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SPATIO-TEMPORAL ANALYSIS OF THE GEOSYSTEMS OF THE TENIZ-KORGALZHYN DEPRESSION BASED ON THE DATA DECIPHERED FROM LANDSAT AND SENTINELSATELLITE IMAGES

Abstract. Studies of the geosystems of the Teniz-Korgalzhyn depression were carried out. The spatial and temporal patterns of the structure, functioning, and dynamics of the development of the landscape components of the territory under study are determined on the basis of computer-aided decoding of multizone space images. With the use of the functionality of modern instrumental GIS and decoding algorithms, the indicators of productivity of geosystems and the anthropogenic transformation are determined. Significant differences in the anthropogenic factor have been established, which have local rather than ubiquitous effects on the dynamics of geosystems against the background of significant changes in the ratio of moisture and productivity. In the last chapter, conclusions are made about the need to control anthropogenic influence and to ensure the rational use of resources of the territory as a factor of sustainable development.

1. Introduction

The territory of the Teniz-Korgalzhyn depression selected for the study, including the Teniz-Korgalzhyn lakes system, according to [1, p. 135-136] is a part of the Tenizsky mega-system, which is represented by the Teniz-Nura macro-geographic system, which unites territories confined to the basins of the Nura, Kulanotpes, Kon and other small rivers that flow into Lake Teniz. The basin area is 105.1 km^2. The watersheds of this macrosystem are located in the northeast along the Niyaz lowlands, Air, in the south along the Besshoky, Aygyrzhal lowlands of the island and in the low mountains of the Sarysu-Teniz anticlinorium. In the Teniz-Nura macrogeosystem, the Upper-Nura, Middle-Nura and Lower-Nura sub-systems, as well as the Kulanotpes-Konskaya, Kipshak-Kerei subgeosystems, were identified.

The territory of our study is occupied by the Middle-Nura and Lower-Nura sub-systems.

The Middle-Nura sub-system is represented by the geosystems of the basins of the right bank inflows - Ashagandy, Zhailmin, Ulkenkunduzdy, and the left bank inflows - Essen and Sherubainury.

The right-bank geosystem functions in conditions of a hilly-rolling small-hill area and a denudation-hilly plain of sumerly dry steppe soil and vegetation. The left bank is characterized by a more drained, dry-steppe biota, forming on the lake-alluvial Kalpaksor and Tassuat plains.

The natural complexes of the Middle-Nura sub-system are represented by paragenetic complexes of floodplains and floodplain terraces. The valley geosystems are formed on three terraces above the floodplains, cut by logs and composed of alluvial sand and pebble deposits, as well as covered with loams of heavy and medium mechanical composition.

The dominant meadow-steppe sparse vegetation is formed on meadow-chestnut soils; chestnut grasses are characteristic of upland grasses, and to the south light chestnut-colored grasses are typical.

The development of geosystems forming in the recharge zones of the Samarkand, Intumak, Samara reservoirs and water releases through the Irtysh-Karaganda canal, occurs under the influence of technogenic factors that change the conditions of their natural self-regulation. Especially high technogenic loads of the geosystem is in the dilution zones of the wastewater of the Temirtau ore-dressing plant. Excess of maximum permissible concentration in rivers by polluting ingredients is on average: for mercury and copper - 4 MPC, oil products - 10 MPC, phenols-9 MPC, ammonium nitrogen - 15 MPC, nitrites up to 16 MPC.

