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Ecological Feasibility of the Arrangement of River Watersheds in the Reclamation of Agricultural Lands

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Abstract: For an environmental feasibility study of the arrangement of river basins developed and implemented choice integral criteria for the assessment of a natural process and based on their degree of interaction of natural processes river basin Chu.

Key words: Nature · Ecology · Land reclamation · Arrangement · River basin · Criteria · Process · Evaluation · Watershed

INTRODUCTION

Common modern situation of the territories of Transboundary Rivers in Central Asia is characterized by a rather tense ecological status due to absence of a scientifically based system of use of water resources for the development of the productive forces of nature-production complex of the region. This situation is caused by the progressive involvement and development of resource potential of vast territories (in our case watersheds), gain on them technogenic impact and violation of the relationships between natural components in geosystems and in the system «human-nature», which led to deterioration of the ecological state of river basins, especially in the lower reaches.

To solve environmental problems in the basin of the Transboundary Rivers of Central Asia is important to: consider and study the watersheds in the form of geosystems a certain rank, including inter caused by a set of components and developing as a whole; to develop models describing the basic processes of the functioning of the watershed with possibly a large set of parameters that take account of changes of the components of geosystems watersheds in the conditions of anthropogenic activity.

In this regard, Golovanov suggests broadening of the scope of research reclamation [1], consideration of complex melioration, as a basic element of the integrated development; application of reclamation measures to improve the ecological sustainability of watersheds; accounting under irrigation, the ability to be leached soils; development of methods for calculation of water and justification of reclamation in river basins with the deployment of the natural-production complex for the provision of food and industrial needs of the individual.

The integrity of the geo-systemic approach requires a clear definition of the object of study, that is, the object of the study is selected watershed area, which is the integral expression of the strong interdependence between the components of geosystem and the earth's surface. The watershed area is considered as geosystem, United on the principle of unity of hydrochemical threads and executes habitat, or ecological functions [1].

The purpose of the work to develop and test the scheme of basin environmental management for the ecological feasibility of the arrangement of watersheds of the Chu River.

MATERIALS AND METHODS

River basin of the Chu river is located to the West of the basin of the lake Issyk-Kul is the largest in the Northern Tien Shan. Flat surface Chu Depression gradually decreases from 1300 m to the East up to 120 m in the West. Morphological border Chu Depression from

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Table 1: Composition of the administrative districts within the boundaries of the river basin Chu

Designation		Area, thousandsq. km		Population, thousandpeople	
Republic	Region	Total	Inpercentage%	Total	Inpercentage%
Kyrgyzstan	Chui	26.6	39.4	810.0	56.8
Kazakhstan	Zhambyl	40.9	60.6	615.0	43.2
Total	67.5	100	1425.0	100	

Table 2: The Generalized quantitative assessment of operational water resources in the basin of the river Chu

	Waterresources (km3)			
Republic	Zone of formation	Sourcetype «Karasu»	Returnwater	Operationalresources
Kyrgyzstan	3.20	1.29	0.81	5.30
Kazakhstan	0.38	-	-	0.38
Total	3.58	1.29	0.81	5.68

the South serves Kyrgyz range (4894 m) and hilly sand plain Moinkumfield, descending in the West from 660 to 200 m [2].

To the Chu river are transboundary watercourses, the length of which 1,067 km, basin area 62500 km2. It formed at the confluence of the Dzhuvanaryk and Kachkar originating from glares in ranges of Kyrgyz and Terskey-Alatoo. The average consumption of water at the outlet from the mountains, where the area of the basin is approximately 25,000 km2, - 130 m3/s the maximum flow in July and August, at the end of July and in early August it dries up, in Decemberresumes. Main tributaries: from the right side - the Chon-Kemin, Yrgayty, Kokpatas;from the left side - Alamedin, Aksu, Kurgaty.

The territory of the Chu river basin occupies the area of 200.36 thousand km2, of which 164.56 thousand km2 in Kazakhstan [2]. The distribution of this area in administrative districts shown in Table 1.

In the basin of the rivers Chu population is 1425.1 thousand people, of them live in rural areas - 883.0 thousand people and in the urban - 542.1 thousand people.

In the basin of the rivers Chu directly under the agricultural lands occupy about 78%, under the plough land - 13%.

Significant areas occupied irrigated lands with a total area of composition is 473.4 thousand hectares, the Main irrigated land is concentrated in the middle part of Chu valley - 435.1 thousand hectares In the upper reaches of the rivers Chu focused 33.1 thousand ha and only 5.2 thousand hectares in its lower reaches.

Quantitative assessment of river flow of the rivers Chu summarized on the basis of materials of observations Kyrgyzhydromet for the period 1980-2002 year and the method of analogy to the rivers which no data are given in Table 2.

