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Degradation of Landscapes of the Sarpinskaya Lowland

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Abstract - **In current conditions, the territory of the Sarpinskaya lowland has clearly expressed degradation of vegetation, salinization and depletion of soils, as well as desertification. These processes are associated with an increase in anthropogenic load and are actively developing in the dry-steppe and semi-desert zones, in particular, on low-humus semi-desert soils and sands. Such processes lead to increase in the area with a reduced projective cover or its complete absence. The desertification of new areas due to intensive cattle grazing continues. Their increasing area and number lead to salinization of irrigated lands and deflation of arable lands. The main reasons for the degradation of agrolandscapes in this territory are climatic tension due to insufficient rainfall, high summer temperatures and anthropogenic tension due to uncontrolled grazing, irrational use of irrigation and lack of normative land reclamation protection of fields from deflation.**

Keywords: degradation, landscape, vegetation, desertification, space images, geoinformation technologies, Sarpinskaya lowland

I. Introduction

Under semi-desert conditions, a natural change in the state of an ecosystem goes through the stages of degradation under adverse conditions and recovery under favourable conditions. Anthropocentric impact leads to critical degradation of such an ecosystem with deterioration in biocenosis of both quantitative and qualitative characteristics. Restoration of landscapes in natural conditions is due to climatic factors and lengthy [1, 2]. Identifying patterns of violation of landscape connections and their restoration is a significant scientific task providing a forecast of the state of landscapes.

The report on the State and Use of Agricultural Land of the Russian Federation in 2017 [3] notes that land degradation continues in the Russian Federation. The report indicates an increase in areas prone to deflation and erosion, salinization of soils which ultimately leads to a decrease in agricultural land productivity and their withdrawal from circulation.

The Sarpinskaya lowland is similar to an irregularly shaped triangle, which borders in the west the Ergeninskaya Upland and the Volga-Akhtuba floodplain in the north and northeast. In the south, the Sarpinskaya lowland smoothly passes into the anthropogenic desert in the South of the European part of the Russian Federation called the Black Earth. Within the Sarpinskaya lowland, there are the north and northeast of the Republic of Kalmykia, the southeast of the Volgograd and northwest of the Astrakhan regions. The lowland includes the following soil types: light chestnut solonetzic with solonetz, brown desert with solonetz, meadow chestnut and meadow steppe downward [4]. The agrolandscapes of the Sarpinskaya lowland belong to the region of gently wavy sea plains with flat-walled, undulating-flat tracts [5].

The waterlessness of the territory and insufficient drainage during irrigation led to an increase in the level of groundwater, salinization of significant areas and land retirement which exacerbates the problem of lack of drinking water.

Features of climatic conditions, soils, and the relief of the Sarpinsky lowland led to a special type of plant communities. The vegetation includes giant ryegrass, calligonum, wormwood, sarsazan on the sand and sandy loam soils and reed grass, wheatgrass, feather grass on light chesnut soils with saltwort and tamarix on solonetz soils. In the landscape plan, the territory of the Sarpinskaya lowland is a combination of semi-desert with white wormwood, fescue, feather-grass, and fragments desert with white wormwood, camphorosma, black wormwood. In the intrazonal territories, there are areas of dry and true steppe represented by wheatgrass and feather grass phytocenosis and motley grass, fescue, feather grass phytocenosis, fragments on meadow-brown soils with white wormwood, quackgrass, wheatgrass meadows. Around limans, there is a differentiation from lake reed marshes to saline meadows and local steppes.

Intensive anthropogenic impact on indigenous types of communities and unregulated grazing of cattle leads to the formation of mobile and semi-fixed sand massifs and appearance of specific ruderal phytocenosis. Landscapes with a predominance of fixed weakly humus sand and without anthropogenic influence, preserve the zonal type of plant communities.

Peculiarities of geomorphological, soil and hydrological conditions on the territory of the Sarpinskaya lowland lead to the formation of intrazonal types of phytocenosis and soils, especially in limans, small lakes overgrown with reeds, litter depressions moistened by the Volga spills and in areas with the presence of ground desalinated waters of the Caspian Sea. The dominant plant communities of the Sarpinskaya lowland have the following groups: turfy-cereal, xerophytic, semi-shrubby, halophytic, meadow halophytic and hydrophytic.

Due to the instability of climatic conditions and the hydrological regime of the Volga catchment, an urgent problem is to study the patterns of landscape functioning and identify mechanisms for restoring their natural potential.

Most of the studied territory by the structure of the land fund is occupied by agricultural land (84.8%). In this connection, the main burden on land resources is anthropogenic in nature, associated with agricultural production, the development of which leads to the degradation of natural ecosystems. Deflation with varying degrees of degradation covers 77% of agricultural land, the share of salinized land is 42% including arable land 3.4%, reclaimed forage land is 57%. In this connection, it is relevant to identify the current state of landscapes in the Sarpinskaya lowland.

