The effect of the global climate change on the vitality of viticulture in Russia

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Abstract. We described in this article the features of the impact of global climate change on wine-growing enterprises of the Russian Federation. Statistical data on the areas under vineyards of all agricultural organizations in the country were analyzed and displayed by regions. The daily amounts of solar radiation arriving at the horizontal surface in the study area are shown and similar climatic conditions are found with some French regions. Information was collected on the dynamics of average monthly and annual temperatures in the southern cities of the RF for 1980 and 2021, which proved that in all regional centers, the main regions of industrial viticulture, over the past 40 years the average monthly and annual temperature has only increased. We provided tables and figures displaying unique information on agroclimatic indicators of the regions of interest. Based on the data presented, conclusions are drawn and measures are proposed for the rational cultivation of vineyards, taking into account the distinctive features of different climatic zones in a changing climate.

1 Introduction

Since the second half of the 20th century, on the territory of our entire planet, has been recorded increase of average annual temperature. The process of so-called global warming is underway. Scientists and researchers attribute the consequences of this trend to: global temperature rise, melting Arctic ice, increasing drought, decreasing cold waves, as well as a decrease in precipitation, rising water levels and the number of floods. Climate change has also affected agriculture, studies have shown a decrease in the yield of agricultural crops and perennial plantings, including grapes.

When establishing the causes of climate change, scientists are divided into two large camps. Some argue that this is due to the massive use of fossil fuels, greenhouse gas emissions, urbanization, forestry and desertification. And others argue that all of the above does not have a significant effect, and the main reason is the change in the tilt of the Earth's axis to the Sun. This phenomenon is designated in astronomy by the term «precession», and it is believed that climate change has been dependent on this cosmic phenomenon for millennia. Adherents of this theory believe that relative warming in the Northern Hemisphere will continue for another one to three thousand years, until its maximum. A

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particularly strong increase in temperature occurs and will continue to occur in the autumn-winter seasons.

«Climate change affects all countries of the world, including Russia. Using multivariate statistical analysis, scientists have identified climate change in the western part of the country but a particularly rapid increase in temperature is observed in the northern regions of the country, where the average annual air temperature in winter is -25°» [1].

One of the pressing questions about the importance of climate change in Russia is related to agriculture. In modern conditions, each region should strive to be self-sufficient and not experience a shortage of food security, and the impact of climate change is the most important factor beyond human control.

We are looking at the impact of climate change on the vitality of Russian viticulture. Global warming and drought are problems that winegrowers around the world have been facing for a very long time. This threat is real. If you search for scientific literature on the impact of global climate change on the viticulture industry in Russia, then it becomes clear that there is a large lack of research and this issue has not been fully studied. However, foreign scientists have been studying this issue for a long time. In the 1990s, some European researchers realized that climate change could have a major impact on grape growing conditions around the world. Thus, already in 2012, Doctor of Science in Plant Biology James Goode noted a reduction in wine production in France by 20%, reduction in yield by 50% in the Loire Valley, in Champagne and Burgundy - 40% and 30% respectively, and grape yields in Italy decreased by 7%. Such data indicate the advisability of conducting a large study on this issue, because the climatic conditions of France are very similar to some areas of southern Russia.

The purpose of the article is to describe the features of the impact of climate change on the viticulture industry in Russia. The given theoretical principles are recommended for agricultural organizations that are engaged or planning to engage in the cultivation of perennial grapevines and research and design organizations dealing with issues of horticulture and viticulture in on-farm land management [2, 3].

2 Objects and methods of research

The object of study is the main regions of grape cultivation in the industrial sector. The methodological basis of the study is the theoretical and methodological works of domestic and foreign scientists relevant in the field of viticulture. The article uses methods and techniques: monographic, abstract-logical, statistical, comparative analysis, descriptive, method of literature analysis. The information basis was books, conference materials, scientific articles and dissertation research and statistical data from ROSSTAT.

