Monitoring of Degraded Agricultural Lands of the Arid Agro-Climatic Zone of the Stavropol Territory

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Abstract: Monitoring, assessment and analysis of the qualitative state of degraded agricultural landscapes within the arid agroclimatic zone of the Stavropol Territory and development of proposals for their further use. Monitoring of agricultural landscapes was carried out on the basis of modern remote and ground-based methods of territory survey and identification of degraded land. Zoning of all agrolandscapes of the agroclimatic zone was carried out on the basis of monitoring studies and the distribution of land according to their suitability for agricultural production. In the course of monitoring studies, it was found that the area of agricultural landscapes of the arid agroclimatic zone exposed to water, wind and joint erosion increased by 46039 ha during the study period and in 2020 is 577758 ha or 24.3% of the territory. At the same time, more than 152 thousand hectares of land have an average degree of degradation, and more than 73.5 thousand hectares have a strong degree. The use of degraded agricultural landscapes in agriculture should be based on their quality condition. The results of long-term monitoring studies and their cartographic support will allow us to preserve and improve agricultural land through the implementation of agrotechnical, hydrotechnical and agroforestry reclamation projects.

1 INTRODUCTION

The land fund of the arid (II) agro-climatic zone of the Stavropol Territory includes nine administrative districts with a total area of 2377675 hectares, of which more than 93% are occupied by agricultural land, represented by 94% agricultural land (Klyushin, 2016). Thus, the use of the land fund is intensive, which affects its quality condition. In some areas, the percentage of agricultural land reaches 96% (Blagodarnensky, Novoselitsky and Ipatovsky districts). During the research period, the land area of this category increased by 33727 hectares. The area of agricultural land is increasing in all districts of the arid zone, except for the Soviet municipal District. The increase in the area was also due to the reserve lands, which for the most part are not suitable or unsuitable for agriculture (Klyushin, 2017). Farming in this area is risky, since the hydrothermal coefficient is 0.7 – 0.9. Summer is dry and very hot. The average monthly winter temperature is -3.5... -5.0 0C, but the minimum January temperatures can reach -32... -34 0C. Precipitation, as a rule, is of a short-term and stormy nature, which can favor the development of erosion and flooding of land, especially in the spring and autumn periods (Dubrovsky, 2017). The soil cover of the arid agro-climatic zone is represented by chestnut, dark chestnut and chernozem soils, as well as salt marshes. On a significant area there are salt marshes with chestnut saline and meadow-chestnut soils. The content of nutrients in soils corresponds to the general trend of the Stavropol Territory (Shapovalov, 2018).

2 MATERIALS AND METHODS

When carrying out monitoring studies on degraded agro-landscapes of the arid agro-climatic zone of the Stavropol Territory, modern methods were used: remote sensing of agricultural lands (using satellite images and unmanned aerial vehicles), ground surveys using precision instruments, modern computer programs. In the course of the research, the

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following were recorded: the area of agricultural landscapes subject to water, wind and joint erosion by type of agricultural land, the causes of their occurrence, the degree of development of degradation processes and the possibility of their further use in agriculture. Based on the results obtained, the zoning of agricultural landscapes was carried out according to the author's method-ology.

3 RESULTS

Analyzing the distribution of agricultural lands of the arid (II) agroclimatic zone by land, we note that agricultural lands predominate in all administrative districts in their composition. So in the Alexandrovsky district, they account for 93.26% of the lands of this category, in Blagodarnensky 94.15%, Budennovsky 95.02%, Ipatovsky 93.3%, Kursk 94.55%, Novoselitsky 95.02%, Petrovsky 94.62%, Sovetsky and Stepnovsky 94.16%. Thus, the use of the land fund is very intensive, which contributes to the development of all types of degradation processes (Yesaulko, 2015).

From the data presented, it can be seen that the intensity of the use of agricultural land in the II agroclimatic zone increases sharply, as the plowing of the territory increases significantly. The maximum areas of arable land are observed in the Soviet (86.11%), Novoselitsky (83.68%), Budennovsky (83.36%) and Blagodarnensky (83.18%) districts and these values are twice higher than the calculated norms. Also, significant areas used for arable land were identified in the Petrov (74.92%) and Stepnovsky (74.54%) districts, and the smallest in the Kursk district - 50.98% [6]. At the same time, during the analyzed period, there was an increase in the area of arable land in five districts, and a decrease in four districts. A large percentage of the plowed area negatively affects the condition of the land, since arable land is not a stable element. Pasture lands belong to stable landscape elements and their areas by administrative districts do not change significantly during the research period, which correlates with changes in the area of arable land. The largest shares of pastures in the composition of agricultural land are noted in Kursk (42.96%) and Alexander (23.68%) districts, and the smallest in the Soviet District – 7.65%. There are no hayfields on the territory of four districts, in other districts their share ranges from 0.07% to 3.37%.

