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ANALYSIS OF THE STATE OF PLANT COVER OF THE BEREZOVKA RIVER BASIN OF THE WEST-KAZAKHSTAN REGION BASED ON NDVI

In the conditions of intensive development of natural complexes, the basins of small rivers undergo irrevocable changes, since they are particularly vulnerable geosystems due to their small morphometric characteristics. At the same time, being small geosystems, they are the most important links in the circulation flows of substances and energy. One of these small rivers is the Berezovka River in the Burlinsky District of the West Kazakhstan Oblast.

This article presents the results of studies vegetation cover dynamics of steppe landscapes in the Berezovka River basin for the period from 1985 to 2019, which has undergone significant changes for decades as a result of anthropogenic and technological impacts. The development of the Karachaganak Oil and Gas Condensate Field had a significant impact on the agricultural landscapes of this territory.

As the resultant parameter, the NDVI vegetation index was used as one of the ecological and climatic indicators, which was determined based on geoinformation processing of satellite images of the area under study. The scientific and practical significance of this study is determined by the fact that the analysis of changes in vegetation cover in different periods was carried out, which allows us to trace certain dynamics.

In the course of the studies of the vegetation cover of the territory, it was revealed that significant areas were still in critical condition, despite a slight increase in NDVI indicators due to the natural increase in steppe landscapes. The research results are confirmed by the cartographic material compiled from satellite images.

Key words: West Kazakhstan region, the Berezovka River basin, the NDVI, steppe landscapes, Karachaganak Oil and Gas Condensate Field

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Батыс Қазақстан облысының Березовка өзені алабындағы өсімдік жамылғысының жағдайын NDVI негізінде талдау

Табиғи кешендерді қарқынды игеру жағдайында кіші өзендер алаптарының қайтымсыз өзгерістерге ұшырауы байқалады, себебі олар өзінің шағын морфометриялық сипаттамалары салдарынан өте осал геожүйе болып келеді. Сонымен қатар шағын геожүйе бола отырып, зат пен энергия алмасудағы маңызды буыны ретіндегі қызметін атқарады. Осындай кіші өзендердің бірі – Батыс Қазақстан облысының Бөрлі ауданындағы Березовка өзені.

Ұсынылған мақалада ондаған жылдар бойы антропогендік-техногендік әсерлердің нәтижесінде маңызды өзгерістерге ұшыраған Березовка өзені алабындағы дала ландшафттарының өсімдік жамылғысы жағдайының 1985-2019 жылдар аралығындағы динамикасын зерттеу нәтижелері көрсетілген. Аталған аймақтың агроландшафттарына Қарашығанақ мұнай-газ кен орнын игеру жұмыстары да елеулі әсер етуде.

Нәтижелік көрсеткіш ретінде NDVI вегетациялық индексі қолданылды, бұл – зерттелген аймақтың ғарыштық түсірімдерінің геоақпараттық өңдеу негізінде анықталатын экологиялық-климаттық индикациялық көрсеткіштерінің бірі. Осы зерттеудің ғылыми және тәжірибелік маңыздылығы өсімдік жамылғысы жағдайының әртүрлі кезеңдердегі белгілі бір динамикасын анықтауға мүмкіндік беретін өзгерістерді талдауда байқалады.

Аймақтың өсімдік жамылғысын зерттеу барысында дала ландшафттарының табиғи өсімі арқасында NDVI көрсеткіштерінің біршама жоғарылауына қарамастан, жерлердің көбі әлі де сыни жағдайда екені анықталды. Зерттеу нәтижелері жерсеріктік түсірім бойынша жасалған картографиялық мәліметтермен расталады.

Түйін сөздер: Батыс Қазақстан облысы, Березовка өзенінің алабы, NDVI, дала ландшафттары, Қарашығанақ мұнай-газ кен орны.

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Анализ состояния растительного покрова бассейна реки Березовка Западно-Казахстанской области на основе NDVI

В условиях интенсивного освоения природных комплексов безвозвратные изменения претерпевают бассейны малых рек, так как они являются особо уязвимыми геосистемами в силу своих малых морфометрических характеристик. При этом, будучи малыми геосистемами, они выступают важнейшими звеньями циркуляционных потоков веществ и энергии. Одной из таких малых рек является река Березовка в Бурлинском районе Западно-Казахстанской области.

В данной статье приведены результаты исследований динамики состояния растительного покрова степных ландшафтов в бассейне реки Березовка за период 1985-2019 гг., который на протяжении десятилетий претерпевает существенные изменения в результате антропогенно-техногенного воздействия. Существенное воздействие на агроландшафты данной территории оказало освоение Карачаганакского нефтегазоконденсатного месторождения.

В качестве результирующего параметра применялся NDVI как один из эколого-климатических индикационных показателей, который определялся на основе геоинформационной обработки космических снимков исследуемой территории. Научная и практическая значимость данного исследования определяется тем, что был проведен анализ изменения растительного покрова в различные периоды времени, что позволяет проследить определенную динамику.