3 The discussion of the results

The agroclimatic conditions of various zones of the country have a great influence on the development of both livestock and crop production. Favorable conditions for viticulture in Russia are in the south, so almost all industrial viticulture is located in the North Caucasus and Southern Federal Districts. The main grape planting areas are located in the Krasnodar Region, the Republic of Dagestan, the Republic of Crimea, the Stavropol Region and the Kabardino-Balkarian Republic (table 1). Income from industrial viticulture occupies a significant part in the economy of these southern regions of Russia.

Table 1. Area of vineyards of all agricultural organizations for 2021 (ha).

Russian Federation	**71 215.7**
Central Federal District	**0.7**
Southern Federal District	**51 055.4**
Republic of Crimea	19 170.9
Krasnodar Region	24 042.0
Astrakhan Region	1.0
Volgograd Region	41.9
Rostov Region	2 313.8
Sevastopol	5 485.8
North Caucasus Federal District	**20 153.8**
The Republic of Dagestan	13 573.5
The Republic of Ingushetia	4.0
Kabardino-Balkarian Republic	352.8
Republic of North Ossetia–Alania	117.0
Chechen Republic	2 051.0
Stavropol Region	4 055.5
Volga Federal District	**5.3**
Siberian Federal District	**0.5**

Source: ROSSTAT [4]

Table 1 shows the area of vineyards of agricultural organizations in all regions of the country. Most of all, grapes are grown in the Krasnodar Region - 24 thousand hectares, the Republic of Crimea – 19,2 thousand hectares and the Republic of Dagestan – 13,5 thousand hectares.

Climatic conditions are not amenable to human will, no one can stop changes in the environment. «According to Roshydromet, the average annual temperature anomaly in Russia for 2021 was +1,35°C, which is significantly higher than the global temperature anomaly, which, according to the Climate Research Group of the University of East Anglia, was +0,49 °C» [5].

Today, winegrowers can only predict, adjust and adapt to weather conditions. One of the significant indicators is shown below in figure 1. It clearly displays the daily amounts of solar radiation arriving at the horizontal surface (in kWh/m^2) of the southern part of our country.

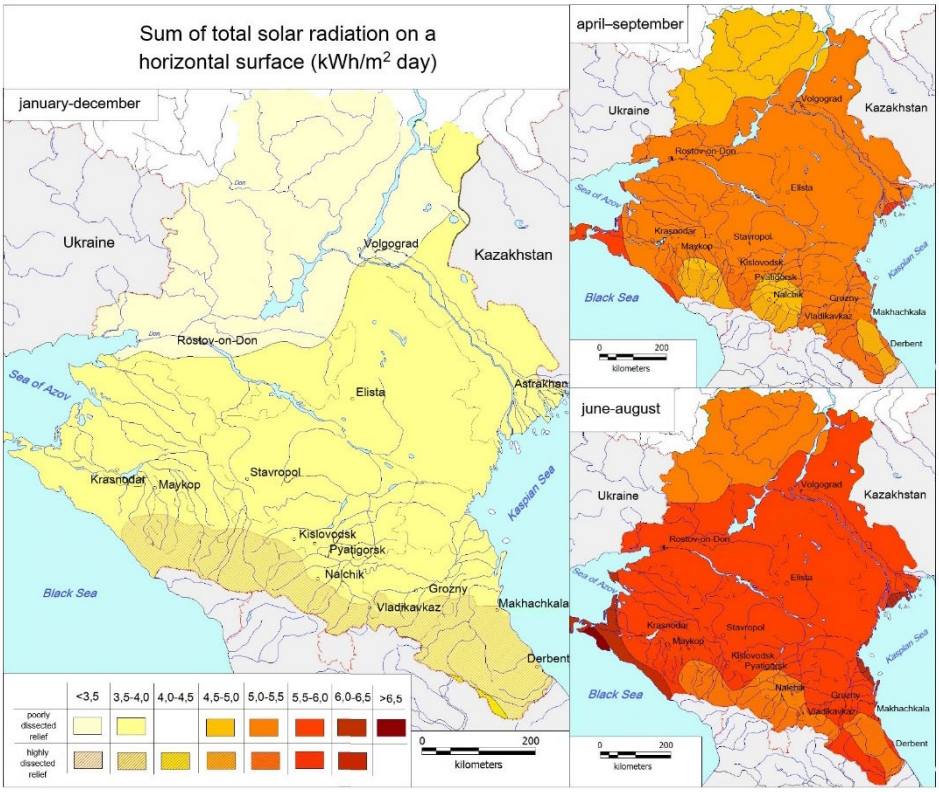

Fig. 1. Natural resource of solar energy on the territory of southern Russia in 2015 [6].

