N E W S
OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN
SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2224-5278
Volume 5, Number 437 (2019), 16 – 25 **https://doi.org/10.32014/2019.2518-170X.121**

UDC 551.58:631+551.4
IRSTI 87.29.91

G. A. Adilbektegi[1], J. S. Mustafayev[2], T. K. Uvatayeva[1], Z. N. Dulatbekova[1], Jozef Mosiej[3]

[1]RSE L. N. Gumilyov Eurasian National University, Astana, Kazakhstan,
[2]JSC Kazakh National Agrarian University, Almaty, Kazakhstan,
[3]Warsaw University of Natural Sciences, Warsaw, Poland.
E-mail: adilbekova.gulmira@yandex.kz ,z-mustafa@rambler.ru, yadulatbekova@gmail.com,
t_uvatayeva@mail.ru, jozef_mosiej@sggw.pl

A NEW APPROACH TO THE EVALUATION OF BIOCLIMATIC POTENTIAL OF LANDSCAPES ON THE EXAMPLE OF NORTHERN KAZAKHSTAN

Abstract. Based on the laws of natural processes, an integrated model has been developed for assessing the bioclimatic potential of landscapes, which mainly includes an assessment of the productivity of vegetation and soil cover, allowing to determine the patterns of formation and functioning of landscape systems, depending on latitudinal zonality and altitude zonation for effective use of agricultural land and to identify their regional differences.

The development of the model and assessment of the bioclimatic potential of landscapes of the natural system is based on the methodology of system studies in the field of geography and ecology, as well as on methods of mathematical modeling of the production process in biology.

Based on the climatic index of the biological productivity of landscapes, D.I. Shashko (B_C) and the energy expended on soil formation, determined by the formula of V.R.Volobuev (Q_i) developed a mathematical model for assessing the bioclimatic potential of landscapes of the natural system, which were used to assess the bioclimatic potential of the landscapes of Northern Kazakhstan.

To assess the bioclimatic potential of the landscapes of the natural system of Northern Kazakhstan, the long-term data of meteorological monthly menus on the meteorological stations of the regions of Northern Kazakhstan, submitted by RSE "Kazgidromet" of the Republic of Kazakhstan, were used.

Analysis of the results of calculating the index of biological productivity of vegetation cover (B_C) and energy spent on the soil-forming process of landscape systems (Q_i) in Northern Kazakhstan indicates that they strictly obey the laws of geographical zoning. Consequently, the climatic index of the biological productivity of landscapes (C_l), which is determined by the ratio of such averaged indicator values as the soil cover productivity index (C_s) and the indicator of the climatic index of the biological productivity of the vegetation cover (C_{bv}) also strictly obey these laws of nature.

The proposed model of the climatic index of the biological productivity of landscapes (C_l) provides opportunities for a real assessment of the resource potential of the natural system when developing an adaptive landscape system of farming and a program of agricultural activities with an optimal load on the geoecosystem.

Based on the climatic index of the biological productivity of landscapes D. I. Shashko (B_c) and energy soil on soil formation, defined by the formula V. R. Volobuyev (Q_i) developed a mathematical model for estimation of bioclimatic potential of the landscapes of the natural system with the use of multi-year meteorological data monthly meteorological stations of the Northern regions of Kazakhstan, submitted to "Kazgidromet" RSE, defined by their quantitative values that can be more accurately determined by means of the climatic index of the biological productivity of landscapes (C_l).

Keywords: nature, landscape, climate, productivity, biology, ecology, potential, index.

Introduction. For the solution of problems of interaction between society and nature, as well as problems related to the understanding of the natural systems functioning, it is necessary to have a detailed description of the landscapes on the major factors, expressed in the form of some mathematical models to evaluate their natural resource potential.

Productivity of landscape systems is not reflected adequately in the existing methodological approaches and methods of assessment of the climate productivity, which requires the development of complex bio-ecological assessment methods of landscapes productivity on the basis of fundamental laws of nature, which should include private assessment of the productivity of its components, that is, soil productivity and vegetative cover.

A complex or integrated feature of climate, soil and other factors positively influencing the growth and development of plants and soils, representing the energy resources of natural systems should be understood under the bio-ecological assessment of productivity of landscapes. The environmental assessment productivity landscapes should be based on the use of geographical laws, manifested in the scale of territorial units of different hierarchical rank, which gives the possibility to explain the nature of the formation and functioning of landscape systems [1, 2].

Purpose of this study is to develop an integral model for the evaluation of bioclimatic productivity of landscapes, including mainly the assessment of plants and soil productivity, to determine the regularities of formation and functioning of natural systems depending on the latitudinal zonation and altitudinal zones for efficient use of agricultural lands and the identification of their regional differences.

