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Қ. И. Сәтпаев атындағы Қазақ ұлттық техникалық зерттеу университеті

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СЕРИЯ ГЕОЛОГИИ И ТЕХНИЧЕСКИХ НАУК



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NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы "ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы" ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Web of Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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**ASSESSMENT OF THE SUSTAINABILITY
OF LANDSCAPES OF THE NORTH-KAZAKHSTAN REGION
TO AGRICULTURAL IMPACT**

Abstract. The article deals with the research of sustainability of landscapes of North Kazakhstan region under conditions of long-term agrogenic load. In this connection and basing on the developed system of indicators there was carried out the assessment of geosystems' conditions and levels of their sustainability to the influence of human agricultural activities. The assessment was made according to thirteen indicators characterizing forming factors, landscapes functional conditions and properties of their main components. Assessment methods were based on the use of different specified rates that were transferred to a relative value (points) and were ranked according to variability (sustainability) of each landscape under direct or indirect agricultural exposure. Besides, this work performs spatial analysis and typology of the regional landscapes according to the index of potential resistance to agricultural influence. It was defined that the most resistant to agricultural human activities landscapes of Northern and central parts of the region are located within forest-steppe natural zone. Low potential resistance is typical of the landscapes located in the South-East of the region within dry steppe subzone and in the landscapes of the river Yesil valley. The level of steppe zone landscapes resistance to agricultural impact is defined as relatively stable. This work provides recommendations on restoration of ecological balance and establishing of stable functioning of the landscapes.

Keywords: landscape, geosystem, sustainability, agriculture, assessment, impact.

Introduction. North Kazakhstan oblast (NKO) is one of the leading agricultural regions of Kazakhstan. The agro-industrial sector covers more than 40% of the regional gross product. Almost a quarter of the republican acreage belongs to NKO. Annually it produces 25-28% of national gross harvest of high-quality grain. The structure of the region land resources refers up to 71%, or 6988.0 thousand hectares to agricultural lands, including 4320.4 thousand hectares of arable land (data of 2017). The rate of tilled soil in the region is 50%, reaching 70% in some administrative districts [1-3].

Long-standing agricultural load on the landscapes of the region had a negative impact on their conditions. There are dehumidification and reduction of soil fertility, increase of areas with wind and water erosion, degradation of agricultural land and reduction of its environmental sustainability [4, 5].

One of the reasons for the current environmental situation is unsustainable functioning of landscapes as a result of an imbalance between their natural potential and the nature of agricultural production. Not taking into account the properties and peculiarities of geosystems, on the one hand, and permissible agricultural load on the components, on the other, may lead to its further deterioration that can adversely affect economic development and food security of the region. Under the conditions of intensive agricultural development, one of the important tasks is maintaining sustainability of geosystems on the basis of complex examination of their state and properties and peculiarities of landscape structure of the region. In this regard, urgency of the undertaken research is quite obvious.

The purpose of the study is to evaluate sustainability of NKO landscapes to agricultural impact and to determine the nature of such impact.

Materials and methods of the study. Agricultural impact is the influence of human agricultural activity that changes properties of landscape components or landscape as a whole, which can lead to non-performance of environmental or social-economic features of the landscape [6]. Accordingly, the landscape resistance to agricultural impact depends on the ability to sustain changes generated by the human agricultural activities and to recover from such impacts preserving the basic properties and functions.

At present, there is no common approach to the assessment of landscapes' sustainability to agricultural impact. Besides, the issue of defining of common assessment criteria still remains undetermined. In addition to this, the complexity of agricultural production and a large number and diversity of agricultural impacts influencing the landscapes complicate the research in this direction. By the same token, natural landscape specificity causes the complexity of analysis and assessment. This is due to the fact that landscapes are distinguished by various natural conditions and therefore different resistance to external influences. Components of landscape, in turn, are characterized by different reactions to certain effects that serve as consequences of their differences in resistance to such loads. Additionally, when one runs the analysis and assessment of landscapes sustainability to agricultural impacts, the level of landscape organization should be taken into account. It is well-known that the higher the level is, the more sustainable the landscape is to the effects of human activities [7-11].

In comparison with other types of anthropogenically modified geosystems, landscapes created by human agricultural activity are closer to the natural landscapes according to their functional and structural properties. Therefore, most studies related to assessing agrolandscapes' sustainability use approaches and methods applied for the assessment of conditions and stability of natural landscapes and ecosystems. Special attention shall be paid to a series of techniques based on study of the basic properties of landscapes and their components, which can serve as indicators of their resistance to various external influences including agricultural load [12-25].