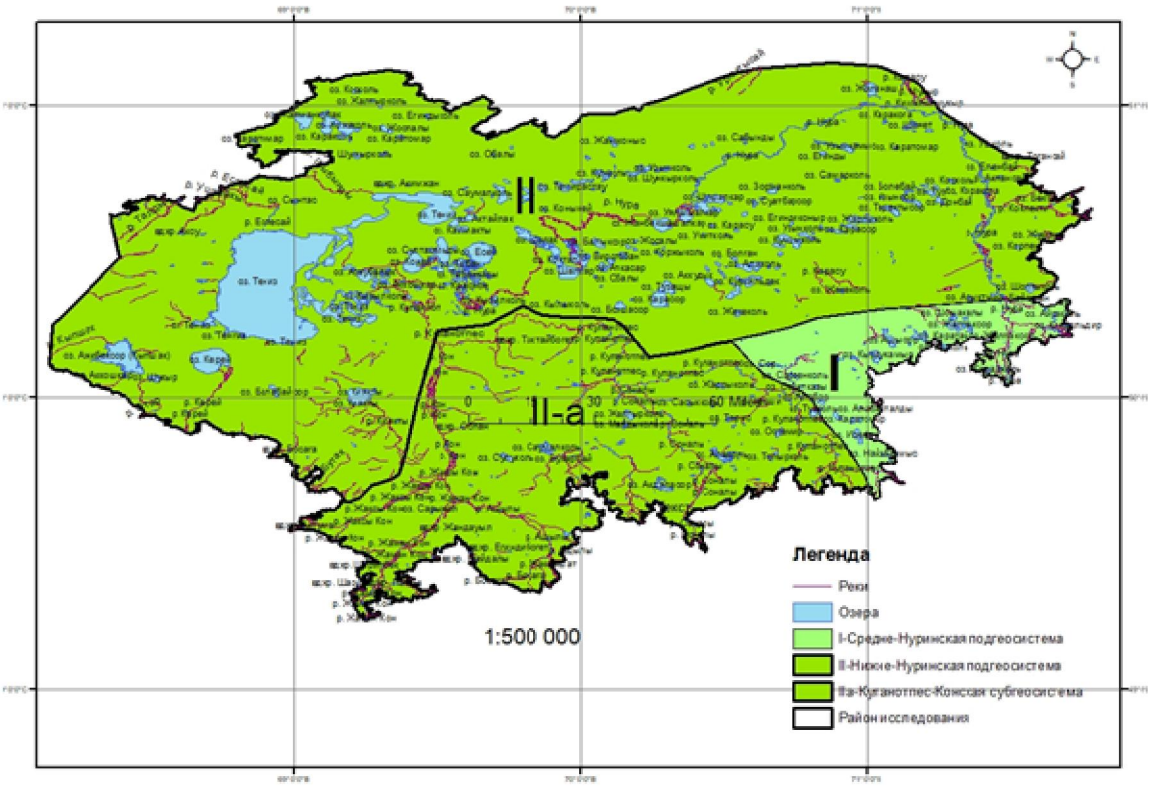

Figure 1 Geosystem Map

Legend	
	Research area
	Rivers
	Lakes
	I- Sredne-Nurinsk sub-system
	II- Lower Nurinsk sub-system
	IIa- Kulanotpes-Konskaya subgeosystem.

Aquatic geosystems also contain a high percentage of mercury salts, cadmium and other pollutants. The capacity of technogenic silts is 2-3.5 m. The content of mercury in them reaches 560 mg / kg (with background - 0.08 mg / kg). Much of the mercury is in active form available for biota uptake. This explains the increase in mercury in the surface runoff during the period of high water flooding, in the case of discharges of water from reservoirs and drainage systems. At the same time, mercury comes from bottom sediments and is a source of secondary technogenic pollution of the environment [2].

In general, as a result of the long-term influence of the factors of technogenesis, the natural potential of the Middle-Nura sub-system is insignificant, many geosystems have impaired processes of self-regulation, and the transformational patterns of biota are characterized by clear signs of desertification. The significant territories used by the mining industry require phytomelioration and other reclamation works [1].

The Lower-Nura sub-systems occupy the territory within the Teniz-Korgalzhyn depression, and the tributaries Ulkenkunduzdy are down the confluence with the Nura River. This is a lake-alluvial drainless basin with moderately dry steppe conditions. Upper devonian metamorphic rocks, covered by a thick neogene-quaternary sediment take part in the lithogenesis of geosystems.

Numerous lake-flow systems, closed depressions, alkaline lakes are widespread. The lakeside geosystems operate in conditions of wetlands and salt marshes. The channel of the river Nura passes through the Besshalkar group of lakes: Shiimalkar, Zhandyshalkar, Uyalyshalkar, Byrtaban, Sholak and

others. Further to the east, freshwater lake Kurgalzhyn is connected with the drain of Lake Teniz by a system of reaches and Asaubalyk lakes.