Methods. As a theoretical basis for the development of the model, the concept of maximum productivity of Tooming X.G was used. (1977), the climatic productivity of A. Meyer's landscapes (1926), S.V. Torrentway (1931), N.N. Ivanova (1941), I.A. Prescott (1946), D.I. Shashko (1967) to determine the productivity of the climate, which reduces to the expression of the magnitude of the climatic coefficient of moistening, use the ratio of the sum of atmospheric precipitation to some function of the deficit of air humidity. R. Lang (1920), E. Marton (1926), S.V. Torentweit (1931), W. Keppen (1931), G.T. Selyaninov (1937), M.I. Budyko (1956), S.L. Merkin (1960) uses precipitation ratios and some air temperature functions as a relative characteristic of moisture supply. G.I. Vysotsky (1905), S.V. Torrentway (1931), N.N. Ivanov (1941), Blaine-Criddel (1950), A.N. Kostyakov (1951), V.Ya. Bakalo (1960) used certain evaporation functions as energy resources in determining the moisture content of geographic zones. The modern views of foreign scientists in the field of geography, biology and ecology, such as the estimation of plant productivity, formulated in the works of A.N. Polevoy (1983, 1988), as well as methods for assessing the microclimatic variability of climatic elements in hilly relief (EN Romanova, 1977; ZA Mishchenko, 1984). For a more detailed assessment of agroclimatic conditions, a ten-day period

Long-term data of meteorological monthly at the meteorological stations of the Northern regions of Kazakhstan, submitted by "Kazgidromet" RSE [3; 4] were used to assess the bioclimatic potential of the landscapes of the natural system of Northern Kazakhstan.

Model development and evaluation of bioclimatic potential of the natural system landscapes is based on the methodology of system researches in the field of geography and ecology, as well as on the methods of mathematical modeling of production process in biology. The methodology is based on: geo-systemic approach that considers natural environment as a single organized structure (landscape) consisting of a number of interconnected and interdependent components – surface layer of the atmosphere, climate, soil, vegetation, groundwater and surface water, and others. Fundamental here are the teachings of V.V. Dokuchayev – A.A. Grigoriev - M.I. Budyko – laws of evolution and geographical zonality of the landscape.

For a quantitative estimation of bioclimatic potential of the natural system landscapes, that is, formation of the production process of the plant and soil covers in the landscape system, the climatic index of biological productivity of landscapes of D. I. Shashko (B_c) [5] and energy spent on projects determined by the V. R. Volobuyev formula (Q_i) [6] are used.

Influence of heat and moisture landscapes on the biological productivity is expressed on a relative scale of bioclimatic potential of the natural system, that is the climatic index of biological productivity of vegetation landscapes of D. I. Shashko (1) [5]:

$$B_c = GF_{(wf)}[\ 100(\sum t > 10^0C / \sum t > 10^0C_0], \quad (1)$$

where B_c - climatic index of biological productivity of the vegetation cover of landscapes; $\sum t > 10^O C$ - the sum of average daily temperatures above +10°C, reflecting the amount of solar energy and heat provision of landscapes; $\sum t > 10^O C_O$ - the sum of average daily temperatures above 10°C, equal to the initial zone of flow formation of river basins, equal to 1000 °C; $GF_{(wf)}$- growth rate for annual rate of atmospheric moisture, which is a ratio of productivity under these conditions moisture for maximum productivity in terms of optimal moisture, and is determined by the formula (2) [5]:

$$GF_{(wf)}= 1.15 \square \lg (20 \cdot M_d) - 0.21 + 0.63 \cdot M_d - M_d^2. \quad (2)$$

Where $M_d = O_c / \sum d$ - humidity index; O_c - atmospheric precipitation, mm; $\sum d$ - sum of the deficit of air humidity of biologically active period of the year, mb.

Thus, when the quantitative value of the humidity index will be equal within $Md = 0.50 \div 0.60$, value of the coefficient of growth $GF_{(wf)}$= 1.0 (figure 1) [5].

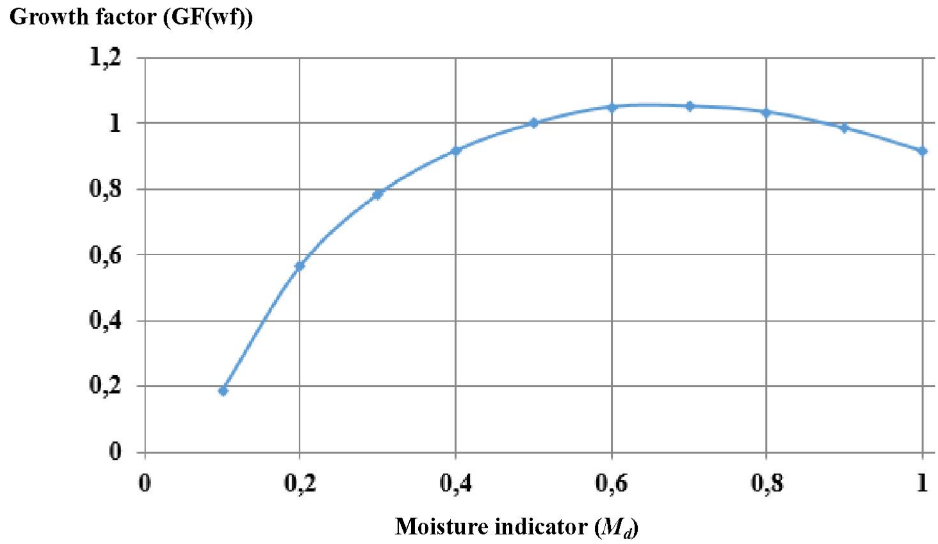

Figure 1 – The dependence of growth rate ($GF_{(wf)}$) of the humidity index (Md)

