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Assessment of the State and Management of Modern Agricultural Landscapes in the Central Black Earth Region

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***Abstract* - The article gives the assessment of the state of agricultural landscapes by key indicators: the degradation processes in the investigated agricultural landscapes; the level of environmental sustainability of the agricultural landscape; the types of land forming the structure of cultivated land; the quality indicators of soil condition. It is noted that water and wind (deflation) erosion processes are observed in most of the territory of the investigated agricultural landscapes. During the course of the research it was found that more than 3.8 thousand hectares were subject to water erosion and more than 1.1 thousand hectares were subject to deflation out of the total area of the investigated territories (in the main farms) of 6 thousand hectares. The coefficient of the ruggedness of relief in the investigated agricultural landscapes is 1.19 km per 100 hectares of territory. The share of perennial grasses in the total area of crop rotation was 7.3% before the introduction of the system of adaptive-landscape farming. This value was increased to 29% due to the introduction of soil-protecting crop rotations, grassing and saturation with perennial and annual grasses of field crop rotations. According to the obtained results, the recommendations for the management of modern agricultural landscapes in the Central Black Earth region based on adaptive-landscape farming systems are proposed.**

Keywords— agrolandscape; farming systems; soil fertility; soil erosion; deflation; crop rotation

I. INTRODUCTION

Nowadays an integral part of landscape geo-ecology is the study of changes in the natural environment, occurring under the influence of anthropogenic factors, as well as ways to manage the sustainability and productivity of agricultural land in turnover [1]. The rational use of soil resources is a prerequisite for the formation of a balanced agro-ecosystem.

However, currently the level of anthropogenic impact on agricultural landscapes is extremely intensive, which leads to the degradation of soil cover, the reduction of biodiversity and the sharp decrease in soil fertility. The monitoring of the state of landscapes and the forecast of their further development is an integral part of the management of modern farming systems for sustainable development [3].

As the intensity of the use of natural environment increases annually, the state of landscapes deteriorates. Due to the large variety of natural conditions, such as climate, atmospheric moisture, the amount of solar radiation, the variety of biological communities and differences in soil-forming material, a different structure of the pedosphere is formed in different regions. The soils of the Central Black Earth region possess a very high potential because 80% of them are represented by black soil. However, due to the high degree of agricultural development of the territory, over 57% of the agricultural landscapes are in a state of breaking [8]. The study conducted by the authors reflects the suggestions on the ways of the assessment of state and management of modern landscapes in the Central Black Earth Region.

II. METHODS AND MATERIALS

The indicators of the state of cultivated lands are as follows: 1. the existing degradation processes and the degree of their manifestation; 2. the level of environmental sustainability of agricultural landscape; 3. the types of land that form the structure of the agricultural landscape, and their area; 4. the qualitative indicators of soil condition: (physical indicators, chemical indicators, soil contamination). The assessment of the state of cultivated lands was carried out in the main farms of the Central Black Earth region with an introduced ecological-landscape system of agriculture (Kantemirovsky district of Voronezh region, Anninsky district of Voronezh region, Talovsky district of Voronezh region, Belgorod district of Belgorod region, Shchebekinsky district of Belgorod region) [7]. The main indicators of the state of agricultural landscapes before and after the introduction of adaptive-landscape farming systems were compared.

The monitoring of the state of agricultural landscapes is based on accurate observations. Thus the following range of methodologies was used.

The first method is field technology. This methodology included the route method and the key method. When using the route method, a continuous sampling of the boundaries of agro-phases and tracts was studied, the nature of the change in

the mesoforms of relief and the features of its dissection were studied, including erosion processes (the identification of gullies, ramps, hollows). During the process of field observations, the empirical approaches such as observation, description, and measurement were used. The key method is carried out on key (stationary) points. At key points the sampling was carried out in order to analyze the qualitative state of soil. The method of key points includes desktop studies and the use of remote sensing materials for aerial and space photography. The photos of agricultural landscapes in this study were takenusing a DJI Phantom 3 SE quadrocopter, satellite data was taken using the Google Maps interactive satellite map online service.

The second method is the method for mapping of morphological structure of cultivated lands. As a result, the maps of the boundaries of natural territorial complexes (NTC) based on the landscape-catchment approach and the maps of soil contours, maps of the agricultural landscape before / after the implementation of the adaptive-landscape system of agriculture were obtained. The mapping was carried out using vector and raster graphic editors such as Easy Trase 7.99, ArcGis 10.2.