Lake Teniz is the final zone of accumulation of suspended particles brought from the Nura, Kulanotpeas, Kon and other small rivers. The salt lake Teniz is connected to the freshwater lake Korgalzhyn by a system of lakes and tributaries - Isei, Sultankeldy, Kokai, Tabankazy, Big and Small Karakol [1].

The structure of aquatic geosystems is complicated by stretches, shallow waters, bays.

The geosystems developing in the recharge zone of these lakes are unstable in relation to the hydrogeological regime and the flow of water to the channels. At present, geosystems that have lost their natural potential due to lowering of groundwater levels, decreasing water flow in rivers and increasing mineralization, are in an unstable condition.

The geosystems of the first lake above-flood terrace are more dynamic due to their greater moisture content and proximity of groundwater. Sandy coastal walls are deflated. The geosystems of the second and third above-flood terrace are more stable in terms of space and time and have a more stable mechanism of self-regulation.

The soil grounds of the dominant juicy-solyanka vegetation of high terraces forming on meadow solonetz are composed of fine-grained, loamy-sandy and silt sediments up to 10 m thick. The degree of intensity and nature of the functioning of geosystems depend on the water-salt balance of these lake-flowing systems. The coupled processes of the hydrochemical and hydrogeological regimes are closely interrelated with the anthropogenic halophytization of the biota, reducing its productivity. In recent years, factors of technogenesis have begun to play a dominant role in the overall mass energy exchange [3].

The dominant associations are fescue-feather-tyrsovye with dark chestnut solonetz soils. Significant expanses of the lowlands are occupied by sedge and reed beds.

On paragenetic complexes of the feeding zone of lakes composed of sandy-clay tolerances, wheatgrass, campfire, ostretsovy salt meadows on meadow solonetz are developed. Mosaic and complex geosystems of a lower order also determine small sand mounds.

The floodplains, as well as the geosystems of the runoff dispersion zones in the Teniz-Korgalzhyn lake-flow system, have a significant diversity of biota and high productivity in the Republic of Kazakhstan. To maintain the ecological balance of these geosystems and to ensure the necessary watering of wetlands, a scientifically-based assessment of their state, structure and functioning dynamics is required.

The purpose of the research is a spatial-temporal analysis of the structure and dynamics of the geosystems of the Teniz-Korgalzhyn basin based on the use of computer methods for thematic interpretation of satellite imagery materials.

The estimated parameters of terrestrial natural geosystems include the steepness of the slopes, the maximum collection area, the horizontal curvature, the maximum curvature, the illumination; for aquatic geosystems (river and lake) - the content of organic carbon, humidity, the reaction of the soil environment, hydrolytic acidity, saturation with bases, the content of mobile iron, particle size distribution; for anthropogenically transformed geosystems (arable land, fallow lands, downed pastures) - spectral brightness characteristics of vegetation, detected from multi-zone images, stocks of elevated phytomass, calculated through the NDVI index.

2. Materials and methods.

As a methodological basis, a geosystem approach has been adopted, which allows to establish the distribution of natural complexes of various ranks.

The riverbed and the adjacent territory, from which the channel collects surface and underground drains, in the landscape plan forms a complex natural system, which F N Milkov called the basin paragenetic system [4]. A characteristic feature is the orderliness of its constituent elements. This is especially well illustrated by the example of a water stream moving from the upper reaches to the mouth of the river, the direction of solid runoff, initially moving from the highest points of the watershed into the river valley, and then together with the channel flow to the mouth. Such a nature of the movement of matter gives the river basin a dynamic unity, both in terms of the longitude and transversion. This feature allowed to consider the river basin as a single erosion complex. The basin is an integral natural-economic geosystem, as it is an arena of interaction between nature and society, where natural, economic and socio-