The purpose of the research was to identify the level of land degradation and to determine the spatial distribution of degradation zones of various levels. At the same time, the tasks were to decode actual satellite images, identify degradation zones, geoinformation analysis of their spatial distribution and develop cartographic layers of landscape degradation of the studied territory.

II. Materials and Methods (The Model)

Cartographic and aerospace research uses distance and biotic features of landscape degradation processes. The landscape approach determines the theoretical and methodological basis for the restoration of degraded lands.

Assessment of the state and land reclamation arrangement of agrolandscapes based on the interpretation of satellite images and the geoinformation technologies makes it possible to identify the state of landscapes and establish the level of their degradation. The developed methodologies in the works of B.V. Vinogradov, K. N. Kulik, A. S. Rulev, V. G. Yuferev and etc. [6–9] showed the possibility of reliable identification of the characteristics of agrolandscapes.

The study of the landscapes of the Sarpinskaya lowland is based on aerospace information of various spatial resolutions. It uses the results of geomorphological, soil, hydrological, geobotanical, and other types of research.

The need to localize the operating conditions of natural-territorial complexes requires the use of landscape mapping. The developing maps will characterize the existing natural potential of the studied landscape and its current state. Geoinformation mapping with the use of data from remote sensing of the Earth has its characteristics, unlike traditional mapping. In this case, the volume of desk studies increases and the volume of field research decreases.

Computer geoinformation mapping uses spatial data and analyzes it to determine the coordinates of objects in the research area, the topological properties of objects; to identify geomorphological features of landscapes, the confinement of soil contours to specific surface areas, landscape defects and their spatial localization.

The use of geographic information technologies is most suitable for mapping the state of landscapes of the Sarpinskaya lowland. A geoinformation analysis of the state of natural-territorial complexes proceeds at the level of facies and natural boundaries which makes it possible to spatially determine the centres of degradation and to justify measures to eliminate them.

Desk studies are necessary for photogrammetry of aerospace images of the research area including their interpretation, classification and analysis. The analysis differentiates the areas with open, moving sands, salt marshes and saline soils, areas covered with water and occupied by anthropogenic objects. Researchers group such sites and establish the level of land degradation.

Because remote sensing data carry information on the current state of the landscapes of the Sarpinskaya lowland, the use and interpretation of the obtained spatial data for their assessment, geoinformation analysis and mapping provide a modern level of scientific knowledge. Assessment of the state of landscapes includes information on the spatial location and levels of their degradation. The statistical spatial analysis considering changes in landscapes, the development of mathematical-cartographic models provides reasonable forecasts of their condition.

The geoinformation analysis to study degradation processes in agrolandscapes reduces the cost of design and survey work, accelerates their pace, and increases the effectiveness of land reclamation.

Assessment of the state of agro and forest landscapes requires criteria to reduce the economic importance of land. The characteristics of land quality deterioration according to each criterion have degradation levels: norm, risk, crisis and disaster, established by B.V. Vinogradov [10, 11].

The study of the state of agrolandscapes is based on the laws of optics. N.A. Mikhailova, D.S. Orlov [12] studied the optical properties of soils and showed the relationship of the reflection of solar radiation by some soil types.

A comparison of the results of remote sensing and standardization of soils, vegetation including grassy vegetation and forest stands, makes it possible to identify the state of landscapes [13].

The modern geographic information technologies and satellite imagery for assessing and mapping the state of landscapes in the Sarpinskaya lowland is a modern research method to analyze spatial data and interpret these data into analytical maps.

III. Results and Discussion

The object of the study was the landscapes of the Sarpinskaya lowland on an area of 6877.438 thousand hectares. The analysis of the degradation of the territory of the Sarpinskaya lowland reveals that 13.6% of the area is affected by wind erosion, 17.6% by water erosion, and 4.1% by salinization.

In our study, the indicator of degradation was the state of the vegetation cover according to the criterion of its correspondence to normal for these natural conditions.

The landscape degradation analysis uses satellite imagery from the Sentinel 2 satellite developed by Airbus Defense and Space, the ESA operator.

We used spectrozonal images of channels B2, B3, B4, with a resolution of 10 m of the shooting period from May 15 to June 15, 2018, with a cloud cover of less than 10%. This allowed us to develop an RGB mosaic covering the entire territory of the Sarpinsky lowland (Fig. 1).