III. RESULTS

As a result of the research, the following data were obtained. Water and wind (deflation) erosion processes are observed in most of the investigated agricultural landscapes. During the course of the research it was found that more than 3.8 thousand hectares were subject to water erosion and more than 1.1 thousand hectares were subject to deflation out of the total area of the investigated territories (in the main farms) of 6 thousand hectares. Creek slopes are subject to plane erosion. This fact leads to their flattening and the formation of washed soils and even deluvial sediments.

Cropped land is subjected to linear erosion, which results in the formation of gullies and hollows. The coefficient of relief dissection in the investigated agricultural landscapes is 1.19 km per 100 hectares of territory. The share of perennial grasses in the total area of crop rotation was 7.3% before the introduction of the adaptive-landscape farming system. This value was increased to 29% due to the introduction of soil-protecting crop rotations, grassing, and saturation with perennial and annual grasses of field crop rotations. This has a positive effect on the state of the soil cover, since perennial grasses prevent the manifestation of water erosion processes and have a high coefficient of soil-protective ability.

The existing degradation processes and intensive use of land in turnover negatively affect the level of environmental sustainability. The studied agricultural landscapes before the implementation of adaptive-landscape system of agriculture mainly belonged to the state of breaking and unstable (the share of destabilizing lands exceeded more than 50% of the total territory of the agricultural landscapes with the slope of the relief up to 1%, and more than 35% with the slope of the relief over 5%). After the introduction of a new farming system, the state of agricultural landscapes reached a threshold of stability, minimally stable and medium-stable state. In some cases, with the exclusion of low-productive cropped land from turnover, the implementation of measures for the continuous forestation of gullies, agro-forestry and meadow ameliorative measures, a highly stable state of the cultivated land was achieved. There is an increase in the content of humus by 0.7% over 5 years on these lands.

The qualitative composition changes according to the types of land. The share of medium-stabilizing lands is increasing due to the creation of an ecological framework based on the convergence of natural environments. The share of land occupied by forests, forest strips and bush zones and perennial plantings is increasing. The territory under destabilizing lands is reduced by the decrease of land occupied by gullies, hollows, unproductive and degraded cropped lands. Due to the design of hydraulic structures and the creation of a network of ponds improves the microclimate, water and thermal conditions on cropped land.

The monitoring of the soil quality was also carried out during the course of the study with the help of such indicators as soil density, overconsolidation, organic material content, particle size distribution, macro- and microelement content, soil biological activity. The following results were obtained. The humus content increased from 4.4% to 5.5%. The depth of carbonates was 0.77 cm.

The optimization measures ensure the creation of sustainable cultivated lands with reproducing and medium-forming functions for conducting adaptive farming. The strategic basis for rational agrarian nature management is determined by the maximum saving of land resources at all the stages from the organization of territories to the planning and management of adaptive nature management. This problem is so global and relevant that if we do not take effective measures now, the consequences will be catastrophic and irreversible. In order to solve the outlined tasks, the modern land management should be guided by landscape-ecological principles and represent the mechanism of agrarian environmental regulation.

The large variety of anthropogenic landscapes was formed: agricultural (cultivated lands), urbanized (residential), recreational, protected and many other types. The cultivated land is characterized by the unification of forms of organization and structure and the methods of land use over large areas, which leads to the decrease in the initial diversity of land types, to structural and biological simplification and weakening of environmental sustainability. The depleted cultivated lands are ecologically more vulnerable and less resistant to external influences, their agroecosystem is unbalanced.

The land used in agricultural production is a complex natural formation; in fact it is a component of wildlife. A person for the organization of their rational use and effective agricultural production solves the problems of environmental management and environmental regulation. The organization and arrangement of the territory of an agricultural enterprise is in the process of land management, therefore, it acts as a mechanism for environmental management and the territorial natural formation used in agriculture represents a cultivated land.

Under the environmental management of the agricultural landscape, it is advisable to understand the system of measures of land management for the organization and arrangement of land (agricultural and non-agricultural) for rational nature management. This system of land management activities should be based on the observance and implementation of landscape - environmental principles of environmental management. In the process of environmental management, an environmentally sustainable agricultural landscape should be formed. This landscape will withstand negative natural processes, the anthropogenic load of the farming system and perform environmental management. Under the rational agricultural environmental management should be understood such agricultural activity, in the process of which there is no degradation of the natural potential of land resources.