Bioclimatic potential, expressed in points, is an integral indicator is the main indicator for assessing agro-climatic importance of the climate and approximately displays biological productivity of zonal soil types, as the yield depends on soil fertility and characterizes the favorable climate [5], which gives the opportunity to determine the potential value of climatic index of biological productivity of vegetation at $GF_{(wf)}$= 1.0 (3):

$$Bpf = [\, 100 \cdot (\sum t > 10^0C / \sum t > 10^0C_0), \quad (3)$$

The climate index of the biological productivity of vegetation layer (Bp) to the potential value of climatic index of biological productivity of vegetation layer of natural systems at $GF_{(wf)}$= 1.0 (Bpf), that is, $C_{bv}= Bp/ Bpf$ are indicators of climate index of vegetation biological productivity.

Energy consumed for soil formation, defined by the V. R. Volobuyev formula [6] to some extent characterizes the productivity of the soil landscapes (4):

$$Q_i = R \cdot \exp(-\alpha_o \cdot \overline{R}), \quad (4)$$

where Q_i - energy consumed for soil formation, kJ/cm^2; α_o - coefficient taking into account the condition of the soil surface.

In a natural system, the principle of energy balance of heat and moisture is observed in natural conditions, where the radiation index of dryness ($\overline{R}$) is equal to 1.0. Therefore, as a criterion of the radiative index of dryness ($\overline{R}$), you can take the limit in the range of 0.9-1.0.

Then, the potential energy expended on soil-forming process (Q_n) provides the potential productivity of the soil can be determined by expression (5):

$$Q_n = R \cdot \exp(-0.9 \cdot \alpha_O). \quad (5)$$

Consequently, the ratio of energy consumed for soil formation under natural conditions (Q_i) to the potential energy expended in soil-forming process (Q_n) represents the productivity of the soil landscapes, that is, $C_S = Q_i / Q_n$ [7].

Thus, the climate index of the biological productivity of landscapes (C_l) is determined by the ratio of such averaged indicator values as an indicator of the productivity of the soil surface (C_S) and the indicator of climatic index of biological productivity of vegetation (C_{bv}): $C_l = C_{bv} \cdot C_S$.

Thus, the developed model of climatic index of the biological productivity of landscapes allows, first, to give quantitative values of qualitative changes of habitats; secondly, modelling of transformation of natural systems under climate change; third, landscape-ecological zoning of the natural systems.

Results. The following parameters were used to assess the energy resources of the natural system of Northern Kazakhstan: the sum of air temperature ($\sum t$) above 10 °C, the amount of humidity deficit of air ($\sum d$, mb), evaporation (E_O, mm), photosynthetic active radiation (R, kJ/cm^2) and the amount of precipitation (O_C, mm) (table 1) [4].

As can be seen from table 1, the quantitative values and energy resources of Northern Kazakhstan decrease from Akmola region to the North-Kazakhstan region, but rainfall increases, according to the laws of geographic zonality. In this case, the sum of air temperature during biologically active periods of the year within Northern Kazakhstan range from 2051 to 3083°C.

Table 1 – Natural-energy resources of Northern Kazakhstan landscape systems

Weather stations	The absolute height (H), m	Indicators of natural and energy resources				
		$\sum t, ^oC$	$\sum d$, MB	E_O, mm	R, kJ/cm^2)	O_C, mm
Akmola region						
Yesil	219	2439	1633	951	139.1	372
Atbasar	303	2267	1504	884	133.4	386
Yeremen-Tau	397	2244	1509	875	132.6	444
Astana	347	2295	1556	895	134.3	411
Kokshetau	228	2241	1408	717	132.5	291
Shuchinsk	398	2051	1230	656	126.2	382
Kostanay region						
Kostanay	169	2359	1546	754	136.4	373
Tobol	207	2373	1537	759	136.9	403
Zhetigara	247	2311	1598	739	134.8	344
Arkalyk	343	2552	2370	817	142.8	373
Turgay	124	3083	2434	925	160.4	282
Pavlodar region						
Irtyshsk	93	2287	1418	732	134.0	359
Uspenka	112	2344	2180	750	135.9	330
Sherbakty	148	2377	1653	760	137.0	319
Pavlodar	144	2486	1510	795	140.6	352
Caldai	162	2369	2200	758	136.7	411
Ekibastuz	197	2511	1729	803	141.4	334
Chiderty	240	2338	2170	748	135.7	378
Bayan-aul	494	2410	1732	771	138.1	401
North-Kazakhstan region						
Ruzayevka	226	2242	1418	718	132.5	392
Bulayevo	132	2049	1202	655	126.1	320
Petropavlovsk	134	2081	1174	665	127.2	320
Yavlenka	114	2164	1283	692	129.9	310