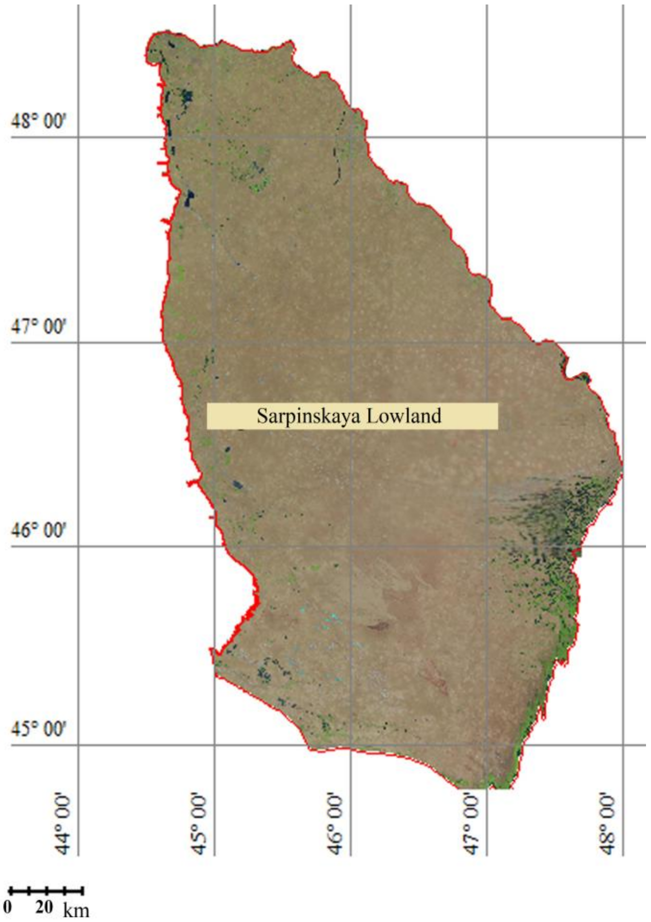

Fig. 1. Cosmap of the Sarpinskaya Lowland

The interpretation of satellite images was carried out using the analysis of the distribution of pixels by the tone in a raster image.

To conduct mapping and analysis of the space image mosaic raster, we used the free open-source geographic information system QGIS-3.8.

Analysis of the raster conducted in the geographic information environment with histograms of the distribution of pixels, allowed us to divide the raster into zones.

Separation by the tone and visual interpretation of images formed zones according to the levels of landscape degradation.

The spatially defined data in the environment of geographic information systems ensured the identification and mapping of zones according to the levels of degradation (Fig. 2).

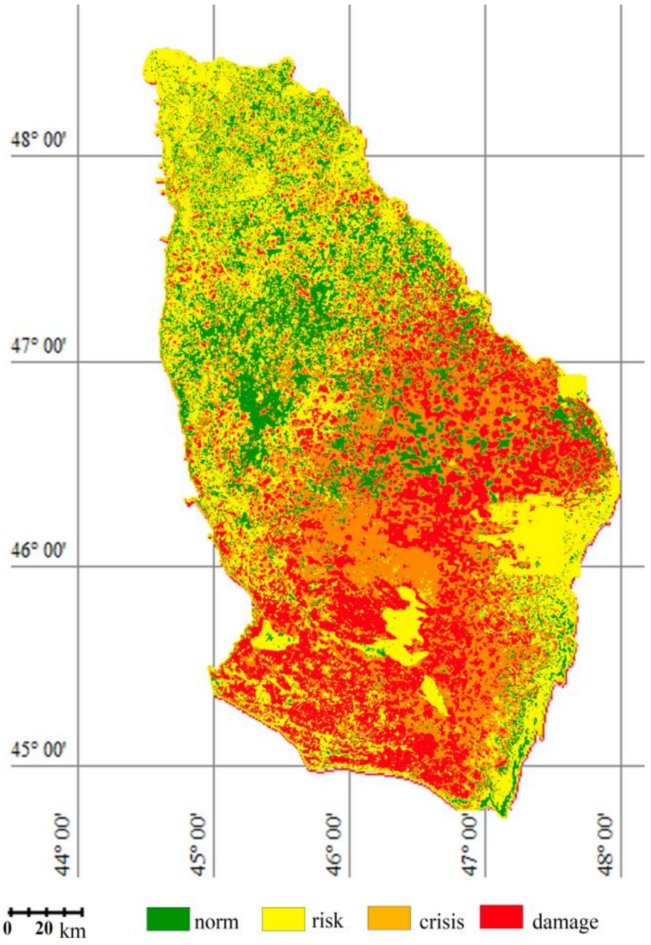

Fig. 2. Map of the zones of degradation levels in the Sarpinskaya lowland

An analysis of the results of geographic information mapping of the degradation of the territory showed (Fig. 3) that only 975,234 thousand hectares belong to the normal level, 2568,563 thousand hectares to the risk level, 1,723,910 thousand hectares to the crisis level, 1,609 disaster levels, 732 thousand ha.