Agricultural production is carried out on a specific territory by a given set of land, with a certain agro-resource potential and forms a new image of the territory and processes taking place in it. A cultivated land is a territory used in the field of agricultural production bearing the burden of anthropogenic influence. Agrotechnological processes of agricultural production have a direct impact on the appearance of the territory and the ecological processes occurring within the agricultural landscape, between the components and the elements of its structure.

The internal ecological relation between the components of nature (landscape) and the elements of the agricultural landscape and the external environment is in constant dynamics. The ecosystem of cultivated lands at the level of agro-bio-geocenoses (field = soil + crop) is, as a rule, unstable, as it is represented by a depleted natural and cultural biotic community. The agrosystem of the modern cultivated land does not have the ability for a long-term ecological balance due to the weakening of the processes of self-regulation. As a result of economic activity, field agricultural landscapes are intensively subjected to degradation and depletion. The state of the agroecosystem of the modern field agricultural landscapes is determined by a set of modes: nutrient, water, heat, air, etc. The main factor of anthropogenic load in the agricultural landscape is agriculture. Non-alternative development and introduction of adaptive farming, based on the balance of agricultural modes, will allow a real shift towards rational use of natural resources in agriculture.

Field agricultural landscape is created by a man; the natural components of it are changed: soil, water, air, flora and fauna, ecological relationships are violated. A distinctive feature of anthropogenic landscapes is a weak natural self-organization and a negative impact on it produced by humanity. As a multifunctional formation, a field agricultural landscape can be suitable for various farming systems. At the same time it should fulfill the function of the most complete correspondence of its natural predisposition; in order to function rationally it must be stable and adapted to local natural conditions.

For the organization and maintenance of adaptive farming in the territory of agricultural enterprises, the issues of the organization of cropped land are solved, aimed at the obtaining maximum agricultural production with the help of more careful use of the potential of natural agro-resources. At the present stage of development of society, the environmental problems of agriculture have become so global and comprehensive that they provoke particular concern on the state of the environment. The processes of soil degradation, and as a result, the violation of the ecological relation between the components of nature in the production process led to the deterioration of human activity environment. Nowadays, the most urgent tasks are not just the organization and construction of cropped land, but the environmental management of field agricultural landscapes.

In the process of environmental management, it is necessary to take measures in order to improve the infrastructure of the field structure of agricultural landscapes, as well as the formation of cultivated fields that are resistant to adverse natural phenomena and the anthropogenic conditions.

A field agricultural landscape, from a landscape-ecological point of view, is a complex territorial agroecosystem created by humanity and intended for growing crops, where the components of nature and the elements of the territory are interconnected and interdependent, and any intervention in the process of land management and farming breaks the fragile agroenvironment and makes it necessary to transfer the agricultural landscape to a new state, to a state of balance to new conditions. During land management the process of organization and creation of cropped land for conducting adaptive farming should be viewed through the prism of environmental management and environmental regulation. These tasks are inseparable from each other and represent a single whole element of agrarian nature management.

The urgent need to change the paradigm in the field of land management obliges to revise the principles, rules and norms of design with the priority of compliance with landscape-ecological requirements. The objectives of the arrangement of agricultural landscapes directly solved in the process of land management. New tasks of environmental management of agricultural landscapes should be solved on the principles of landscape-ecological land management.

The resistance of agricultural landscape to the manifestation of negative natural processes and anthropogenic load is created when organizing and setting up of agricultural lands in the course of environmental management. The main task of the landscape-ecological land management of agricultural enterprises is the organization and formation of sustainable agricultural landscapes, resistant to natural phenomena and anthropogenic conditions of agricultural landscapes. They are necessary for the realization of adaptive farming with optimal agro-ecological modes and provision of cost-effective agricultural production.

It is possible to ensure sustainable development of agriculture in the case when agriculture will be adapted to local natural ecosystems, and the territory will be organized and regulated on the basis of the principles of landscape ecology. An integrated approach to agricultural production, as one of the most important sectors of environmental management, makes it necessary to consider the agroecosystem and agricultural landscape as a single interdependent system.

It must be admitted that nowadays there are practically no sustainable agricultural landscapes, where agroecosystems of agriculture are balanced and conditions for adaptive farming are created. Previously adopted farming systems and methodologies for solving the issues of the optimization of rational use of land by agricultural enterprises, from the standpoint of maximum economic efficiency of production, did not stand the test of time. The economy of agriculture is still not stable; farming is suffering from the manifestation of negative environmental conditions. Realizing that, the agricultural landscape is the territory of an agricultural enterprise, which is organized and arranged in the process of land management, the environmental management conditions for conducting adaptive farming are laid down by a system of land management activities. These main conditions should present the basis for the formation of sustainable agricultural management based on the new - landscape-ecological land management of agricultural enterprises, designed to create sustainable agricultural landscapes with an optimal ecosystem, where all the modes for adaptive farming are balanced. The sustainability of the agricultural landscape, the ecological balance of the agroecosystem modes and the economic efficiency of agricultural management in general depend on the level of competence of the solution of these issues.