Climatic assessment of landscape systems productivity in Southern Kazakhstan is defined on the basis of indicators characterized by a degree of endowments of the natural environment: humidity coefficient ($Wf= O_C/ E_O$) [8], index of dryness ($\overline{R}=R/LO_C$) [9], hydrothermal coefficient ($HTC= 10 \cdot O_C/ \sum t$) [10], bio-climatic productivity ($BCP = Wf (\sum t/1000)$) [10] and increased humidification ($M_d = O_C / \sum d$) [5] (table 2).

Table 2 – Climatic productivity of landscape systems in Northern Kazakhstan

Weather stations	The absolute height (*H*), m	Indicators of heat and humidity				
		Wf	*HTC*	*BCP*	M_d	$\overline{R}$
Akmola region						
Yesil	219	0.34	0.15	0.83	0.23	1.49
Atbasar	303	0.36	0.17	0.82	0.26	1.44
Yeremen-Tau	397	0.43	0.18	0.96	0.26	1.33
Astana	347	0.37	0.18	0.85	0.18	1.31
Kokshetau	228	0.43	0.16	0.96	0.26	1.45
Shuchinsk	398	0.51	0.17	1.05	0.31	1.32
Kostanay region						
Kostanay	169	0.39	0.16	0.92	0.24	1.36
Tobol	207	0.46	0.17	1.09	0.26	1.32
Zhetigara	247	0.40	0.15	0.92	0.22	1.56
Arkalyk	343	0.46	0.15	1.17	0.21	1.53
Turgay	124	0.16	0.09	0.49	0.12	2.27
Pavlodar region						
Irtyshsk	93	0.43	0.16	0.98	0.25	1.49
Uspenka	112	0.44	0.14	1.03	0.28	1.62
Sherbakty	148	0.32	0.13	0.76	0.19	1.72
Pavlodar	144	0.31	0.14	0.77	0.23	1.60
Caldai	162	0.54	0.17	1.28	0.22	1.33
Ekibastuz	197	0.32	0.13	0.80	0.19	1.69
Chiderty	240	0.51	0.16	1.19	0.24	1.44
Bayan-aul	494	0.38	0.17	0.92	0.23	1.38
North-Kazakhstan region						
Ruzayevka	226	0.43	0.17	0.96	0.26	1.35
Bulayevo	132	0.58	0.16	1.19	0.27	1.58
Petropavlovsk	134	0.56	0.15	1.17	0.21	1.59
Yavlenka	114	0.60	0.14	1.30	0.24	1.61

As can be seen from table 2, the parameters characterizing heat and moisture supply of Northern Kazakhstan landscape systems increase from the Southern to the Northern part of the region, taking into account the quantitative values of indicators of energy resources and rainfall. Thus, the humidity index (M_d) within Akmola region ranges from 0.18 to 0.26, Kostanay region – 0.12-0.26, Pavlodar region - 0.19-0.28 and North Kazakhstan region - 0.21-0.26.

On the basis of information and analytical materials presented in table 1 and 2, which characterize energy resources and heat and moisture supply landscape systems of Northern Kazakhstan, defines bioclimatic potential (*BCP*) and climatic index of biological productivity (B_C) of landscapes (table 3).

As can be seen from table 3, the climatic index of biological productivity (B_C) of landscape systems of Northern Kazakhstan in regions, that is, within Akmola region varies from 105.6 to 126.8, Kostanay region – 101.7-128.1, Pavlodar region - 111.7-129.3 and North Kazakhstan region - 114.7-121.1 points, to a certain extent is provided by the similarity with the moisture ratio (*Wf*) [8], index of dryness ($\overline{R}$) [9], hydrothermal coefficient (*HTC*) [10], bio-climatic productivity *BCP* [10] and an indicator of hydration (M_d).

Table 3 – Bioclimatic potential (*BCP*) and climatic index of biological productivity (B_C) of Northern Kazakhstan landscape systems