В ходе исследований растительного покрова территории было выявлено, что значительные территории все еще находятся в критическом состоянии, несмотря на некоторое увеличение NDVI за счет естественного прироста степных ландшафтов. Результаты исследований подтверждаются картографическим материалом, составленным по спутниковым снимкам.

Ключевые слова: Западно-Казахстанская область, бассейн реки Березовка, NDVI, степные ландшафты, Карачаганакское нефтегазоконденсатное месторождение.

Introduction

During the period of intensive development of advanced technologies and remote sensing of the Earth, various indicators and parameters obtained during the processing of satellite images have widely been used.

The currently available field data are generally difficult to use to predict regional or global changes, since such data are traditionally collected at small spatial and time scales and vary in type and reliability. Satellite images and indicators that can be obtained by their computer processing have become a potential “gold mine” for scientists in this sense (Pettorelli, 2005).

This particular circumstance is of particular relevance for the territory of Kazakhstan, stretching from west to east for 3,000 km, and conducting regular detailed field studies in these conditions is very difficult.

Among the indicators that are relevant and useful for maintaining and increasing agricultural productivity, also for monitoring the current state and forecasting natural landscapes, the index of the vegetation cover – NDVI is widely used. The concept of applying this indicator was first introduced by the American scientist F. Kriegler in 1969 (Kriegler, 1969), and J. Rouse in 1973 (Rouse, 1974); new possibilities for using vegetation indices were presented in the works of A.Cherepanov, E. Druzhinina, E. Sutyrina et al. (Cherepanov, 2011; Sutyrina, 2013).

Object of the study

The target of regional mapping and analysis of the state of vegetation cover is the West Kazakhstan region, in particular, the basin of one small rivers, and the subject of study is to analyze the index of vegetation cover of the steppe landscapes of the Berezovka River basin.

The Berezovka River is located on the right bank of the Ural River in the northeastern part of the West Kazakhstan region (figure 1).

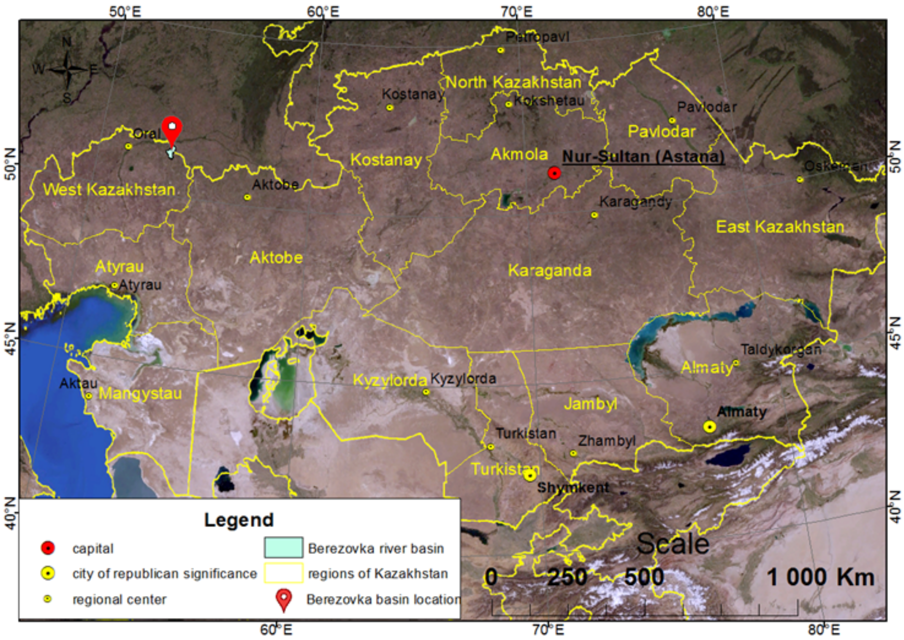

Figure 1 – Geographical location of the Berezovka River basin (West Kazakhstan region, Republic of Kazakhstan)

The river originates from the slopes of the Ural-Ilek (Podural) plateau, flowing from south to north, on the border area near the village of Zharsuat, it flows into the waters of the Ilek River (into the Maly Ilek channel), which finally flows into the largest river Ural. In water-short years, runoff is unstable. The upper reaches of the river in summer are prone to drying out. The length of the river is about 46 km. The area of the Berezovka River basin is about 580 km^2. Thus, according to hydrometric parameters, the Berezovka River belongs to the category of small rivers.

The territory is located southwest of the Podural plateau on a strongly and moderately dissected hilly-steppe plain, cut by watercourses unloading into the river Ural basin (Production project, 2016). The absolute heights of the river basin territory range from 50-100 m in the northern half to 120-220 m in the southern half, having a slightly undulating plain relief with lowering from south to north (figure 2). The geomorphological structure is presented in Figure 3.