«The map of solar energy characteristics was built for different periods of the year: the year as a whole, the warm six months (April–September), summer (June–August). At the same time, they are arranged into sheets of 3 to allow comparison and selection of the optimal period for using solar energy.

The average annual daily amounts of total solar radiation on a horizontal surface within all regions under consideration are 3,5-4,0 kWh/m^2 day, averages for warm six months are 4,5-6,0 kWh/m^2 day, averages for summer are 5,0-6,5 kWh/m^2 day» [6]. These values indicate a significant solar energy resource in the southern part of the country.

After analyzing the «Weather and Climate» website, which collected data from online and literary sources on climate indicators, table 2 was compiled.

Table 2. Dynamics of average monthly and annual temperatures in the southern cities of the Russian Federation for 1980 and 2021, °C

City	1980			2021		
	January	July	In a year	January	July	In a year
Southern Federal District						
Krasnodar	-3.1	24.7	11.3	1.9	26.2	12.4
Simferopol	-3.0	21.7	10.0	3.7	24.9	11.9
Astrakhan	-9.9	25.9	9.4	-1.3	28.3	12.3
Volgograd	-13.7	23.7	6.5	-3.8	27.2	9.9
Rostov-on-Don	-8.6	23.5	8.7	-0.9	26.5	11.0
North Caucasus Federal District						
Makhachkala	-2.0	25.7	12.2	3.0	26.0	13.5
Nalchik	-6.4	22.8	9.4	0.6	24.1	11.3

Vladikavkaz	-6.4	21.2	8.5	2.1	22.6	10.9
Grozny	-5.6	25.8	10.8	0.4	26.0	11.6
Stavropol	-6.8	23.1	9.0	0.5	25.0	10.6

According to Table 2, we can conclude that in all regional centers, the main regions of industrial viticulture, over the past 40 years, average monthly and annual temperatures have only increased [7]. «Forecasts in Eurasian crop production until 2050 leaves no doubt about the need to adapt the agricultural industry to climate change: under arid scenarios, climate-related yields will decrease by 15%, respectively» [1].

As is known, when choosing the correct specialization of agro-industrial production in a particular area, a detailed study of weather conditions is carried out. Including before choosing a territory for planting vineyards, it is necessary to conduct a comprehensive accounting of climatic resources (heat, moisture, sum of active temperatures), which is carried out by the method of agroclimatic zoning. Let us consider the indicators of the sum of active air temperatures in the territory of the leading region in terms of vineyard area of the Krasnodar Region (fig. 2).

Fig. 2. Sum of active air temperatures on the territory of the Krasnodar Region [8].

Figure 2 indicates that «the sum of active temperatures in the Krasnodar Region fluctuates in the range of 3650-3950 ºC in the northern zone, 3500-4100 ºC in the central zone, 3750-3850 in the western zone, 3100-4100 ºC in the foothill zone and 3800-4400 ºC in the Black Sea zone. These indicators confirm that the region is provided with heat for the cultivation of grape varieties of all ripening periods. However, it is noted that climate change may reduce suitability in warm and dry areas of the region» [9].

In Russia, all the main wine-growing regions, one way or another, are located in the temperate continental climate zone. Therefore, there is always a need to cover non-frost-

resistant grape varieties to preserve plantings during low temperatures. The only Black Sea agroecological zone of the Krasnodar Region, with its subtropical climate zone, makes it possible to cultivate these plants without cover for a whole year. Knowing this information, in the long term, it can be assumed that climate change will have a positive effect on the suitability of crops grown in areas with low summer temperatures. For example, at the moment the nearby Rostov Region is in a risky viticulture zone due to frost, and continued global warming could eliminate these climate risks.