Weather stations	The absolute height of terrain (*H*), m	Indicators of bioclimatic potential			
		M_d	$GF_{(wf)}$	$\frac{\sum t>10^oC}{\sum t>10^oC_o}$	B_C, points
Akmola region					
Yesil	219	0.23	0.52	2.439	126.8
Atbasar	303	0.26	0.54	2.267	122.4
Yeremen-Tau	397	0.26	0.54	2.244	121.2
Astana	347	0.18	0.46	2.295	105.6
Kokshetau	228	0.26	0.54	2.241	121.0
Shuchinsk	398	0.31	0.58	2.051	118.9
Kostanay region					
Kostanay	169	0.24	0.53	2.359	125.0
Tobol	207	0.26	0.54	2.373	128.1
Zhetigara	247	0.22	0.51	2.311	183.2
Arkalyk	343	0.21	0.50	2.552	127.6
Turgay	124	0.12	0.33	3.083	101.7
Pavlodar region					
Irtyshsk	93	0.25	0.55	2.287	125.8
Uspenka	112	0.28	0.57	2.344	133.6
Sherbakty	148	0.19	0.47	2.377	111.7
Pavlodar	144	0.23	0.52	2.486	129.3
Caldai	162	0.22	0.51	2.369	120.8
Ekibastuz	197	0.19	0.47	2.511	118.0
Chiderty	240	0.24	0.53	2.338	123.9
Bayan-aul	494	0.23	0.52	2.410	125.3
North-Kazakhstan region					
Ruzayevka	226	0.26	0.54	2.242	121.1
Bulayevo	132	0.27	0.56	2.049	114.7
Petropavlovsk	134	0.21	0.50	2.081	104.1
Yavlenka	114	0.24	0.53	2.164	114.7

The analysis of plant cover biological productivity index calculation results (B_C) and of the energy expended in the soil formation process landscape systems (Q_i) of Northern Kazakhstan suggests (table 4) that they strictly obey the laws of geographic zonality. Thus, the climate index of the biological productivity of landscapes (C_L) which is determined by the ratio of such averaged indicator values as an indicator of the productivity of the soil surface (C_S) and the indicator of climatic index of vegetation biological productivity (C_{bv}):

Table 4 – Climatic index of the biological productivity of landscapes (C_L), the index of soil surface productivity (C_S) and the indicator of climatic index of vegetation biological productivity (C_{bv}) of Northern Kazakhstan landscapes

Weather stations	Index of biological productivity						C_S
	of vegetation			of soil cover			
	B_C	B_{CP}	C_{bv}	Q_i	Q_n	C_S	
Akmola region							
Yesil	126.8	243.9	0.52	69.1	80.4	0.86	0.447
Atbasar	122.4	226.7	0.54	67.6	86.3	0.78	0.421
Yeremen-Tau	121.2	224.4	0.54	71.3	82.9	0.86	0.464
Astana	105.6	229.5	0.46	72.2	82.4	0.88	0.405
Kokshetau	121.0	224.1	0.54	67.1	82.8	0.81	0.437
Shuchinsk	118.9	205.1	0.58	67.9	78.9	0.86	0.498
Kostanay region							
Kostanay	125.0	235.9	0.53	68.4	85.2	0.80	0.424
Tobol	128.1	237.3	0.54	73.6	85.6	0.86	0.464
Zhetigara	183.2	231.1	0.79	64.9	84.3	0.77	0.608
Arkalyk	127.6	255.2	0.50	69.5	89.3	0.78	0.390
Turgay	101.7	308.3	0.33	55.0	100.3	0.55	0.181
Pavlodar region							
Irtyshsk	125.8	228.7	0.55	66.5	83.8	0.79	0.429
Uspenka	133.6	234.4	0.570	63.6	84.9	0.75	0.427
Sherbakty	111.7	237.7	0.47	61.6	85.6	0.72	0.338
Pavlodar	129.3	248.6	0.52	66.4	87.9	0.75	0.390
Caldai	120.8	236.9	0.51	73.5	85.4	0.86	0.438
Ekibastuz	118.0	251.1	0.47	64.1	88.4	0.72	0.338
Chiderty	123.9	233.8	0.53	68.7	84.8	0.81	0.429
Bayan-aul	125.3	241.0	0.52	70.8	86.3	0.82	0.426
North-Kazakhstan region							
Ruzayevka	121.1	224.2	0.54	70.6	82.2	0.85	0.459
Bulayevo	114.7	204.9	0.56	60.4	78.8	0.77	0.431
Petropavlovsk	104.1	208.1	0.50	60.7	79.5	0.76	0.380
Yavlenka	114.7	216.4	0.53	60.7	81.2	0.75	0.397

Thus, the proposed model for the evaluation of bioclimatic potential of landscapes in natural systems, compared to the humidity index (M_d) and climatic index of biological productivity (B_C) of the landscapes is characterized in that the first model allows to estimate any of the fundamental predictors of vegetation and soil cover, to determine the resource potential and productivity of landscapes, and secondly the soil and climatic potential of landscapes installed using the most important indicators such as increased soil productivity, which is determined on the basis of the energy expended in the soil formation process in natural conditions and the climate indicator index of biological productivity of vegetation, providing a comprehensive accounting of climate and environmental conditions of natural systems.

Discussion. Based on the climatic index of the biological productivity of landscapes D. I. Shashko (B_C) and energy expended on soil formation, defined by the V. R. Volobuyev formula (Q_i) developed a mathematical model of the bioclimatic potential of landscapes in natural systems taking into account the formation and functioning of the soil and vegetation of landscape systems..