Perennial plantings are available on small areas and in districts they occupy from 0.1% to 1.3%. Their largest areas are concentrated in the Budyonnovsky district (3690 hectares), where they are represented by vineyards, the area of which has grown by 282 hectares over the period of research.

Water erosion of agricultural landscapes is widespread on the territory of the arid zone of the Stavropol Territory and monitoring of lands that are subject to this negative process is carried out to determine these areas with mandatory setting of boundaries and calculating areas. An important point of monitoring is to determine the degree of degradation and the reasons why this process occurs. The dynamics of the areas of erosion processes provides grounds for assessing and eliminating the consequences on agricultural land (Trukhachev, 2018). With the development of technology and technologies, monitoring of erosion processes can be done with high accuracy and operativeness. It is necessary to carry out methodological improvement of the process of monitoring agricultural landscapes on the basis of remote sensing of the Earth and GIS technologies.

Many factors contribute to the development of water erosion, deflation and other negative processes. The main ones, of which is the large plowing of the territory, which in some areas exceeds the recommended norms by 30%, as well as a significant amount of pure vapor in crop rotations (Pavlova, 2016).

The area of eroded agricultural land in the II agroclimatic zone during the research period has a discontinuous shape. Thus, the maximum area of degraded land was identified in 2000, but this indicator is only 3887 hectares higher than in 2020. The minimum area of lands degraded by water erosion was discovered in 2006, and it amounted to 214268 hectares, after which their stable increase is noted. At the same time, there is a constant growth of lands subject to an average degree of erosion, the minimum area in 2006 (39527 ha), and the maximum in 2020 (55516 ha). The dynamics of the area of heavily eroded lands fully corresponds to the dynamics of the total land area of the II agroclimatic zone exposed to water erosion. The largest total area of eroded sites was found in the Blagodarnensky (51912 ha), Novoselitsky (51136 ha) and Petrovsky (46771 ha) districts. At the same time, the number of lands subject to medium and severe water erosion in these areas is one of the lowest, except for the Petrovsky district. The smallest areas of eroded lands were found in the Kursk (9807 ha) and Stepnovsky (10798 ha) districts, and this applies to both medium and highly degraded areas. In many areas, over a twenty-year period, there has been a decrease in the area of erosive agricultural land.

For the arid zone of the Stavropol Territory, such a phenomenon as planar or linear water erosion is very frequent. This is due to the fact that precipitation in the warm season, as a rule, is of a downpour nature and, accordingly, this leads to the flushing of the fertile soil layer or the erosion of a certain part of the agricultural landscape, where the concentration of runoff occurs. Also, the development of water erosion is facilitated by the relief and the absence of perennial grasses in the structure of cultivated areas.

The results of monitoring of lands degraded by water erosion obtained by us during the research period give grounds to assert that the area of degraded lands is constantly increasing, and there is also an increase in the degree of degradation. In all administrative districts of the arid zone, there is a tendency to increase the areas of eroded lands with a medium and strong degree of erosion (Fig. 1).

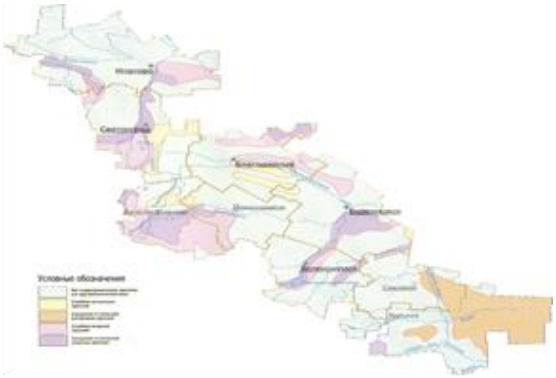

Figure 1: Eroded agricultural landscapes of the arid agroclimatic zone of the Stavropol territory.