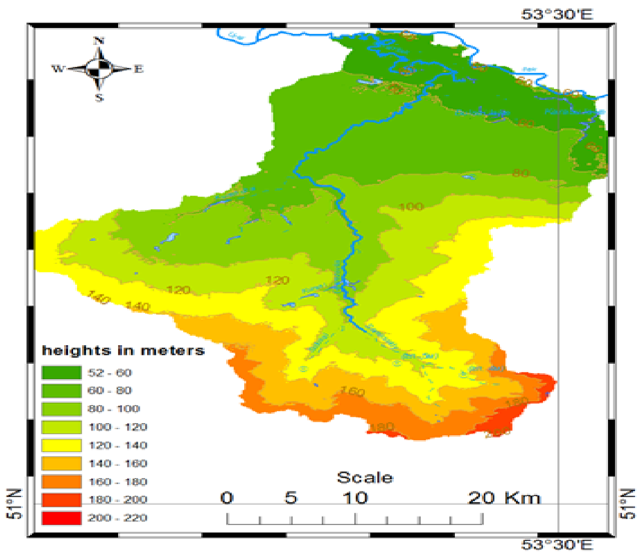

Figure 2 – Map of the distribution of absolute heights in the Berezovka River basin

Deluvial slopes are indented by cloughs and ravines. The width of the ravine is from several meters to 0.3-0.5 km. Ravines of various shapes and configurations, ravines with symmetrical sodded slopes prevail. In ravines with asymmetric slopes, erosion processes are noticeably activated. The depth of the ravines is from 1 to 5-7 or more meters.

The river basin is located in the depths of the temperate climate zone. The average monthly temperature of the hottest month (July) is 23.5 °C; the average maximum temperature of the hottest month is 29.6°C. The average monthly temperature of the coldest month (January) is minus 11.7°C.

The study area belongs to areas of insufficient moisture, characterized by a small amount of precipitation (250-300 mm) and large amounts of evaporation.

One of the characteristic features of the thermal regime of the territory is a sharp increase in temperature during the transition from winter to spring and from spring to summer. Taking into account the significant freezing of soils in winter (100-150 cm), such a rapid increase in temperature during snowmelt is accompanied by redistribution and runoff of meltwater into negative relief elements, causing the development of water erosion processes and causing heterogeneity of the soil cover structure with a wide development of soil combinations (complexes, combinations, patchiness) associated with various meso – and micro-relief bedding of soils.

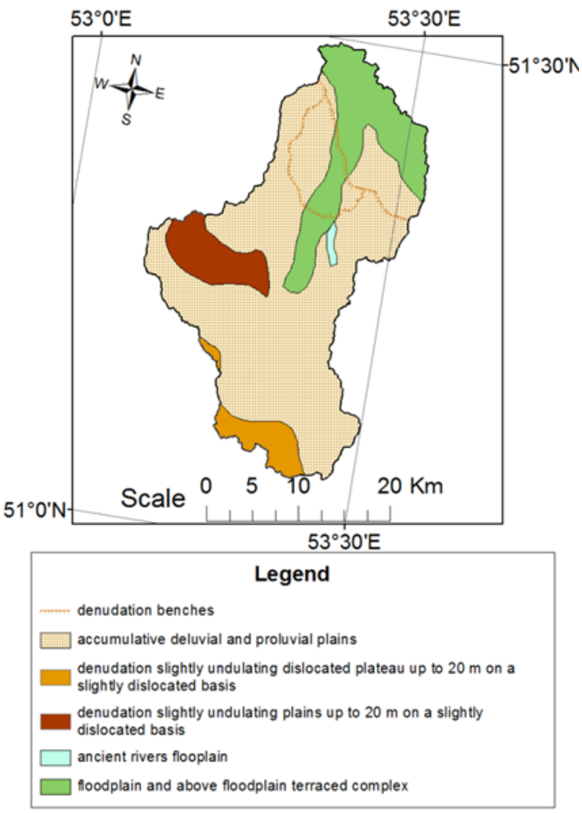

Figure 3 – Geomorphological structure of the Berezovka River basin

According to the agro-climatic zoning, the basin territory is located in a slightly arid warm zone with a humidification coefficient in the range of 0.6-0.8 and the sum of active air temperatures above 10 °C in the range of 2900-3100 °C (Baisholanov, 2017: 44).

The sharp aridity of the climate does not contribute to the development of a dense network of rivers in this territory. According to the water regime, the rivers are of the Kazakhstan type with a marked predominance of runoff in the spring. Their nourishment is mainly due to melting snow water (Production project, 2016).

The hydrographic network of the territory is formed by the Berezovka River, which dries up in summer, and its tributaries. In the spring, the rivers form large floods due to the influx of melt water. The tributaries of the Berezovka River mostly dry up in the summer (figure 4), on the site of which dry channels are formed, the main of them are Sulusay, Sarak-Saldy, Konshubay clough, and Kalminkov clough.