The comparative assessment of the climatic index of the biological productivity of landscapes (C_L), which is determined by the ratio of such averaged indicator values as the indicator of soil cover productivity (C_S) and the indicator of the climatic index of the biological productivity of the vegetation cover (C_{bv}) also strictly obey these natural laws with the existing methods for assessing the climatic productivity of the natural system, that is, the wetting factor ($Wf = O_C/E_O$) [8], the dryness index ($\overline{R} = R / LO_C$) [9], the hydrothermal coefficient ($HTC= 10 \cdot O_C/ \sum t$) [10], the biology productivity (see table 2 and 4), that they have many similarities, they also obey the laws of geographical zoning, only differ in quantitative values, characterizing the qualitative state of the natural system.

The proposed model opens up possibilities for a realistic assessment of the resource potential of natural systems in the development of adaptive-landscape farming systems, and agricultural program activities with optimal load on geoecosystem.

Г. Ә. Әділбектегі[1], Ж. С. Мустафаев[2], Т. К. Уватаева[1], Ж. Н. Дулатбекова[1], Jozef Mosiej[3]

[1]РМК ШЖҚ «Л. Н. Гумилев атындағы Еуразия ұлттық университеті», Астана, Қазақстан,
[2]«Қазақ ұлттық аграрлық университеті» коммерциялық емес акционерлік қоғамы, Алматы, Қазақстан,
[3]Жаратылыстану ғылымдарының Варшава университеті, Варшава, Польша

СОЛТҮСТІК ҚАЗАҚСТАН ЖАҒДАЙЫНДА ЛАНШАФТТАРДЫҢ БИОКЛИМАТТЫҚ ӘЛЕУЕТІН БАҒАЛАУДЫҢ ЖАҢА ЖОЛЫ

Аннотация. Табиғи жүргінің заңдылықтарының негізінде, құрамында өсімдік және топырақ жамылғысының өнімділігін бағалауға бейімделген, ландшафттардың биологиялық-климаттық әлеуетін бағалауға арналған интегралдық үлгісі құрылған. Ал ол ландшафттық жүйелердің ендік аймаққа және биіктіктік белдеулікке байланысты қалыптасу және қызмет ету заңдылықтарын анықтай отырып ауылшаруашылыққа арналған жерлерді тиімді пайдаланудың жолдарын және аймақтық өзгешілігін анықтай алады.

Табиғи жүйенің ландшафттарының биологиялық-климаттық әлеуетінің үлгісі және оны бағалау география және экология саласының жүйелік зерттеу әдістемесіне және биология ілімінің өнімдік жүргісі математикалық үлгілеудің әдісіне негізделген.

Солтүстік Қазақстанның ландшафттарының биологиялық-климаттық әлеуетін бағалау үшін, Д.И. Шашконың ландшафттық биологиялық өнімділігінің климаттық белгісін ($Б_к$) және В.Р. Волобуевтың топырақтың түзілуіне шығын болатын күн сәулесінің қуатын (Q_i) анықтауға арналған өрнегінің негізінде табиғи жүйенің ландшафттарының биологиялық-климаттық әлеуетінің үлгісі құрылған.

Солтүстік Қазақстанның табиғи жүйелерінің ландшафттарының биоклиматтық әлеуетін бағалау үшін Қазақстан Республикасының «Қазгидромет» РМК-ның Солтүстік Қазақстан облыстарының метеорологиялық бекеттерінің көпжылдық орташа айлық мәліметтік деректері пайдаланылды.

Солтүстік Қазақстанның ландшафттық жүйелерінің өсімдік жамылғысының биологиялық өнімділігінің белгісін ($Б_к$) және топырақтың түзілуіне жұмсалған энергия қуатын (Q_i) есептеудің нәтижелерін талдау негізінде, олардың географиялық аймақтандыру заңдылығына қатаң түрде сәйкес келетіндігі көрсетілді. Сондықтан, топырақ жамылғысының өнімділігінің өлшемдік көрсеткіші ($K_п$) және өсімдік жамылғысының биологиялық өнімділігінің климаттық белгісінің ($K_{бр}$) ортақтасқан көрсеткіштердің арақатынасымен анықталатын, ландшафттардың биологиялық өнімділігінің климаттық белгісі ($K_л$) табиғи заңдылықтарға қатаң түрде сәйкес келеді.

Ландшафттардың биологиялық өнімділігінің климаттық белгісін анықтауға ұсынылып отырған үлгі ($K_л$), егіншіліктің бейімделген-ландшафттық жүйесін құру кезінде табиғи жүйелердің қорлық әлеуетін шынайы бағалауға және геологиялық-экологиялық жүйеге түсетін жүктемені оңтайлау арқылы ауылшаруашылық қызмет бағдарламаларын әзірлеуге мүмкіндік береді.

Түйін сөздер: табиғат, ландшафт, климат, өнімділік, биология, экология, әлеует, индекс.