Available water resources of the Shu river are W_p= 4.87 km3 and taking into account return flows, W_p = 5.68 km3.

Creating a Model of Integrated Assessment: Dokuchaev [3] and his disciples Kostyakov [4] and Brudastov [5] and inherent school melioration science considers the deep science approach to improve land as part of the whole natural-territorial complex of associated interdependence component properties of natural objects and the close relationship between the processes of their operation [6-9].

As a working hypothesis put forward by Kolomyts [10] the position of the structural levels of landscape organization, fledge at a conceptual model of a landscape as hierarchical control systems, where each geocomponent is considered in the system of structural levels "background-frame-processor pattern" [11]. In this background and frame to form a processor input variables and types of landscapes and the resulting characteristics of their functioning act as the system output.

In order to assess the physical and geographical background and landscape frame used indicators of the natural environment: degree of absolute heights (ΔH), the amount of biologically active temperatures ($\Sigma t^o C$), duration of frost-free period (T_o), evaporation (E_o), the amount of air humidity deficit (Σd), photosynthetically active radiation (R), the average annual temperature (depth of groundwater) (Δ), the work performed by the flow of groundwater ($A_i = v^2 . m . g/k$ where g the acceleration of gravity; m - coefficient of filtration; v- the weight of the fluid; v-velocity of groundwater flow).

For the evaluation of soil-meliorative condition of landscape-geographic zones can be used ecological-meliorative potential of the landscape ($\overline{M}$), which characterizes the work ($\overline{A}n$) perpetrated by a liquid in the process of precipitation relation to soil solution concentration ($\overline{C}_n$). That is, they can be considered as the ability of a system «soil - ground water and topsoil exempted from easily soluble salts: $\overline{M}=\overline{A}_n/\overline{C}_n$ where: $\overline{M}$ - ecological-meliorative potential or meliorative indicator of landscape; $\overline{A}_n$ - the work in the elementary volume flow of water infiltration in the soil layer; $\overline{C}^*$ - average concentration of salts in the system of surface water - soil - ground water» [9]:

$$\overline{A}_n = O_c/[\frac{R}{L}-(1-t)\frac{R}{L}(1-\overline{\Delta})],$$

$$\overline{C}^* = \left[C_o + (1-t)\frac{R}{L}(1-\overline{\Delta})\cdot C_\Gamma / O_c\right]/C_{rid},$$

where: C_o is the initial concentration of soil solution in the soil layer; C_{rid} permissible concentration of salts in the soil solution, which corresponds to the parameter of non-saline soils; C_Γ- the salt concentration in groundwater; $(1-t)$ - the duration of the infiltration (t = T/365), T - duration of the vegetation period; Δ - depth of the groundwater table.

Undivided system blocks the natural system of the «framework of the processor assessed using the following indicators [11]:

- Annual amount of precipitation (O_c);

The intensity of moisture exchange inside between soil and groundwater ($\overline{g}=g/(O_c+O_p)=\exp(-1.5\overline{R})$);

Evaporation index ($\overline{E}=E/(O_c+O_p)=\sqrt{\overline{R}\cdot th(1/\overline{R})(1-ch\cdot\overline{R}+sh\cdot\overline{R}}$, where E - evaporation from the soil surface, mm; O_p-net irrigation rate; *th,sh,ch*- hyperbolic tangent, the sine and cosine) the runoff coefficient ($\overline{C}=1-\overline{E}$).

Processor (internal geo flows) natural system evaluated using agro-climatic parameters: hydrothermal coefficient (HTC = 10 . $Oc/\Sigma t$), indicator humidification ($M_d = O_c/\Sigma d$), the coefficient of moisture ($K_w = O_c/E_o$), assessment of humidification ($Ko = Oc/0.18\Sigma t$), aridity index ($\overline{R}=R/LO_c$), energy coefficient of heat moisture transfer ($K_m = LE/P$, где P- heat transfer; LE - the costs of heat for evaporation);

Landscape pattern of the natural system of assessed with the natural environmental performance [11]:

Biological productivity of the soil [6]:

$$\overline{B} = B/PY = \alpha_1\cdot\overline{R}\cdot\exp(-\alpha\cdot\overline{R}),$$

where PY-the potential biochemically provided yield of agricultural cultures under optimum conditions; α-coefficient taking into account the state of vegetation; α_1-proportionality; B- biological productivity of the soil reclamation;

The energy which goes on soil formation [12]:

$$\overline{Q} = Q/R = \exp(-\alpha_o\cdot\overline{R}),$$

where Q is the energy which goes on soil formation, kcal/cm2 / year; α_o -coefficient taking into account the state of the soil surface;