Wind erosion or deflation is the destruction of the soil cover under the influence of strong wind. Deflation can be natural (normal, geological) and accelerated (anthropogenic), which is caused by improper land use and a large anthropogenic load on agricultural land. The territory of the Stavropol Territory is characterized by a complex relief and the presence of a large number of wind corridors. The average maximum wind speed is 15 m/s, but in different parts of the region the wind speed can increase to 26-30 m/s. Of course, in such conditions, the risk of deflation is maximum and, as we have already noted, the area of deflation-prone lands in the region is about 4.5 million hectares. In addition, our region is characterized by such a phenomenon as dust storms, which can occur at almost any time of the year. Dust storms cause great damage to agriculture and especially to crops and soils.

Monitoring of agricultural lands during surveys showed an increase in the area of deflated lands during the research period. The minimum values of the total area of the areas subject to deflation were found according to the state of the land in 2000 (213060 ha), and the maximum values for 2006 (245715 ha), which is 8743 ha more than the area of land identified in 2020. The number of lands on which the average degree of deflation has been detected, since 2000, has increased more than 2.5 times, to 83571 hectares in 2020. The area of heavily ventilated lands has increased 9282 hectares during the same time.

Analyzing the situation by administrative districts, we consider it necessary to single out the Kursk district, in which about 34% of agricultural lands are already deflated, including 16.6% to an average degree and 7.5% to a strong one. Over the entire period of research, the number of lands subject to deflation increased by 9601 hectares. Also, a difficult situation has developed within the boundaries of the Petrovsky district, where more than 26% of the lands suffer from the negative effects of wind. There are no lands degraded by wind erosion in the Stepnovsky district, and in the Soviet District their area is minimal (39 ha).

The area of deflated agricultural land has grown by almost 24 thousand hectares over the period of research, while the area of land with a weak degree of degradation has decreased, but the areas of land with medium, strong and very strong degree of degradation have significantly increased.

Monitoring of lands subject to wind erosion has shown that the development of these processes tends to decrease the area on arable land, and on other types of agricultural land to increase. Pasture lands are less susceptible to deflation, but favorable conditions for the development of negative processes are created on sloping lands and in areas where there is no dense grass. In addition, an increase in the number of livestock in the private sector is a serious problem that negatively affects the state of natural forage lands. Because of this, the load on pastures increases and pasture turnover is not observed, which leads to desertification of individual territories (Volkov, 2017). In most administrative districts of the arid zone of the Stavro-Polish region, such a situation is noted.

The development of deflation depends on many factors and urgent measures are needed to preserve land and protect agricultural landscapes to reduce the intensity of its development. The reduction in the area of deflated arable land is associated with increased attention to arable land and the use of anti-erosion measures, but the qualitative condition of hayfields and pastures, as well as perennial plantings is ignored (Fig. 2).

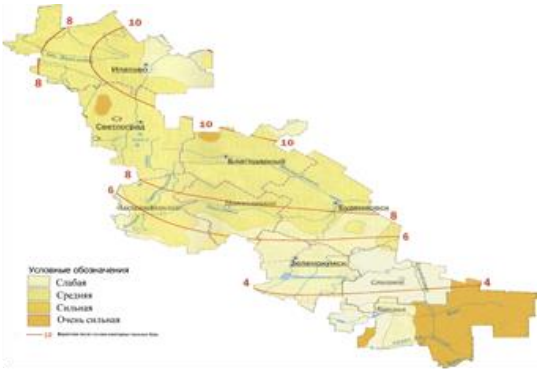

Figure 2: Deflated agricultural landscapes of the arid agroclimatic zone of the Stavropol territory.

Every year more and more agricultural lands are exposed to the combined effects of water and wind erosion, which leads to a rapid deterioration in the quality of these lands. The development of joint negative processes is typical for many regions of Russia, which of course includes the Stavropol Territory. The result of the impact of water and wind erosion is an in-tensive decrease in the upper fertile soil layer and a decrease in humus and nutrient reserves. That is, it is no longer possible to obtain high yields and high-quality products in eroded areas. Also, as a result of the development of erosion, the physical, biological and chemical proper-ties of soils deteriorate sharply.

The natural causes of both water and wind erosion include, first of all, relief, geology, climate, soils and the density and character of vegetation cover. There are also anthropogenic or as they are also called socio-economic causes of the occurrence and development of erosion. These include large plowing of the territory, an increase in the sowing of row crops, a decrease in the sowing of perennial grasses, non-compliance with pasture turnover, that is, not rational use of agricultural land.