Г. А. Адильбектеги[1], Ж. С. Мустафаев[2],
Т. К. Уватаева[1], Ж. Н. Дулатбекова[1], Jozef Mosiej[3]

[1]РГП на ПХВ «Евразийский национальный университет им. Л. Н. Гумилева», Астана, Казахстан,
[2]НАО Казахский национальный аграрный университет, Алматы, Казахстан,
[3]Варшавский университет Естественных наук, Варшава, Польша

НОВЫЙ ПОДХОД К ОЦЕНКЕ БИОКЛИМАТИЧЕСКОГО ПОТЕНЦИАЛА ЛАНДШАФТОВ НА ПРИМЕРЕ СЕВЕРНОГО КАЗАХСТАНА

Аннотация. На основе законов природных процессов разработана интегральная модель для оценки биоклиматического потенциала ландшафтов, включающая преимущественно оценку продуктивности растительного и почвенного покровов, позволяющих определить закономерности формирования и функционирования ландшафтных систем в зависимости от широтной зональности и высотной поясности для эффективного использования земель сельскохозяйственного назначения и выявления их региональных различий.

Разработка модели и оценка биоклиматического потенциала ландшафтов природной системы базируется на методологии системных исследований в области географии и экологии, а также на методах математического моделирования продукционного процесса в биологии.

На основе климатического индекса биологической продуктивности ландшафтов Д.И. Шашко ($Б_к$) и энергии, затрачиваемой на почвообразование, определяемой по формуле В.Р. Волобуева (Q_i), разработана математическая модель для оценки биоклиматического потенциала ландшафтов природной системы, которые использованы для оценки биоклиматического потенциала ландшафтов Северного Казахстана.

Для оценки биоклиматического потенциала ландшафтов природной системы Северного Казахстана, использованы многолетние данные метеорологических ежемесячников по метеорологическим станциям областей Северного Казахстана, представленные РГП «Казгидромет» Республики Казахстан.

Анализ результатов расчета индекса биологической продуктивности растительного покрова ($Б_к$) и энергии, затраченной на почвообразовательный процесс ландшафтных систем (Q_i) Северного Казахстана свидетельствует о том, что они строго подчиняются законам географической зональности. Следовательно, климатический индекс биологической продуктивности ландшафтов ($К_л$), который определяется соотношением таких осредненных индикаторных величин, как показатель продуктивности почвенного покрова ($К_п$) и показатель климатического индекса биологической продуктивности растительного покрова ($К_{бр}$) тоже строго подчиняются этим законам природы.

Предложенная модель климатического индекса биологической продуктивности ландшафтов ($К_л$) открывает возможности для реальной оценки ресурсного потенциала природной системы при разработке адаптивно-ландшафтной системы земледелия и программы сельскохозяйственной деятельности с оптимальной нагрузкой на геоэкосистему.

Ключевые слова: природа, ландшафт, климат, продуктивность, биология, экология, потенциал, индекс.

Information about authors:

Adilbektegi Gulmira Adilbekkizi, Candidate of Geographical Sciences, acting. Associate Professor of the L. N. Gumilyov Eurasian National University, Astana, Kazakhstan; adilbekova.gulmira@yandex.kz; http://orcid.org/0000-0002-1521-0145

Mustafaev Zhumakhan Suleimenovich - doctor of technical sciences of the Russian Federation and the RK, professor of the Kazakh National Agrarian University, Almaty, Kazakhstan; z-mustafa@rambler.ru; http://orcid.org/0000-0003-2425-8148

Uvatayeva Togzhan Kairatovna, Master of the 2nd course of the specialty 6M060800 - Ecology of the L. N. Gumilyov Eurasian National University, Astana, Kazakhstan; t_uvatayeva@mail.ru; http://orcid.org/0000-0002-2404-6260

Dulatbekova Zhanna Nurzhankuzy, Master of the 2nd course of the specialty 6M060800 - Ecology of the L. N. Gumilyov Eurasian National University, Astana, Kazakhstan; yadulatbekova@gmail.com; http://orcid.org/0000-0002-2522-0822

Mosiej Jozef, Professor of the Warsaw University of Natural Sciences, Warsaw, Poland; jozef_mosiej@sggw.pl; http://orcid.org/0000-0002-8040-7032

REFERENCES

[1] Mustafayev Z.S. (2016) Ecological substantiation of agricultural land reclamation LAMBERT Academic. Publishing: 378 (in Rus.).

[2] Mustafayev Z.S., Adilbektegi G.A., Ryabcev A.D. (2007) Methodological basis for assessing the stability and resistance of landscapes. Taraz. ISBN: 9965-724-18-0.

[3] Scientific and Applied Reference Book on Climate of the USSR (1989). Series 13, Long-term data. Part 1-6, issue. Book 2. Gidrometeoizdat, Russia (in Rus.).

[4] Mustafayev Z.S., Ryabtsev A.D. (2012) Adaptive landscape land reclamation in Kazakhstan. Taraz. ISBN: 978-601-7300-02-9.

[5] Shashko D.I. (1985) To take into account the bioclimatic potential. [Agriculture] 4: 19-26 (in Rus.).

[6] Volobuyev V.R. (1974) Introduction to the energy of soil formation. Nauka, Moscow (in Rus.).