Figure 4 – Upper reaches of the Berezovka River

In the system of soil geographical zoning, the subzone of dry steppes in the area of distribution of dark chestnut soils, which occupy the largest territory within the study territory. The soil cover of the watershed surfaces is represented mainly by dark chestnut normal soils. In conditions of a more segmented relief, chalk deposits lie close to the surface, and dark chestnut carbonate soils prevail here. On the slopes of ridges, on the sides of river valleys, ravines, and cloughs, dark chestnut eroded soils are widespread. On lowering under conditions of additional moistening (the bottoms of cloughs, ravines, and above floodplain terraces), there are meadow-chestnut normal and solonetzic soils and their complexes with solonetzes, as well as meadow soils. The soil cover of the lowest level of river valleys flooded during floods is represented by floodplain meadow and forest-meadow soils which are formed on layered alluvial deposits (Production project, 2016).

Dark chestnut normal and carbonate soils, being the predominant component of the soil cover of the territory, are good arable land used in agriculture without radical improvements and irrigation. As a result of this, almost all of them are plowed up (at present, deposits of different ages), and areas with natural soil and vegetation cover are confined to lands that are unsuitable for agricultural use from one or another point of view (ravines, areas with close bedding or exposure of bedrocks, with wide development in the soil cover of solonetzic soils, etc.). Soils located in arable land are subject to erosion and require erosion protection.

The vegetation cover is represented mainly by the Eurasian steppe, feather grass, and fescue associations with the participation of feather, grass and fescue, wormwood, and a small number of forbs (Figure 5).

Figure 5 – Forbs and shrubs of the Berezovka River basin

The prevailing one is the steppe type of vegetation dominated by sod grasses (*Stipa, Festuca, Koeleria, Agropyron*) and to a lesser extent sod sedges (*Carex*). Widely represented steppe forbs, which include rhizomatous Veronica (*Veronica*), bedstraw (*Galium*); taproot pink (*Dianthus*), blue cornflower (*Centaurea*); subshrubs (Lerch wormwood – *Artemisia lercheana*), steppe shrubs meadowsweet (*Spiraea*), and pea shrub (*Caragana*).

Plant growth begins from the date of the steady transition of the daily air temperature above its biological minimum temperature. For most plants and crops, this limit is 5 °C (early spring crops), for late spring crops – 10 °C, and thermophyte crops – 15 °C. The duration of the vegetation period of vegetation cover in the Berezovka River basin; in the northern half 155-160 days, and the southern half 160-165 days. The moisture supply of the vegetation period is characterized by an insufficient value of the coefficient of moisture in 0.6-0.69. The aridity of the vegetation period is estimated as a semidry period with hydrothermal coefficient values from 0.5-0.59 in the north to 0.4-0.49 in the south. The bioclimatic potential is 30-35 c/ha (Baisholanov, 2017: 74).

The landscapes of the Berezovka River basin are the landscapes of accumulative plains of the dry-steppe zone. A more detailed classification of the landscapes of this territory is given in the study of Ramazanova N. (Ramazanova, 2019), according to which the northern part of the territory belongs to floodplain landscapes composed of loams, sand, gravel and pebbles, with mixed grass meadows and aspen forests on meadow soils. The central part of the Berezovka River basin is represented by landscapes on a poorly segmented accumulative-alluvial plain, composed of loams, sandy loam, sands with white wormwood-oatmeal and wheatgrass vegetation on chestnut soils with meadow solonetzes. In the southern part, there are landscapes of denudation strongly segmented plains composed of clay, loess loam with oatmeal grass vegetation on dark chestnut normal soils. Small woodlands are available in the floodplains of the river Ilek.

The study area belongs to the North Eurasian semi-arid grain zone and is ecotonal, which indicates the special vulnerability of the territory due to anthropogenic disturbances and climate change (Wright, 2012).

Based on the above, the landscapes can be classified as unstable. In this case, any impact on the formation of soil cover leads to the processes of degradation and desertification of the territory.

Materials and methods

As it is known, NDVI (Normalized Difference Vegetation Index) is a normalized differential vegetation index, usually called the vegetation index, which is a parameter of the amount of phytosynthetic active vegetation biomass. NDVI can show a significant correlation with some parameters of a completely different area, productivity (temporary changes), biomass, moisture, and mineral (organic) soil saturation, evaporation (evapotranspiration), the amount of precipitation, the thickness and characteristics of the snow cover. There is a correlation between the NDVI indicator and productivity for different types of ecosystems (Figure 6) (gis-lab.info).