The index of the soil [13]

$$S = [6.4(G_{hH}+0.2G_t)/600] + 8.5\sqrt{N\%\Phi\%K\%}\cdot 5.1\cdot\exp[(H_g-1)/4],$$

where G_{hu} - humate humus, t / ha; G_t - fulvic humus, t / ha; $N\%\Phi\%K\%$ - respectively the share of allowable floor or acceptable standards of nitrogen, phosphorus and potassium in relation to their content as possible; H_g-hydrothermal meq/100 g soil acidity;

An indicator of a favorable climate [13]:

$$CL = \sqrt{\left[arctg\left[(T-6^o)/4\right]+1.57\right]}\cdot\sqrt{\left[arctg\left[(HF-112)/4\right]+1.57\right]}$$

where T - the average annual air temperature, °C; HF-performance indicator humidification defined by the formula Volobuev: $HF = 43.2IgO_c - T$).

Thus, the strategic objectives of ecological and geographical dynamics forecasting components of river basins in terms of human activities need new scientific and methodological approaches to the territorial organization of the natural system of river basins, as major changes spatio- temporal scales occur in these natural objects due to the intensive use of natural resources and the distribution of productive forces.

RESULTS AND DISCUSSION

Under a complex arrangement of watersheds implies a holistic system of gradual measures on large genetically homogeneous areas (watersheds), creating cultural landscapes, where nature is optimized on a scientific basis and increase land productivity while retaining and, if necessary and improve the overall ecological stability of landscapes, which is determined by the natural energy resources (landscape background and framework) river basins (Table 3).

Table 3: Natural-climatic resources landscapes of the river basin Chu

Meteorologicalstations	H, м	T_v, day	t_i, °C	R, кДж/ см^2	$\Sigma_t oC$	E_o, мм	Σ, мб
Mountainlandscapesclass							
Tuya-Ashu	3090	70	-1.7	88.2	514	200	519.7
Karakudzhar	2800	115	-0.4	100.5	834	410	994.3
Piedmontsubclasslandscapes							
Baytyk	1579	123	6.2	126.9	1513	600	1589.0
Kordai	1145	167	9.2	182.8	2900	880	2247.8
Piedmontplainslandscapessubclass							
Bishkek	756	191	10.3	200.0	3400	990	2360.7
Merke	703	187	8.6	192.1	3200	960	2522.3
Plainlandscapesclass							
Tolebi	456	186	9.8	207.6	3700	1020	3095.7
Moiynkum	351	184	8.4	200.0	3400	1020	2552.9
Kamkaly-kol	207	185	9.1	219.2	3900	1180	3477.0

Table 4: Ecological-meliorative indicator of landscape system of river basin Chu

Meteorologicalstations	H, м	C_o, г/л	C_g, г/л	Δ, м	$\bar{A}_n$	$\bar{?}$*	$\bar{M}$
Mountainlandscapesclass							
Tuya-Ashu	3090	0.30	1.00	10.0	1.67	0.60	-
Karakudzhar	2800	0.30	1.00	10.0	0.76	0.60	-
Piedmontsubclasslandscapes							
Baytyk	1579	0.40	1.20	10.0	0.86	0.80	-
Kordai	1145	0.40	1.30	10.0	0.30	0.80	0.38
Piedmontplainslandscapessubclass							
Bishkek	756	0.50	1.50	6.0	0.41	1.00	0.41
Merke	703	0.50	1.50	6.0	0.29	1.00	0.29
Plainlandscapesclass							
Tolebi	456	0.60	3.30	3.0	0.13	1.70	0.08
Moiynkum	351	0.90	3.50	3.0	0.14	2.00	0.07
Kamkaly-kol	207	1.50	6.00	3.0	0.12	2.50	0.05

The ability of natural systems performed in an elementary volume flow of infiltration water in a soil layer, which is characterized by ecological-reclamation indicators of the landscape which are of major importance in the soil-meliorative zoning landscape-geographical zones (Table 4).

As seen from Table 4 work in an elementary volume flow in-infiltration waters, the soil layer ($\bar{A}_n$) from the side of the mountain tothe lowland areas is gradually reduced and the average salt concentration in the system of surface water - soil - ground water» ($\bar{C}$*), on the contrary, increases. Therefore, the ecological-meliorative potential or meliorative landscape indicator ($\bar{M}$), subject to the law of vertical zonality is reduced. This pattern shows the available opportunities for the formation of the process of soil salinization in the lowland parts of the river basin Shu, resulting in a deterioration of the soil-meliorative condition of landscapes.The main natural function of the river basin («frame - processor»), first – flow forming and this is the fundamental importance of the division of the territory, the second - in a special way the united geosystems (the principle of unification and unity of the hydrogeochemical streams of one object for its unloading), perform important environmental forming or ecological functions, in - thirds spatial basis for nature management (allocation of lands of different purpose, including agriculture, human settlements, industry, transport, waste disposal) and environmental arrangement (Table 5).