demographic processes are interrelated, therefore, in solving the problems of territorial planning, it is rational to use the principles of the geosystem-basin concept. Integrating properties of water flow allow us to consider the basin as an integral systemic formation not only from the perspectives of hydrology, geomorphology, landscape geochemistry, but also as a geosystem from the standpoint of integrated physical geography. The main natural resources (mineral, water, land, biological) in the landscape are spatially associated in various combinations. This determines the need to search for optimal scenarios for environmental management that form the prospects for effective territorial development. The previous environmental paradigm often serves as an obstacle to the actual implementation of environmental protection measures in practice and needs to be transformed. In this regard, the majority of physicists and geographers (V. B. Sochava [5], V. N. Solntsev [6], V. S. Mikheev [7], K. M. Janaleeva [8], L. M. Korytny [9] and others) approve of the promise of a functionally holistic approach to the differentiation of the natural environment and the geosystem-basin approach as its leading component. The basin approach to the calculation and analysis of substance balances is in fact the basis of landscape geochemistry. Its founder, B. B. Polynov considered geochemical landscapes as areas of the earth's surface, dynamically connected by streams (primarily water). The predominant “closure” of the salt balance, as well as the balance of water and solid, within the river basin has been proven. Such an approach is of particular importance in the analysis of technogenic flows of matter - it is a question of geoecological research in the broad sense of the word. It is water bodies that usually become the final links of the “chain” of pollution: not only substances discharged directly into water bodies, but also those initially existing in the atmosphere, in the soil, and in solid waste fall here. In the geographic system, all components are equal and all relationships between them are to be studied. V.B. Sochavaya was the first to formulate the concept of geosystems as natural formations, to some extent altered by anthropogenic factors. The concept of "geosystem" covers the entire hierarchical series of natural geographic unities from a geographical envelope to its elementary structural units. Geosystem is the unity of the process and the result, the genesis and modern organization, functioning and structure, as well as the state at each point in time [10]. According to G.M. Dzhanaleyeva, geosystems of the river basin of intracontinental basins are paragenetic natural territorial complexes united by the unity of vertical and horizontal currents of matter and energy, formed under the conditions of one lithogenic basis and a single direction of geographic flow [8].

According to L M Korytnyi, almost all land is a collection of basins, which is the main rationale for the widespread use of the basin concept [9].

The basin approach, however, is considered not only from the point of view of geomorphology. Scientists who study the geochemistry of the landscape and operate the term “salt-collecting basin” are interested in river basins. The basin approach using the calculation and analysis of the balance state of matter underlies the geochemistry of the landscape. The founder is B B Polynov [10], who considered geochemical landscapes as areas of the earth's surface connected by geochemical flows. Of particular importance is this approach when analyzing man-made flows of matter in geo-environmental studies. Water bodies usually become the final links of the “chain” of pollution: substances that are discharged into water bodies but are found in the atmosphere, in soils, and in solid waste fall here. However, all representatives of different directions in the basin approach are united by the recognition of the river basin as a complete geosystem.

The geosystem-basin approach to the study of the differentiation of matter in the basins of surface runoff implies the interconnection and interdependence of substance migration in the adjacent geosystems. Plots of the same local microgeosystem turn out to be on different sides of the watersheds, which usually serve as a kind of geochemical screen for the obstruction of water, most airborne and mechanical migrants.

The concept of "geosystem" covers the entire hierarchical series of natural geographic unities from a geographical envelope to its elementary structural units. A geosystem is the unity of the process and result, the genesis and modern organization, functioning and structure, as well as the state at each moment in time.

A geosystem is a part of a territory characterized by a uniform relief, one type or subtype of soil, and a set of plant communities with a general species composition and productivity, a similar response to natural and anthropogenic influences, and resistance to them [11].

To determine the boundaries of geosystems and to study their dynamics, we used scenes of coatings with Landsat and Sentinel images. Pictures were selected summer, spring and autumn season with the lowest possible clouds. In a complex with images, large-scale topographic maps of the region were used (1: 500,000 - 1: 200,000). Meanwhile, there is a certain specificity of working with this data.

So, for example, Landsat TM images are presented in series of different years, from 1982 to 2018. But between them there is a certain difference in the structure of the data itself.