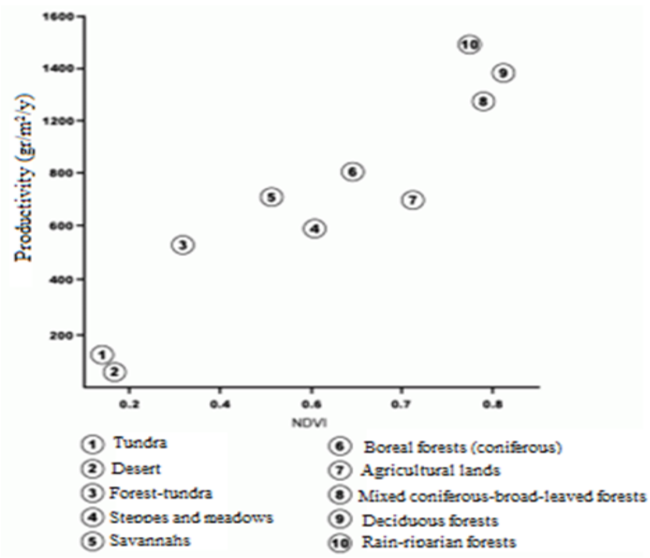

Figure 6 – Sustainable correlation of NDVI indicators and ecosystem, productivity

Due to the peculiarities of reflection in the NIR-RED spectral areas, nature objects not related to vegetation have a fixed NDVI value, which allows using this parameter for their identification (Bratkov, 2017).

This characteristic is quite actively used for regional mapping and analysis of various types of landscapes, and for assessing the resources and areas of biosystems at the scale of countries and continents (gis-lab.info). Also, satellite images and parameters obtained from their composite lines, such as the NDVI and Geographic Information Systems, are widely used in studies of soil erosion (Barmaki, 2012).

Besides, NDVI can be used not only to accurately describe the nature of the underlying surface, but also to monitor precipitation and drought, growth and yield conditions, and to identify weather effects and other important characteristics for agriculture, ecology, and economics (Acharya, 2019).

Vegetation indices (NDVI) of the study area were obtained by processing satellite images using the Raster Calculator utility in the Map Algebra kit of ArcGIS software. Multispectral satellite imagery from Landsat 4-5 satellites (images for 1985 and 2009) and Landsat 8 (Figure 7) from the US Geological Survey as of early June 2019 (earthexplorer.usgs.gov) served as the initial data.

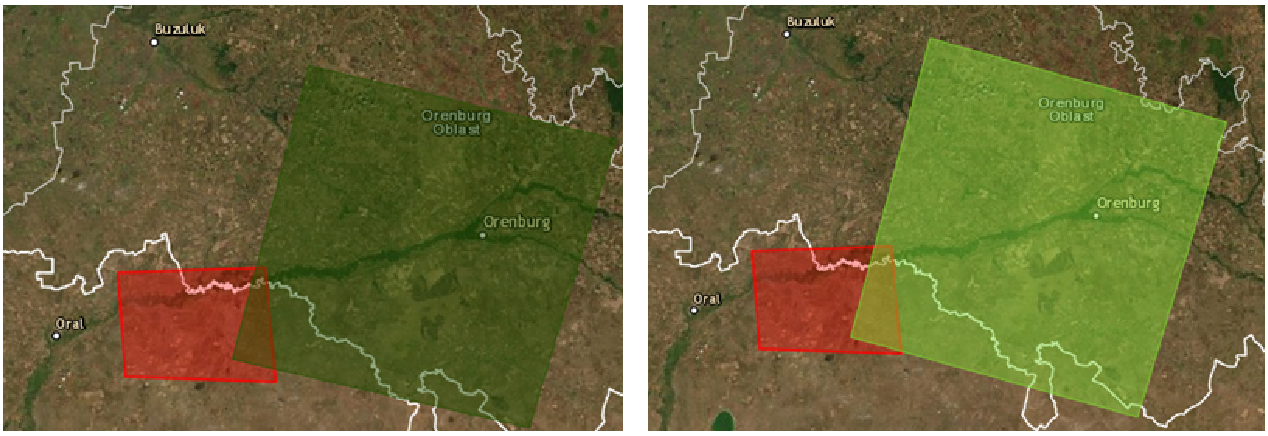

Figure 7 – Coverage of the study area with Landsat 4-5 (2009) and Landsat 8 (2019) satellite images

The data obtained from Landsat satellites are used to solve a large number of subject problems, including, for example, measuring the extent and classification of vegetation cover, determining the state of crops, geological mapping, and monitoring soil erosion in the coastal zone, etc. (Sutyrina, 2013: 58)

Results and discussion

Analysis of NDVI indicators of vegetation cover in the Berezovka River basin territory

To analyze the vegetation index of the vegetation of the study area, satellite images as of the beginning of June 1985, 2009, and 2019 were taken, taking into account significant changes in the scale of economic development of the territory, radical changes in the management and organization of agricultural sectors, as well as the quality and processing capabilities of images at the indicated time.