Theoretical and methodological basis of research was found in the works of our specialists in the field of landscape study, agrolandscape study and geocology: N.A. Solntsev, L.G. Ramenskiy, L.S. Berg, A.G. Isachenko, G.N. Vysotskiy, M.A. Glazovskaya, V.A. Kovda, B.B. Polynov, F.I. Milkov, K.V. Zvoirykin, V.N. Nikolayev, V.I. Kiryushin, B.I. Kochurov, V.S. Preobrazhenskiy, I.V. Orlova, V.I. Bulatov, Z.U. Mamutov, A.I. Iorganskiy, M.B. Esimbekova and others, and in foreign studies of agriculture, landscape and agroecology made by: M. Arshad, S. Navrud, J. Iverson Nassauer, D. Chelaru and others.

As the informational background of the research we used literature, industry-specific and thematic maps, published and stock materials of industrial government organizations and agencies (Department of Land Cadastre and Technical Survey of Real Estate, Government for citizens State Corporation NCJSC in NKO, Republican Scientific-Methodical Center of Agrochemical Service RSE of the Kazakhstan Ministry of Agriculture, Department of NKO Agriculture MPUI, Department of Statistics in NKO, etc.) for the period of 2010-2016, as well as materials of summer field works in 2017.

The studies were carried out with use of complex landscape-geographical methods, such as comparative-geographical, cartographic, mathematical, statistical, extrapolation, systematic, cross-spectrum analysis, etc.

The assessment included several stages: defining the methods, indicators (criteria) and assessment parameters, preparation of evaluation scale, collecting and aggregating the necessary data, including materials of field research, evaluation according to the evaluation scale, definition of sustainability degree, and analysis of the obtained results. The final stage of the research included working out the recommendations on solving issues of agricultural environmental management, restoration of ecological balance and sustainable functioning of the landscape.

Field studies were carried out on typical for the region key areas of forest-steppe and steppe natural zones. There were 15 key areas in total. Their allocation was based on a number of factors: morphological landscape characteristics, structure of soil, agro-climatic and natural-agricultural zoning, type of agricultural use of the region territory. Study of the basic components of landscapes (relief, climate, soils, and vegetation) was carried out according to standard procedures. The field work included comprehensive landscape description of keys, soil pit testing and selected soil sampling. Chemical-analytical investigations of soil samples were carried out in certified laboratories of the branch of "National Centre of Expert Review" Republican State Enterprise on the Right of Economic Use of the Committee for Public

Health of the Ministry of National Economy of the Republic of Kazakhstan in NKO in accordance with approved methods.

In the course of our study we analyzed different approaches and criteria for the assessment of sustainability of landscapes impacted by human agricultural activity: the ratio of naturalness level, ecological-economic balance, including determining the coefficient of relative, absolute tension and natural areas protection, the coefficient of ecological stability (stabilization), the degree of actual erosional feature and potential risks of erosion, Simpson's diversity index, index of ecological balance, correlation of farmland, soil fertility, etc.

In order to assess sustainability of NKO landscapes to agricultural impacts we used the approach proposed by I. V. Orlova, modified in relation to the studied region. The substance of the approach is that the components of geosystem have different response and resistance from the point of view of agricultural impact on the geosystem. Therefore, the components shall be separately evaluated using point-based system with subsequent summation, which allows to consider each of them and construct landscapes according to their overall sustainability [9].

Hereafter you can see the figures taken as estimated parameters of sustainability of NKO geosystems to agricultural impacts (table).

Scale of assessment of sustainability of landscapes of North-Kazakhstan region to agricultural impact

N	Assessment measures	1 point	2 points	3 points	4 points	5 points
1	Hydrothermic index	$\leq 0,40$ $\leq 0,20$	0,41-0,60 0,21-0,40	0,61-0,80 0,41-0,60	0,81-1,0 0,61-0,80	$\geq 1,1$ $\geq 0,81$
2	Wind conditions, number of days with strong winters	more than 51	–	21-50	–	less than 20
3	Relief	undulating	gently rugged	rolling / interfuvial	flat and gently rolling	flat
4	Slope angle, degrees	$\geq 20,1$	5,1-20,0	3,1-5,0	1,1-3,0	0-1,0
5	Degree of natural drainage	drainless	0,2-1,0 slightly drained	1,1-3,0 average	3,1-10,0 good	$\geq 10,1$ very good
6	Geochemical situation	accumulative	transaccumulative	transit	transeluvial	eluvial
7	Soil Texture	sand	sandy soil	light loam	medium-textured loam	clay loam
8	Type of water regime	desuctive exudative	exudative	nonleaching	regularly leaching	leaching
9	Degree of hydromorphic feature	hydromorphic	–	semihydromorphic	–	automorphic
10	Humus horizon thickness, cm	$\leq 10,0$	10,1-30,0	30,1-50,0	50,1-80,0	$\geq 80,1$
11	Humus content in the soils of 0-20 cm, %	$\leq 2,0$	2,1-4,0	4,1-6,0	6,1-9,0	$\geq 9,1$
12	Actual soil acidity, pH	strongly acid ($\leq 4,5$) or strongly alkaline ($\geq 8,6$)	acid (4,6-5,0) or alkaline (7,6-8,5)	mildly acid (5,1-5,5) or mildly alkaline (7,0-7,5)	close to neutral (5,6-6,0)	neutral 6,1-7,0
13	Cation exchange capacity, mg/eq 100 g of soil	<10	10-20	21-30	31-40	>40

Statistical calculations and processing study data and materials of field work were conducted using software of Microsoft Office, Statistica 6.0, MapInfo Professional 11, ArcGIS 10.1.