The conducted geoinformation studies of the spatial distribution of soil types on the territory of the Sarpinskaya lowland developed a vector map of soil contours (Fig. 4) and determine their area (Table 1).

Spatial information about soils and their areas reveals the most vulnerable, for degradation, areas needed first of all further research.

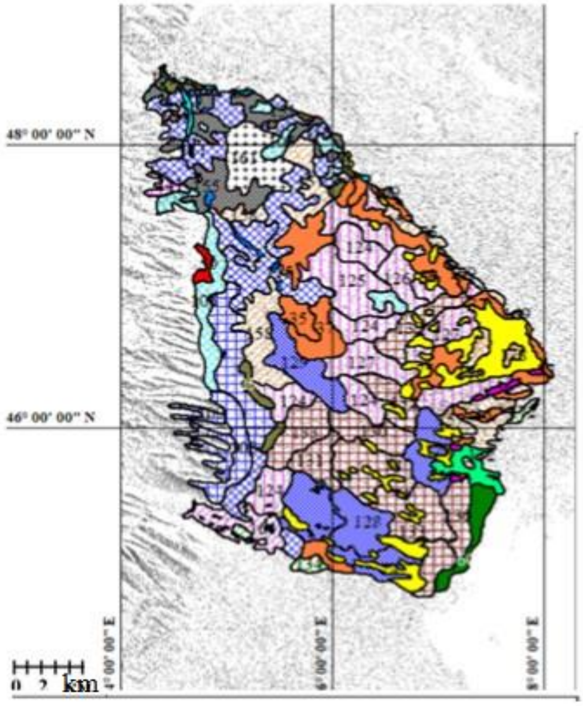

Fig. 3. Histogram of the distribution of the Sarpinskaya lowland territory by degradation levels

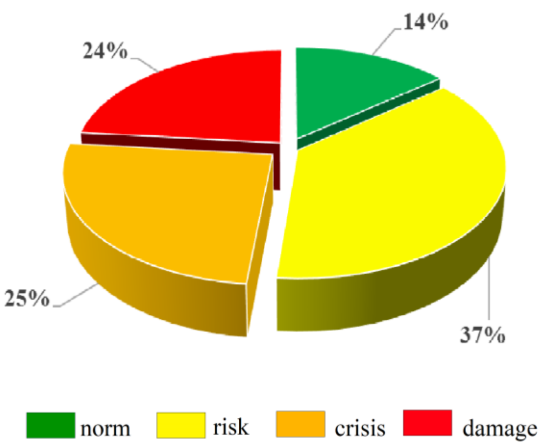

Fig. 4. Map of the soil contours of the Sarpinskaya lowland

The distribution of soil contours by area showed that brown soils with solonetzes, about 17%, and brown soils with sands, about 16%, have the largest areas.

TABLE I. NUMBER OF SOIL CIRCUITS AND THEIR AREA IN THE SARPINSKAYA LOW

Soil type (contour number)	**Number of contours**	**Area, ha**
Sands&Brown (178)	3	50165
Alluvial soddy&Alluvial meadow	1	13135
Alluvial meadow&Brown (169)	9	144607
Solonetz&Solonchak (163, 164)	1	127888
Solonetz&Solod (161)	1	175953
Solonetz&Meadow chestnut (159)	1	11264
Solonetz&Brown (157, 158)	5	33159
Solonetz&Light chesnut (150-156)	11	308294
Meadow&Solonchak (141)	1	25491
Meadow chestnut&Meadow (134)	1	27635
Brown&Sands	11	1100456
Brown&Solonchak	6	676417
Brown&Solonetz	15	1144871
Light chestnut&Solonetz	17	766895
Light chestnut&Meadow (108,109)	4	451442
Light chestnut&Meadow chestnut (104-107)	7	264601
Soils of ravines and gullies (76)	1	1435
Sands (71-75)	37	534126
Alluvial (61-69)	5	46332
Meadow-boggy (57-60)	1	92630
Solod (49-50)	6	58635
Meadow (44-48)	1	78839
Brown (35-37)	1	2856
Brown (35-37)	18	657291
Light chesnut	8	83022
Total	172	6877438

IV. Conclusion

The spatial distribution of degradation zones following the assessment and the developed map indicates an extremely unfavourable situation. Disaster zones occupy 24% of the territory and, especially in its southeastern part, have large areas of open moving sands with the extremely low projective cover which negatively affects the functioning of the landscape as a whole.

If we consider another 25% of the territories degraded to a crisis level, then about half of the territory needs urgent measures, primarily a phyto-reclamation.

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