The spatial distribution of the vegetation index in the territory of the Berezovka River basin in 1985, 2009, and 2019 is presented in Figures 8-10.

On the NDVI distribution map, as was the case at the beginning of June 1985, very low indicators of the vegetation index are observed, which indicates the lamentable state of the land. 95% of the territory is occupied by areas with values from minus 0.22 to 0.23, which are typical for desert territories. It may be said that the critical state of agricultural land was the result of the widespread extensive development of virgin and fallow lands, which began in the 50s of the twentieth century.

The distribution map of the above index,as it was the case at the beginning of June 2009, illustrates the decrease in the proportion of sectors with minimal values, which, in our opinion, is explained by the processes of natural restoration of landscapes as a result of the decline of agriculture and the country’s economy as a whole after the collapse of the USSR. And although the republic’s agriculture was restored in 2009, during the years of independence of Kazakhstan, it was still not on the scale and volume that was observed during the existence of the USSR.

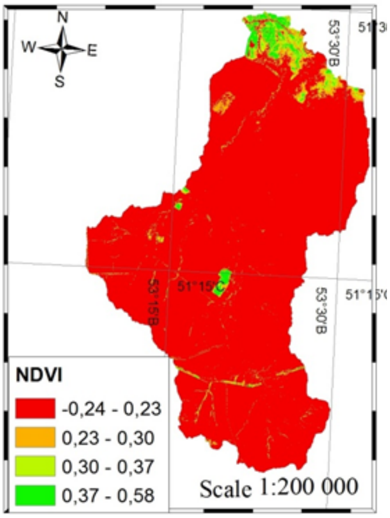

Figure 8 – Territorial distribution of NDVI indicators of the steppe landscapes of the Berezovka River basin of West Kazakhstan region (as at the beginning of June 1985)

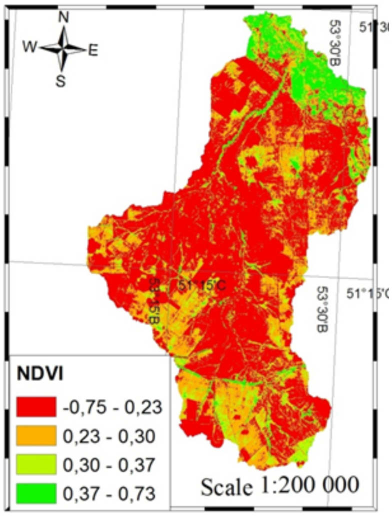

Figure 9 – Territorial distribution of NDVI indicators of the steppe landscapes of the Berezovka River basin of West Kazakhstan region (as at the beginning of June 2009)

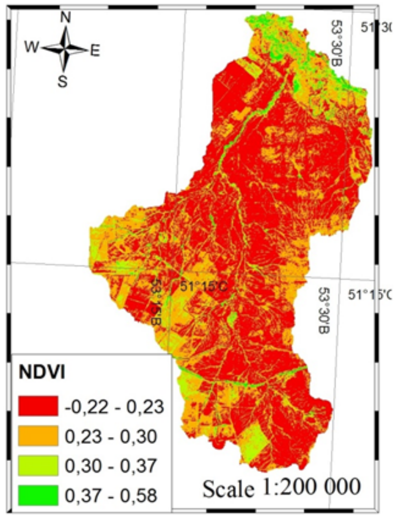

Figure 10 – Territorial distribution of NDVI indicators of the steppe landscapes of the Berezovka River basin of West Kazakhstan region (as at the beginning of June 2019)

According to the map data for 2019, we see that a significant proportion of the study area is also characterized by low NDVI values (from -0.23 to 0.22), which according to the discrete NDVI scale, indicates that these areas are occupied by open spaces with no or insignificant interspersed vegetation.

Thus, one of the anthropogenic factors was the consequences of the development of virgin and fallow lands in the 1950s, which was also confirmed by American studies conducted from 2001 to 2008, according to which the NDVI trends in the study area were also negative, although by some accounts, as a result of the decline in the agricultural sector of the economy, the Northern Eurasian grain zone has been in a recovery phase since 1999 (Wright, 2012).

One of the modern factors of anthropogenic impact, in our opinion, is the increase in hydrocarbon production in the West Kazakhstan region at the Karachaganak oil and gas condensate field (KOGCF), as well as the construction of major pipelines, including transcontinental ones, that significantly increase the environmental hazard associated with the oil and gas industry.

According to the observations in field studies of the Berezovka River basin, it was noted that active construction work of facilities for oil and gas production was underway, which was accompanied by deep construction and excavation work through the use of heavy technical equipment. The vegetation of the territory is sparse, traces of burning are traced, and many areas formerly occupied by arable land are now abandoned or seeded with perennial crops.

