system in the Russian Federation in terms of the methodology for determining macroregions.

Sustainable development of the livestock sub-sector, in particular, requires the development of an adaptation strategy that should take into account the availability of water resources, ensuring the balance and redistribution of the feed base, the implementation of veterinary measures, the development of appropriate state support mechanisms that should help stabilize the financial condition of economic entities of various organizational and legal forms. engaged in cattle breeding.

The results of the study can provide a scientific basis for developing recommendations for improving state regulation and supporting the development of small businesses in the agro-industrial complex. The author's approach to the study of the response characteristics of different types of agricultural producers to changes in the natural and climatic ecosystem will allow developing and implementing strategic development programs, determining the directions of state regulation and the need for state support. The data obtained can become one of the bases for recommendations for improving the institutional model of state regulation of the Russian agro-food complex.

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