The assessment was carried out according to each indicator separately on the basis of a correlation of the actual data with the tabulated gradation. Points for each of the analyzed indicator were summed up. The highest possible score representing the highest sustainability of the landscape to agricultural impact was taken as 100%. The received sums of points were calculated relative to maximum score according to the formula [14]:

$$C = \frac{100 \sum_{g=1}^n C_g}{Q},$$

where C means assessment of the landscape sustainability to agricultural impacts in %; C_g – points for each indicator; Q – maximum possible amount of points; g – the number of the indicator; n – number of indicators (signs).

The results of calculations were correlated with the gradation, according to which there are five levels of landscape sustainability to agricultural impact: stable (81-100%), relatively stable (61-80%), less stable (41-60%), unstable (21-40%), extremely unstable (less than 20%) [9].

Results and discussion. Spatial analysis of the obtained data allowed to reveal that within the studied region the most sustainable to agricultural impact landscapes are forest-steppe of the (typical and south outlier) natural areas (indicator of sustainability is 76-81%). This is due to the fact that here the landscape sustainability is stipulated by fairly high rate of forest cover in comparison with other territories of the region. Forests, thickets of trees and shrubs create ecological framework that supports environmentally sustainable landscapes. The forest-steppe zone is characterized by less plowed land and greater share of environment-stabilizing components of landscape. Within the zone, you can observe better drainage, favourable hydrochemical conditions and wind regime. The soils are characterized by relatively high humus content (4,1-4,4%) and thickness.

Those landscapes close to the valley of the Yesil river (55-60%) and landscapes of dry steppe sub-zone (53-60%) are less resistant to the effects of human agricultural activity.

The landscapes within the Yesil river valley are characterized by less favorable geochemical situation and type of water regime with hydromorphic soils. If taking into consideration humus horizon thickness they are inferior to the upland areas and are characterized by low humus content (2.3%) and weak maturity. The features of the valley determined the specific landscape structure and sustainability of its landscapes to the impacts of external factors. Gradients, division of land by temporary streams, marked steepness of the slopes especially on the right bank of the valley reduce potential resistance of landscapes to external influences including agricultural.

The dry steppe subzone has rather high level of agricultural development that adversely affects the sustainability of its landscapes. Forest and shrub vegetation makes a small part in the soil structure. Subzone is characterized by insufficiently favorable hydrothermal conditions. All the soils despite relatively high level of natural fertility (2,8-3,7%) are characterized by less favorable water-physical properties. Additionally, this subzone has widespread sodic-saline soil complexes with unfavorable physical and chemical properties. Here there is a high likelihood of soil degradation processes related to the character of wind regime with frequent days of strong winds. This determines lower landscapes' sustainability to the impacts of farm environmental management.

The steppe zone within the region is represented by two subzones: northern temperate arid and south arid. Despite many years of intensive agricultural development the landscapes of this zone are specified by relative sustainability to agricultural impacts (68-75%) due to its high natural potential in accordance with gradation. In conditions of intensive agricultural environmental management sustainable landscapes are ensured by reserves of natural soil fertility and their good water-physical properties. The humus content in soils is 4,0-4,7%. Besides, flat poorly broken relief with slight slopes, uniform morphological structure of landscapes and eluvial geochemical position help to maintain the sustainability of the landscapes.

Those landscapes that are less stable or unstable to the impacts of human agricultural activity call for special attention when organizing and conducting agricultural operations at any stages of agricultural production. The use of such landscapes for agricultural purposes should be subject to acceptable level of agrogenic load while preserving their resources and capabilities, as well as putting various restrictions on agricultural natural management.

Relatively resistant to the agricultural impact, landscapes are able to withstand current agricultural load and to ensure further development of agricultural production but only subject to the ecological balance between their maximum capabilities and agricultural load, as well as implementation of measures to maintain natural ecological potential. Here agricultural activity is associated with a lower risk of violating the balance of nature.

Conclusion. After assessing sustainability of landscapes of North-Kazakhstan oblast to agricultural impacts we revealed the following pattern: the most sustainable landscapes are in Northern and central parts of the region. The closer you move to the South, the less the landscapes sustainability to agricultural impacts is. Low potential sustainability is typical of landscapes located in the South-East of the region within the dry steppe subzone and landscapes of the Yesil river valley.