Landsat 5 has a channel structure - VIS (3), NIR (1), SWIR (2), TIR (1); Landsat 7 - panchromatic, multispectral: VIS (3), NIR (1), SWIR (2), TIR (1) with a plan resolution of 15 m for the panchromatic channel and 30 m for the multispectral zone; Landsat 8 - panchromatic, multispectral: VNIR (6), SWIR (2), TIR (2) with a resolution of 15 m for the panchromatic channel, 30 m for the near and middle zone of the spectrum and 100 m for the thermal zone.

To highlight the boundaries and classify the components of geosystems, all the original remote sensing data was converted into mosaic coatings developed in the ENVI 5.0 program with a spatial resolution of 30 m. (1982 - 2013).

For collecting and processing a modern data slice (2014-2018) in studies Remote sensing systems from Sentinel satellites of series 1, 2 were used.

The first Sentinel-1A radar satellite was first launched into orbit on April 3, 2014 by the European Space Agency (European Space Agency, ESA). He became the first in the satellite constellation of the global monitoring of the environment and safety Copernicus. Sentinel-1A is developed by Thales Alenia Space. It has C-SAR synthesized aperture radar equipment (developed by Astrium), which provides all-weather and round-the-clock delivery of satellite images.

Sentinel-2A, 2B satellites of the second series are equipped with an optical-electronic multispectral sensor for surveying with a resolution of 10 to 60 m in the visible, near-infrared (VNIR) and short-wave infrared (SWIR) zones of the spectrum, which guarantees the display of differences in vegetation, including number and temporary changes, and also minimizes the impact on the quality of shooting the atmosphere. In their class, their capabilities correspond to Landsat-7 and SPOT-5 images.

In the process of thematic processing of images, calculations of theindices were MNDWI and NDVIapplied with the construction of index maps for the entire territory of the TeBott-Korgalzhyn system. NDWI is an indicator of the moisture content of soil and leaves of plants [12]. To calculate the index, the spectral brightness values in the green (Green) and near-infrared (NIR) spectral ranges are used:

$$NDWI = (Green - NIR) / (Green + NIR),$$

where Green is the reflection in the green region, NIR is the reflection in the near infrared region of the spectrum.

NDVI (Normalized Difference Vegetation Index) is an indicator of photosynthetically active biomass on the Earth's surface. To calculate it, the spectral brightness values are used in the red and near infrared spectral regions:

$$NDVI = (NIR - Red) / (NIR + Red),$$

where NIR is the reflection in the near infrared region, Red is the reflection in the red region of the spectrum.

The calculations of the indices made it possible to obtain a series of derived images describing the degree of moisture content of geosystems as one of the agroclimatic indicators, and the intensity of vegetation as an indicator of the state (see Fig. 1, 2). A visual and representative analysis of the images allowed us to establish a general trend of the increasing influence of moisture, moreover, uneven, and with fluctuations in individual periods. For example, in 1992, there was an increase in moisture content not only in floodplain plains, but also in denudation plains with shrub-wormwood-grass vegetation, as well as in diluvial-proluvial plains with shrub-wormwood-tyrs vegetation on chestnut soils, in lakeside alluvial plains with hairy meadows of Azhreka, wormwood, and fescue-wormwood groups on saline and meadow saline lands with dark chestnut soils. After a few 20 years, there was a slight decrease in moisture content, which naturally affected the landscapes. So, for example, by 2018, we observe the concentration of

moisture mainly in floodplain and lake-alluvial plains with wormwood, feather-grass and meadows on dark-chestnut soils with saline soils (Fig. 3).

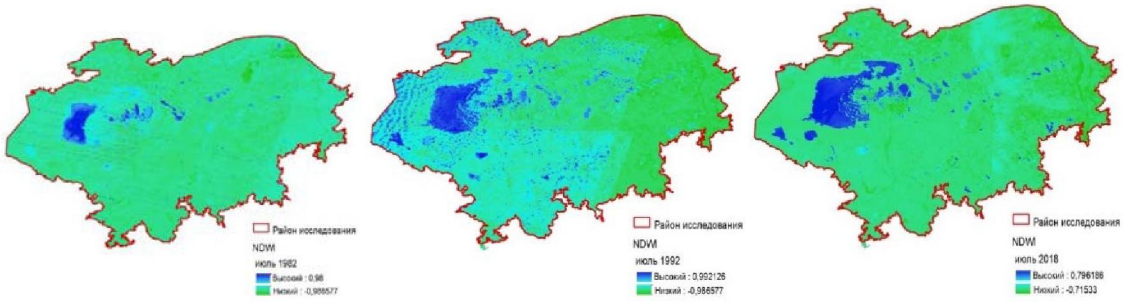

Figure 2 -Moisture content of vegetation, calculated fromvalues
NDWI: 1982, 1992, 2018