Rising temperatures are not the only manifestation of climate change. Sea level rise has accelerated in recent decades due to increased ice loss in the world's polar regions. For example, the authorities of the Maldives predict that by the end of the 21st century the islands will go under water. Their Minister of Environment and Climate Change repeatedly has issued similar warnings. However, the average height relative to the sea in their country does not exceed one meter, therefore it is considered the lowest in the world. And scientists assume that in 80 years the water level in the sea will reach exactly 1 meter. Let's ask ourselves whether there are areas in our country where grape enterprises are located near the seas? Thus, we can consider the Taman Peninsula, whose vineyards are surrounded by the Black and Azov Seas (fig. 3). Floods are extremely rare here, the last major disaster struck the peninsula in October 1969. Having also studied the relief on the shores of the peninsula in the «google earth» program, the minimum height was 5 meters above sea level, then the height of the relief only increased. Therefore, in our opinion, the vineyards of the Taman Peninsula do not face the threat of flooding from rising water levels in the sea.

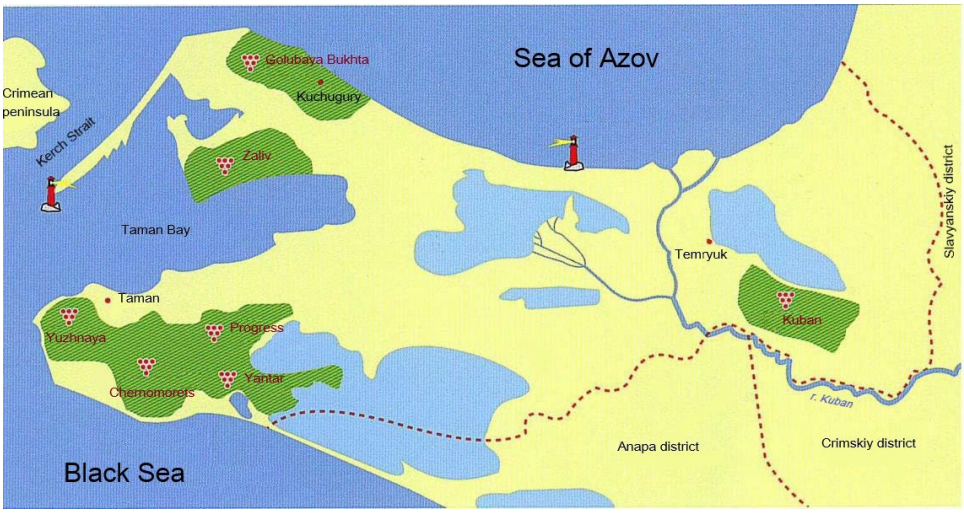

Fig. 3. Location of grape enterprises on the Taman Peninsula

Taman ranks 2nd in the Krasnodar Region in terms of duration of sunshine. In Figure 1, you can see confirmation of this, because only in this area is the highest total solar radiation in the warm six months and in the summer. Also, the climate here is similar to the conditions of the south of France, where there is a decrease in yield due to the drought that has arisen, but on our peninsula, there are no significant decreases. The Temryuk Region is characterized by a unique geographical location for viticulture, only here is non-covered viticulture of classic varieties possible [10].

4 Conclusions

Based on the above, we can conclude that for the rational cultivation of a grape plantation, in the context of global climate change, it is necessary to periodically update and record data on weather indicators separately for each agroclimatic region. Having received the data, various agrotechnical measures are applied and varieties are selected for the conditions of a particular area. First of all, winegrowers are interested in soil and climatic indicators: heat and moisture supply or the sum of active temperatures, the amount of precipitation and unseasonal frosts. Focusing on the goals of the enterprise, they select grape varieties, and based on weather conditions, they select clones and rootstocks to adapt to external factors. Focusing on the goals of the enterprise, they select grape varieties, and based on weather conditions, they select clones and rootstocks to adapt to external factors.

In the context of global climate change, it is periodically necessary to adapt vineyards to new climatic conditions. Thus, by modifying seedlings, plant drought-resistant planting material in dry areas, and frost-resistant planting material in cold areas, to obtain a stable, high yield in a constantly changing climate.

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