Different levels of landscapes sustainability to the influence of agricultural activities require functional zoning of the region to areas with different agricultural environmental management.

In order to maintain the landscapes sustainability to agricultural impacts we need to develop a program of rational and balanced agricultural environmental management on landscape basis and to introduce ecologization of all agricultural production processes.

The results obtained during the research can serve as informational backup for planning and implementation of programs and projects in agricultural environmental management for regional and local authorities.

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СОЛТҮСТІК ҚАЗАҚТАН ОБЛЫСЫ ЛАНДШАФТТАРЫНЫҢ АУЫЛШАРУАШЫЛЫҚ ӘСЕРІНЕ ТҰРАҚТЫЛЫҒЫН БАҒАЛАУ

Аннотация. Мақала көп жылдық агрогендік жүктеменің жағдайында Солтүстік Қазақстан облысы ландшафттарының тұрақтылығын зерттеуге арналған. Көрсеткіштердің әзірленген жүйесінің негізінде гео-жүйелердің жағдайы бойынша және адамның ауыл шаруашылық әрекеттерінің оларға әсер етулеріне тұрақ-

тылықтарының деңгейіне баға берілген. Бағалау қалыптастыру факторлардың сипаттамасында, ландшафтардың жұмыс істеу шарттарында, олардың негізгі компоненттерінің қасиеттерін сипаттайтын он үш көрсеткіш бойынша жүргізілді. Бағалау әдісі ауыл шаруашылық әсерінің тікелей немесе жанама әсерінің әрқайсысының өзгермелілігін (тұрақтылығын) ескере отырып, салыстырмалы мәндерге (балл) аударылған әртүрлі есептік көрсеткіштерді пайдалануға негізделген. Ауыл шаруашылық әсерлерге тұрақтылықтың нақты көрсеткіштері бойынша аймақтың ландшафттарын типке келтіру жүзеге асырылған және кең шеңберде сараптама жасалған. Облыс аумағының солтүстік және орталық бөлігінің орманды-дала табиғи аймағында орналасқан ландшафтары адамның ауылшаруашылық қызметінің әсеріне төзімді болып табылады. Төмен әлеуетті тұрақтылық құрғақ дала подзонаның оңтүстік-шығыс аймағында орналасқан ландшафттар және Есіл өзен аңғарының ландшафттар сипатталады. Дала аймағының ландшафттарының ауыл шаруашылық әсеріне төзімділік деңгейі салыстырмалы түрде тұрақты деп белгіленген. Баяндамада экологиялық тепе-теңдікті қалпына келтіру және агрогендік табиғаттың антропогендік әсерін тигізетін геосистемалардың тұрақты жұмыс істеуін қалыптастыру бойынша ұсыныстар ұсынылған.

Түйін сөздер: ландшафт, геожүйе, тұрақтылық, ауыл шаруашылық, баға, әсер.

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ОЦЕНКА УСТОЙЧИВОСТИ ЛАНДШАФТОВ СЕВЕРО-КАЗАХСТАНСКОЙ ОБЛАСТИ К СЕЛЬСКОХОЗЯЙСТВЕННОМУ ВОЗДЕЙСТВИЮ

Аннотация. Статья посвящена исследованию устойчивости ландшафтов Северо-Казахстанской области в условиях многолетней агрогенной нагрузки. На основе разработанной системы показателей проведена оценка состояния геосистем и уровня их устойчивости к воздействию сельскохозяйственной деятельности человека. Оценка проводилась по тринадцати показателям, характеризующим факторы формирования, условия функционирования ландшафтов, свойства их основных компонентов. Методика оценки базировалась на использовании различных расчетных показателей, которые переводились в относительную величину (баллы), ранжировались с учетом изменчивости (устойчивости) каждого из них под прямым или косвенным сельскохозяйственным воздействием. Выполнен пространственный анализ и осуществлена типология ландшафтов региона по показателю потенциальной устойчивости к сельскохозяйственному воздействию. Выявлено, что наиболее устойчивы к воздействию сельскохозяйственной деятельности человека ландшафты северной и центральной части территории региона, располагающиеся в пределах лесостепной природной зоны. Невысокой потенциальной устойчивостью характеризуются ландшафты, располагающиеся на юго-востоке области в пределах сухостепной подзоны, и ландшафты долины р. Есиль. Уровень устойчивости к сельскохозяйственному воздействию ландшафтов степной зоны определен как относительно устойчивый. В работе предложены рекомендации по восстановлению экологического равновесия и формирования устойчивого функционирования геосистем, испытывающих антропогенное воздействие агрогенного характера.

Ключевые слова: ландшафт, геосистема, устойчивость, сельское хозяйство, оценка, влияние.

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