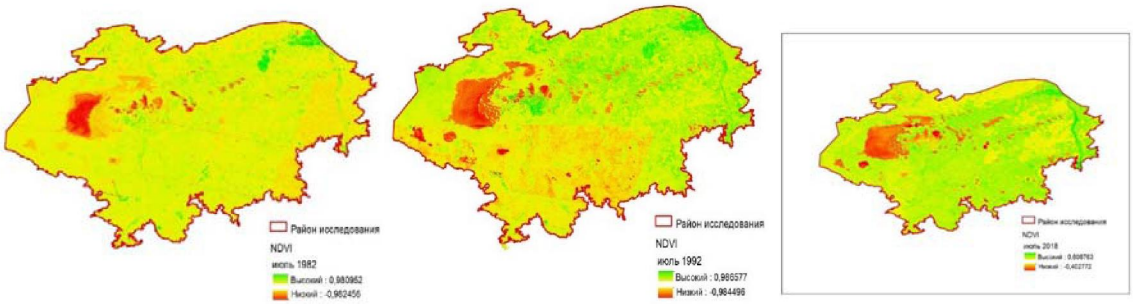

Figure 3 - Vegetation intensity dynamics of vegetation, calculated from NDVI values: 1982, 1992, 2018

The values of the NDVI index are quite strongly correlated with the distribution of NDWI, however there are some differences. The meridional zones of average degree of moisture (this can be seen in the eastern part of the territory) practically do not manifest themselves on NDVI maps. NDVI index values here are either average or higher. Hence, we can assume that the productivity of geosystems here depends not only on the nature of wetting, but also on other factors, such as anthropogenic influence, the growth of the natural / biological load on ecosystems, the change in the microclimate in a less favorable direction, etc.

3. Results

In the course of the research we obtained: a generalized map of geosystems of the Teniz-Korgalzhyn depression; Based on the digital terrain model SRTM, as well as on the basis of the interpretation and study of the space-time changes of the Teniz-Korgalzhyn lake-flow system, a new landscape map has been constructed.

In the classification of geosystems, three 3 orders were identified: 1) terrestrial natural, 2) terrestrial anthropogenically transformed and 3) aquatic.

Natural geosystems include areas in which the anthropogenic impact has not reached significant sizes and they are only slightly altered by human activity. At the same time, a part of terrestrial geosystems, which have lost their natural soil and vegetation cover, is considered as terrestrial anthropogenically transformed, or rather, natural-anthropogenic geosystems. To the aquatic geosystems we assign the geosystems of the water surfaces of numerous lakes and large rivers.

In the study of the Teniz-Korgalzhyn depression, two sub-systems are distinguished: the Middle-Nura sub-system and the Lower-Nura sub-system, whose development is timed to the Nura river flow within the basin, where space-time connections dominate from the source to the mouth.

Based on the SRTM survey materials, a digital model of the territory was created, which made it possible to isolate the prevailing types of landscapes in a complex with soil conditions, vegetation and geological and geomorphological conditions, assess their condition and degree of resistance to anthropogenic impact.

So the prevailing landscapes are the denudation plains with a shrub and wormwood vegetation with the participation of dark-chestnut soils, etc. The main forms of relief include flat and low-slope, flat geosystems dominate in the territory, but are also characterized by low-altitude Geosystems and sand massifs.

In general, it is fair to say that the patterns of distribution of geosystems of a region are mainly determined by interrelated factors: climatic conditions and the geological and geomorphological structure of the territory. It is the ratio of these factors that causes a significant variety and contrast of habitats. However, as follows from the analysis of different-time shots, while maintaining all the prevailing landforms and its morphometric properties, over the past few decades, other factors have changed significantly - climate, soil, increased anthropogenic influence.