One of the grave consequences was the complete resettlement of residents of the village of Berezovka in the vicinity of the city of Aksai, with the complete liquidation of the village due to the detrimental effect of oil and gas on the KOGCF on the life and health of the rural population. The field is one of the largest gas condensate fields in the world and belongs to the first hazard class since the produced gas has a high content of hydrogen sulfide. In November 2014, in Berezovka, where over 1.5 thousand people lived, there was a massive poisoning with unknown gas from the Karachagan field, located 5 km away from the village (aksay.kz).

The decision to relocate the villages of Berezovka and Bestau is associated with the completion of the economic and technical assessment of the prospects for the Karachaganak project, which implies an increase in the sanitary protection zone (SPZ). These two villages fall into the new SPZ, therefore, the full resettlement of their inhabitants was recognized as the best option (inbusiness.kz).

Also, the degradation and desertification processes of the Berezovka River basin can be noted when comparing the map data and the graph of the correlation dependence of NDVI and the productivity of various ecosystems (Figure 4). The average value of the vegetation index is estimated at 0.24 units, whereas, according to the correlation graph, this value corresponds to the values of the desert and semi-desert zones. The steppe zone is characterized by an average NDVI of 0.4 units.

According to the degree of degradation, depending on the vegetation index, the territory can be classified as follows:

– NDVI>0,37 – relatively normal state of landscapes

– 0,3<NDVI<0,37 – landscapes are at some risk

– 0,23<NDVI<0,3 – landscapes are in critical condition

– NDVI<0,23 – landscapes are in a disastrous situation

According to this gradation and the results of the geoinformation analysis of map data (Figure 8), it was found that about half (49%) of the basin territory had indicators below 0.23, that is, they were in a disastrous situation, 34% of the territory was in critical condition, i.e. 83% of the landscapes of the basin underwent significant changes (Figure 11). This means that the desertification process progresses intensively due to the anthropogenic impact. Former fertile geosystems may lose the ability to self-repair and permanently be out of agricultural circulation.

The development of the oil and gas complex is a powerful source of negative impact on various components of natural systems. Continuous oil and gas production leads to significant changes in natural aquatic ecosystems and soil cover. The main environmental problems of the soil include heavy metal pollution, emissions of radionuclides, etc. (Akhmedenov, 2014)

According to the regionalization of the territory of the Republic of Kazakhstan in terms of atmospheric pollution potential, the considered region belongs to the 3rd zone of air pollution potential, that is, to the zone of increased air pollution potential. It is characterized by high natural dust content, low leaching ability of precipitation, and powerful industrial development of the region.

A relatively high indicator of the density of emissions of harmful compounds into the air basin is typical to the Burlinsky district, where oil and gas enterprises and other industrial facilities are concentrated. The main pollutants of the air basin of the region are oil and gas companies, boiler houses, motor vehicles, and elevators that emit harmful substances into the atmosphere, the volume of which from stationary sources in the region in 2013 amounted to 60.4 thousand tons. The air is most polluted with carbon monoxide. In 2015, eight excesses of MPC for nitrogen dioxide (NO_2) were registered in four settlements (Production project, 2016).

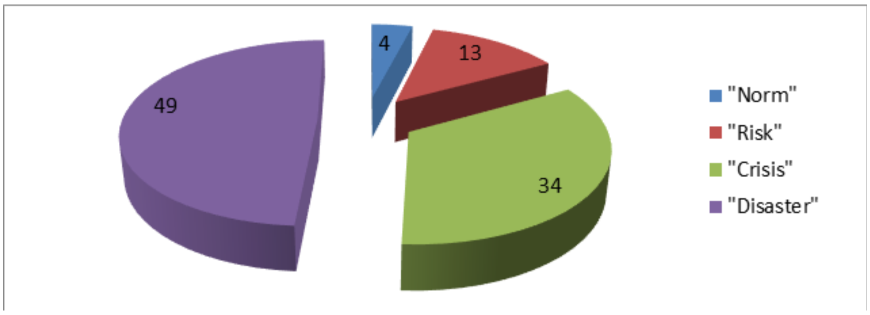

Figure 11 – Weight fractions of the steppe landscapes of the Berezovka River basin according to the degree of degradation, %

According to estimates of the impact on the natural environment of the Karachaganak deposit, regarding the time frame, the impact on the land and vegetation cover will be long-term. By their nature, the most negative effect among the "solid and liquid wastes" components is exerted by mineral salts and alkaline solutions (reagents), which inhibit plant growth and lead to soil salinization (Almagambetova, 2011).

Anthropogenic transformations of the earth's surface of this territory are exacerbated by the formation of karst-suffosion relief forms. In June 2012, were discovered 3 karst formations near the village of Berezovka and a field of such holes near the village of Zhanatalap. These places are directly adjacent to the territory of the Karachaganak field. According to one version, the reason is the dynamics of the groundwater level caused by the rise in the water level in the reservoir on the Berezovka River. Moreover, the formation of craters near Berezovka and the village of Zhanatalap can be associated with the unloading of saline horizons and the displacement of limestone by eluvium caused by erosion and denudation processes (Akhmedenov, 2014).