[7] Perko D., Hrvatin M., Ciglič R. (2015) A methodology for natural landscape typification of Slovenia, Acta geographica Slovenica 55-2. DOI: 10.3986/AGS.1938 (in Eng.).

[8] Ivanov N.N. (1941) Zones of humidification of the globe. [Proceedings of the USSR Academy of Sciences] 3: 15-32 (in Rus.).

[9] Budyko M.I., Ronov A.B., Yanshin A.L. (1985) History of the atmosphere. Gidrometeoizdat, Russia: 208 (in Rus.).

[10] Blum W.E.H. (2005) Functions of soil for society and the environment, Rev Environ Sci Biotechnol 4(3):75–79. DOI: 10.1007/s11157-005-2236-x (in Eng.).

[11] Bunce R.G.H., Barr C.J., Clarke R.T., Howard D.C., Lane A.M.J. (1996) Land classification for strategic ecological survey, Journal of environmental management 47-1. DOI: 10.1006/jema.1996.0034 (in Eng.).

[12] Feddes R.A. et al. (1978) Simulation of field water use and crop yield. Simulation Monographs, Pudos, Wageningen. ISBN:902200676X

[13] Curry R.B. (1971) Dynamic simulation of plant growth. I. Development of a model. Trans., ASAE, 14: 946-959. DOI: 10.1016/0002-1571(74)90023-5 (in Eng.).

[14] Hargrove W.W., Hoffman F.M. (2005). Potential of multivariate quantitative methods for delineation and visualization of ecoregions, Environ. Manag., 34, 39-60. DOI: 10.1007/s00267-003-1084-0 (in Eng.).

[15] Katerji N., Iihomme J.P. (1991) A simple modeling of crop water balance for agrometeorological applications, Ecol. Modell, 1-2: P.11-25. DOI: 10.1016/0304-3800(91)90052-3 (in Eng.).

[16] Luo Y., Loomis R.S., Hsiao T.C. (1992) Simulation of soil temperature in crops, Agr. And Forest Meteorol, 1-2: 23-28. DOI: 10.1016/0168 1923(92)90023-W (in Eng.).

[17] Splinter W.E. (1974) Modeling of plant growth for yield prediction, Agric. Met: 243-245. DOI: 10.1016/0002-1571(74)90023-5 (in Eng.).

[18] Timrat T.A. (2008) Soil pollution: origins, monitoring and remediation, second edition. Springer, Germany. ISBN: 978-3-540-70777-6

[19] Thompson L.M. (1964) Multiple regression of weather and technology in crop production. Weather and our food supply, CAED Rept.20, UBA: 75-92. DOI: 10.2307/1239954

[20] Thornley J.H.M. (1976) Mathematical models in plant physiology. A quantitative approach to problems in plant and crop phisiology. London. New York. ISBN 0126905509.

[21] Kenzhaliyev B.K., Surkova T.Yu., Yessimova D.M. Concentration of rare-earth elements by sorption from sulphate solutions // Complex Use of Mineral Resources. 2019. N 3. P. 5-9. https://doi.org/10.31643/2019/6445.22

[22] Mochamad B. Triyono, LilisTrianingsih, Didik Nurhadi. Students' employability skills for construction drawing engineering in Indonesia // World Transactions on Engineering andTechnology Education. 2018. Vol. 16, Issue 1. P. 29-35.

[23] Kenzhaliyev B.K., Berkinbayeva A.N., Sharipov R.H. (2015). Research of the Interacting Process of Copper-Base Alloys with Leaching Solutions under the Action of Different Physicochemical Factors // American Journal of Applied Sciences. 12(12), 982-992. https://doi.org/10.3844/ajassp.2015.982.992

[24] Kenzhaliyev B.K., Dosymbaeva Z.D., Iskhakova R.R., Suleimenov E.N. (2015). Investigation into the Use of Electrochemical Extraction to Draw Gold from Refractory Ores // American Journal of Applied Sciences. 12(11), 857-864. https://doi.org/10.3844/ajassp.2015.857.864

[25] Lavrinenko S.V., Arpentieva M.R., Kassymova G.K. (2019). Motivation of technical university students and its impact on the effectiveness of the educational process // International youth scientific conference "Heat and mass transfer in the thermal control system of technical and technological energy equipment" (HMTTSC 2019). https://doi.org/10.1063/1.5120670

[26] Kenzhaliyev B.K., Iskhakova R.R., Dosymbayeva Z.D. (2015).Sorption Extraction of Noble and Non-Ferrous Metals from Process Leaching Solutions // American Journal of Applied Sciences. 12(11), 875-884. https://doi.org/10.3844/ajassp.2015.875.884

[27] Almagambetova A., Tileubay S., Taimuratova L., Seitmuratov A., Kanibaikyzy K. Problem on the distribution of the harmonic type Relay wave// News of the National academy of sciences of the Republic of Kazakhstan. Series of Geology and Technical Sciences **2019**. 1(433): 242-247 (in Eng.). ISSN 2518-170X (Online), ISSN 2224-5278 (Print). https://doi.org/10.32014/2019.2518-170X.29