4. Discussion

Based on the integration of classical geographic research methods with remote sensing methods and the GIS tool base, new data were obtained on the state, structure and dynamics of the functioning of the Middle-Nurinsk and Nizhne-Nurinsk sub-systems of the Teniz-Korgalzhyn depression.

A 1: 200 000 scale soil map was updated for the study area, and a new geosystem map at 1: 200 000 and 1: 500 000 scales was compiled in ArcGIS. The structure of the legend on the presented maps is based on the classification divisions of geosystems of various ranks. So, on the basis of the geosystem map, many aspects of differentiation and areal relationships between various sub-systems are identified. Thus, the detailed geosystem structure of the region is determined. It is worth noting the important role of information obtained from the interpretation of multi-zone satellite imagery in the form of structural components of the natural environment, classified and recognized in images of different spatial and radiometric resolution.

In addition to the distinguished structure of geosystems, indicator indicators, the so-called soil-vegetation indices (NDWI, MNDWI, NDVI), are the basis for calculating productivity. Many side factors affect their numerical values - species composition of vegetation, closeness, condition, slope exposure and surface tilt angles, soil color under sparse vegetation, etc. For example, according to Rouse et al., 1973 and Kriegler et al., 1969 If the density of vegetation cover is more than 70%, the index is moderately sensitive to changes in the soil background [13,14]. To avoid such situations, which weaken the reliability and information capabilities of remote sensing data, remote surveys are best carried out along selected key areas and routes that best cover the diversity of the study area.

5. Conclusion

Conducted studies have shown the feasibility of using, along with the classical methods of physical-geographical research, innovative methods of remote examination of the state of the environment using GIS tools and computer-aided interpretation algorithms.

The established spatial-temporal changes in the state and structure of the geosystems of the Teniz-Korgalzhyn depression make it possible to single out the following as key factors: climatic conditions, geological and geomorphological structure, and anthropogenic influence. The latter has a direct impact on the anthropogenic transformation of geosystems, which is confirmed by a decrease in the productivity of landscapes in the floodplain part and the most densely populated areas. At the same time, it is fair to say that this does not fit into the dynamics of the dynamics. For example, a time analysis of July images from 1982 to 2018 shows a whole inverse pattern — that is, increase in vegetative activity. Perhaps this is a consequence of the improvement of the microclimate of the territory as a whole, although it does not exclude the increased anthropogenic influence in local foci. The presented methodology can be recommended for mapping and monitoring land use, monitoring changes in vegetation, water resources.

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ПРОСТРАНСТВЕННО-ВРЕМЕННОЙ АНАЛИЗ ГЕОСИСТЕМ ТЕНИЗ-КОРГАЛЖЫНСКОЙ ВПАДИНЫ НА ОСНОВЕ ДАННЫХ, РАСШИФРОВАННЫЙ ПО СНИМКАМ LANDSAT И SENTINELSATELL

Аннотация. Были проведены исследования геосистем Тениз-Коргалжынской впадины. Пространственно-временные закономерности структуры, функционирования и динамики развития ландшафтных компонентов исследуемой территории определяются на основе компьютерного декодирования многозонных космических снимков.

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LANDSAT ЖӘНЕ SENTINELSATELL КЕСКІНДЕРІНЕН АЛЫНҒАН МӘЛІМЕТТЕР НЕГІЗІНДЕ ТЕҢІЗ-ҚОРҒАЛЖЫН ОЙСЫНЫҢ ГЕОЖҮЙЕЛЕРІН КЕҢІСТІК-УАҚЫТТЫҚ ТАЛДАУ

Аннотация. Реферат Зерттеу жұмыстары Теңіз-Қорғалжын депрессиясының геожүйелерінде жүргізілді. Зерттелетін аймақтың ландшафт компоненттерінің құрылымының, жұмысының және даму динамикасының кеңістіктік-уақыттық заңдылықтары көп аймақтық спутниктік суреттерді компьютерлік декодтау негізінде анықталған.

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