Natural erosion activity is poorly expressed, but recently, in connection with the intensive industrial and economic development of the region, the banks of the river are destroying the construction of coffer dams (washed off in floods), dams and pipelines; the floodplain is covered by a network of country roads (Production project, 2016).

The main shifts in land use are also expressed in the fact that the area under arable land and shrubbery has diminished, and the area occupied by settlements and industrial and infrastructure facilities, inland water bodies, and recreational facilities has increased dramatically (Ramazanova, 2012).

Study results

1. To comprehensively investigate the physical and geographical conditions for the formation of the vegetation cover, the geological and geomorphological, natural and climatic features of the study area were studied; a map of the Berezovka River basin, hypsometric, and geomorphological maps were compiled. By its natural and climatic conditions, the territory of the Berezovka River basin belongs to small river basins, which are characterized by a weakly wavy accumulative and denudation relief with a marked ravine-clough system, formed in conditions of continental climate with arid hot summers and frosty winters, and insufficient moisture. The landscape structure is represented by dry-steppe landscapes on dark chestnut and chestnut soils of mainly loamy and heavy loamy mechanical composition, on which forbs-grassy plant associations grow.

2. During the study, we obtained data on the spatial distribution of NDVI indicators, which reflected the current state of the vegetation cover for 1985, 2009, and 2019. The indicators of the vegetation index from 1985 to 2019 tended to increase as a result of the economic recession in the post-Soviet period and the natural restoration of landscapes. Therefore, territories with negative NDVI values in 1985 occupied more area than in subsequent years.

3. When comparing data for the indicated time periods, it can be stated that despite the fact that a natural recovery of the geosystems of the Berezovka River basin is traced, significant territories (83%) are still in distress; that is, NDVI indicators are less than 0.23, which correspond to the desert parameters. This indicates a slower rate of landscape restoration and still low biomass productivity.

4. The process of the natural restoration of the landscapes of the study area may be disrupted as a result of the expansion of mining and construction and excavation works related to the further development of the Karachaganak field. In this context, not only environmental changes are obvious, but also the deterioration of the health of the local population is an issue here and as a result, measures have been taken on liquidation of the villages of Berezovka and Bestau and resettlement of residents in nearby settlements.

Conclusion

Thus, based on the geoinformation analysis of the NDVI, it was found that a significant part of the steppe landscape in the Berezovka River basin was characterized by low NDVI indicators (in 2019, an average of 0.24 was typical for desert landscapes), due, in our opinion, to the consequences of extensive development of virgin and fallow lands in the Soviet period, as well as an increase in hydrocarbon production at the KOGCF, and can be withdrawn from agricultural circulation due to uselessness.

Areas with sparse vegetation (NDVI for 2019 – from 0.22 to 0.37) occupy a small part of the total basin area and are distributed mainly on the outskirts of the study area. Relatively dense vegetation cover with shrubs and forest cover (NDVI from 0.37 to 0.59) occupies very insignificant parts and stretches along the floodplain of the Ilek and Berezovka Rivers, as well as along both sides of a motorway running along the southern end of the basin as in the form of artificial plantings.

In general, there is a decrease in the vegetation index from south to north with a sharp increase in the floodplain of the Ilek River. According to the laws of latitudinal zoning on a flat territory, this indicator should increase from south to north, which indicates a disturbance of natural processes under the influence of anthropogenic factors.

The existing processes of landscape degradation in the Berezovka River basin are complicated by the fact that the river belongs to small rivers, which are known to have an increased degree of vulnerability and a low degree of resistance to anthropogenic influences, which can eventually become irreversible. The small size of the river forms a specific hydrological regime, which differs from the regimes of large and medium rivers with a very high sensitivity to natural, climatic and anthropogenic changes in the basin. Small plain rivers, due to their low water content and little slope, cannot tolerate a large amount of washed alluvium. And because of the upper layers of the soil cover in the river basin have been excavated, all loose material with temporary water courses can be transported and accumulated in the river bed, which will directly lead to its shallowing. This particular circumstance is also observed in changes of water consumption in the Berezovka River, which, as water is taken and the climate dries up, becomes shallow year after year. In the territory of the river basin, especially near the territory of the Karachaganak field, cases of soil gaps have become more frequent, which is associated with a change in the level of groundwater and the unloading of saline horizons.

The numerous cases of natural gas poisoning of residents of the villages of Berezovka and Bestau are also clear evidence of the detrimental effects of the oil and gas industry.

In this regard, special attention is required to the administrative decisions on land use, which can influence the trends of NDVI as a tool for regional and local environmental monitoring in an area where comprehensive environmental data are occasional. Under these conditions, the remote sensing approach using the vegetation index can serve as one of the tools for further regional environmental studies.

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