Agricultural landscape cannot be separated from its agroecosystem - it is a single whole element, the basis of agriculture. Only at the level of a scientific hypothesis, they can be considered separately, for a deeper understanding of the entire system of land management measures for the arrangement of cropped land for the organization of adaptive farming with optimal agricultural modes, a unified system of agricultural environmental management. Such abstraction is necessary for the improvement of the land-organizing mechanism for the arrangement of agricultural territory for the purpose of subsequent management of adaptive farming.

The agricultural landscape is the territory of an agricultural enterprise, which is organized and arranged in the process of land management, and the ecological basis for adaptive farming should be laid in the process of landscape-ecological land management. Such a system of land management measures for the organization and arrangement of the territory should be considered as a method for the construction of field agricultural landscapes, and agricultural landscape itself is the basis for the functioning of the agroecosystem. In the agroecosystem, the optimal modes are formed for the growth of crops (nutrient, water, heat, air, etc.).

The sustainable field agricultural landscape provides the formation of an optimal system of ecological relations between the components of nature (soil, water, air, animal and plant world) and the elements of the territory (forest and bushy stripes, tree-shrub plantings, road network, buffer lanes, troughs, water bodies, hydraulic structures, etc.). The landscape will be resistant to negative natural processes and creates optimal conditions for the growth of agricultural crops of agriculture.

Only in the process of land management of agricultural enterprises, through the organization and construction of a field agricultural landscape, the process of “farming” fits into nature and adapts to specific natural conditions. Such an approach creates real conditions for the environmental management of agricultural landscapes and provides reliable conditions for the maintenance of optimal agricultural management. Distinctive climatic conditions in the context of micro-zones determine the need for their careful study and accounting for the rational organization and management of agricultural production.

The organization and arrangement of the territory of agricultural enterprises is particularly influenced by the relief of territory.

The local basis of erosion in the section of micro-zones is also significantly different and affects the methods of the arrangement of the territory.

Relief, as a set of outlines of the surface of earth, bearing the historical imprint of the course of agro-climatic processes, is one of the main energy natural factors and determines all ecosystem modes of natural landscapes (nutrient, thermal, aquatic, air, etc.) and is subjected to transformation.

The conditions of farming depend not only on the topography, other factors, and components of nature (hydrology, flora and fauna) also have an impact.

Water resources of the region are represented by rivers, lakes, ponds and reservoirs. These resources determine the natural watering of the territory and form the water regime of the ecosystems of agricultural landscapes. The modern water network is formed by rivers and temporary streams.

Favorable climatic conditions for the development of agricultural plants are formed at the optimum amount of moisture and heat, when the hydrothermal coefficient (HTC) is 1.0.

The natural resource potential of the land reserve forms the basis of agriculture and its main branch of agriculture. Its rational use is the basic requirement and condition of modern agricultural use of natural resources, carried out on the basis of projects of farm landscape-ecological land management. It is possible to create optimal conditions for the rational use of land and efficient farming only if it is adapted to the rich variety of zonal natural and climatic features of the region.

IV. Conclusion

According to the landscape-catchment approach, the formation of agricultural landscapes should be based on the formation of agro-phases - elementary areas with the same soil differences, relief, water, heat, nutrient and air modes of soil. This approach is successfully implemented in the formation of adaptive-landscape farming systems. The assessment of the state of agricultural land in the Central Black Earth region suggests a conclusion about occurring large-scale degradation processes and the general deterioration of soil fertility as a result of anthropogenic activities. The washing of the fertile layer, the decrease in the organic component of the soil, the growth of the territory occupied by the gully net, leads to a sharp decrease in the productivity of land. However, on the basis of the conducted research, the effective measures are

proposed for the management of the state of modern agricultural landscapes.

The increase in the share of medium-stabilizing lands, the carrying out of ameliorative agroforestal and grassing measures, the removal of degraded and unproductive cropped land from land turnover makes it possible to form sustainable farming systems. The yield of the main crops in such agricultural landscapes is 30-35% higher, and in years with unfavorable climatic factors, this value can reach 47%.

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