As a result of monitoring the lands degraded by joint water erosion and deflation, we have established a stable increase in the area of degraded lands of all types (Magomedov, 2018). As a result of land monitoring, we have established a stable increase in the area of land degraded by water and wind. Over a twenty-year period of research, the area of eroded agricultural land in the arid zone has grown by 100%. This is a very high intensity of the degradation of highly productive lands. Of great concern is the significant increase in the land area of the arid (II) agroclimatic zone, which is subject to various degradation processes. As of 2020, this area is 59098 hectares and this is the maximum value for the entire period of monitoring studies that show the activation of these processes. It is also possible to state an increase in the number of lands with an average and severe degree of erosion. There is no such problem on the territory of two districts - Sovetsky and Stepnovsky. Significant eroded areas were identified in the Blagodarnensky (22707 ha) and Ipatovsky (12603 ha) districts. Also, only in the Ipatov district were found areas heavily eroded by water and wind.

Analysis of the data obtained shows a significant increase in the area of agricultural land subject to water erosion and deflation. In addition, there is an increase in medium-degraded lands and the appearance of highly degraded agricultural landscapes. This fact indicates the absence of comprehensive concrete measures to combat joint negative processes and measures aimed at protecting and improving agricultural land. Monitoring of degraded lands by the combined manifestation of water erosion and deflation is necessary, since the area of eroded lands is constantly increasing. The development of water erosion and deflation occurs in the direction of increasing the degree of degradation across all lands, which can lead to the loss of large areas of arable and pasture lands in a short period of time.

Figure 3: Combined water and wind erosion on agricultural landscapes of the arid agroclimatic zone of the Stavropol territory.

Agrolandscapes subject to joint degradation processes are distributed in noncharacteristic territories. These include the Kursk, Stepnovsky, Sovetsky and Budyonnovsky municipal districts, where the occurrence of this problem occurred during the period of our research. This indicates that the intensity of agricultural production is constantly increasing, and in addition, according to these districts, there is a significant increase in the area of agricultural land and especially arable land.

A systematic approach to monitoring agricultural landscapes in our work is based on the coverage of

the entire study area by combining modern means and technologies (space photography, aerial photography and ground surveys) and a set of indicators of the qualitative state of land based on the emergence and development of degradation processes. Systematic monitoring of agrolandscapes makes it possible to carry out work on zoning and zoning of the territory of an agricultural region with the appearance of the territories of the spread of the main processes of land degradation. We implement a systematic approach based on the analysis of the use of agricultural landscapes (by type of land) and monitoring studies of all degradation processes with subsequent cartographic support for land monitoring.

4 DISCUSSION

This The obtained research results show that the problem of the development of degradation processes remains very serious. Studies conducted by other scientists confirm the severity of the problem for other territories of the region. Previously published works show that the areas of agricultural landscapes subject to negative processes are constantly changing depending on the implementation of various targeted programs aimed at the protection and protection of ugodii. Our research over a twenty-year period indicates the actualization of the problem of degrdation of agricultural landscapes, since the areas of degraded land tend to increase constantly.
The results of monitoring studies obtained in the past were not used to predict the development of degradation processes in the study area. It is also necessary to develop and implement comprehensive programs for the protection, restoration and protection of agricultural landscapes, as there is a real threat of deterioration of their quality and withdrawal from agricultural production.

5 CONCLUSION

Based on the results of monitoring of agricultural landscapes, it is possible to state an increase in the intensity of the development of degradation processes, which leads to the loss of once fertile soils and a significant shortage of crop yields. On the basis of studies of degradation processes, cartographic support of monitoring of agrolandscapes in the context of agroclimatic zones of Stavropol on the basis of modern geoinformation technologies was carried out. Cartographic schemes of erosion zoning, zoning for salinization and flooding, as well as a scheme for the use and protection of the lands of the Stavropol Territory have been developed.

Reclamation and reclamation measures on degraded agricultural landscapes will prevent the reduction of agricultural land areas and obtain stable crop yields. In addition, environmental problems of the use of agricultural land subject to various types of degradation will be solved. The development and implementation of adaptive land management projects in all districts of the dry agroclimatic zone of Stavropol should be aimed at protecting agricultural landscapes and improving their quality condition, taking into account regional and zonal features of agricultural land use. In addition, the developed schemes of forest reclamation, agrotechnical, hydrotechnical and soil protection measures are aimed at correcting the existing ecological situation and protecting agricultural landscapes from degradation processes.

The results of land monitoring over a twenty-year period indicate a difficult environmental situation and the aggravation of the problem of degradation of agricultural landshafts. The developed matrices of the main problems of agricultural land use are necessary for the development of comprehensive measures aimed at correcting the current situation.

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