That is the trinity functions of the river basin, which define the scientific and practical expediency of dividing the territory on the watersheds of different sizes, in which opens the possibility of comprehensive assessment of the territory and water bodies, elaboration of common program for improvement, taking into account the interests not only of individual land and water users, but also the interests of all the people living on it and restoration and preservation of nature is very topical.

A comprehensive approach to the organization of reclamation measures, based on the basin and landscape-ecological principles, taking into account systematic research - consideration basins and anthropogenic load

Table 5: Communication of the water and energy balances of landscapes in the basin of the rivers Chu

Meteorologicalstations	H, м	O_c, мм	$\overline{g}$	$\overline{E}$	$\overline{C} = 1 - \overline{E}$
Mountainlandscapesclass					
Tuya-Ashu	3090	698	0.0013	1.000	0.000
Karakudzhar	2800	362	0.0012	1.000	0.000
Piedmontsubclasslandscapes					
Baytyk	1579	513	0.0011	1.000	0.0000
Kordai	1145	264	0.0071	1.000	0.000
Piedmontplainslandscapessubclass					
Bishkek	756	393	0.0078	1.000	0.000
Merke	703	270	0.0061	1.000	0.000
Plainlandscapesclass					
Tolebi	456	132	0.000	1.000	0.0000
Moiynkum	351	132	0.000	1.000	0.0000
Kamkaly-kol	207	139	0.000	1.000	0.0000

Table 6: Heat and moisture landscapes of the river basin Chu.

Meteorologicalstations	H,м	HTC	K_w	Md	$\overline{R}$
Mountainlandscapesclass					
Tuya-Ashu	3090	13.60	3.49	1.34	0.52
Karakudzhar	2800	4.34	0.88	0.36	1.16
Piedmontsubclasslandscapes					
Baytyk	1579	3.39	0.86	0.32	1.03
Kordai	1145	0.89	0.30	0.12	3.30
Piedmontplainslandscapessubclass					
Bishkek	756	1.16	0.40	0.17	2.10
Merke	703	0.84	0.29	0.11	3.40
Plainlandscapesclass					
Tolebi	456	0.36	0.13	0.04	7.10
Moiynkum	351	0.39	0.13	0.05	7.70
Kamkaly-kol	207	0.36	0.12	0.04	11.0

within it as an integrated system consisting of interconnected units (processor(internal geo flows), which are joined based on cause-effect relationships (Table 6).

The quantitative characteristics of natural conditions of heat - and moisture-sufficiency of the basin of the rivers Chu, convincingly suggests that in mountain andpiedmont areas of landscape system can be relatively high productivity of the natural conditions due to full proportionality of heat and water resources, i.e. natural system does not require reconstruction.

System analysis of indicators characterizing the degree of natural heat and moisture, piedmont plains and plain areas of the basin of the rivers Chu and allows to make a conclusion that the observed quantitative change them depending on the vertical zone, requires the need for a comprehensive reconstruction of the natural system, to increase the productivity of landscapes.

However, in a process of transformation or reconstruction of landscapes of river basins on the natural have to create the agro-landscapes or natural-technical systems, where by human activities are balanced heat and moisture, taking into account their natural regime.The purpose of complex development of the watershed is the creation of so called by cultural landscapes, including land for different purposes, in which the activities of a person is optimized on the scientific basis for man and nature, i.e. it is necessary to complex construction are not certain lands and large genetic homogeneous territories landscapes, watersheds based on the assessment of heat and power-geo security landscape system [9]. This concept is broader complex melioration of lands, although it is in any case it does not rule out complex melioration of certain types of land, in reasonable scale, are basic in this arrangement, but not the only.

For the most effective arrangement of landscape systems of river basins need more agro-ecological assessment of the area, which provides a reflection of a more differentiated picture agro geochemical patterns and allows to increase the objectivity of assessment of the ecological state of soil and vegetation cover, that is, the landscape pattern of the natural system (Table 7).

Table 7: Ecological state of soil and vegetation cover properties landscapes of the river basin Chu

Meteorologicalstations	*H*, м	*HF*	*Q*, кДж/cm^2	$\overline{B}$	*CL*	*S*
Mountainlandscapesclass						
Tuya-Ashu	3090	101.40	69.37	0.0678	0.72	5.10
Karakudzhar	2800	123.40	57.98	0.0700	0.70	6.80
Piedmontsubclasslandscapes						
Baytyk	1579	124.60	78.52	0.0818	0.92	12.90
Kordai	1145	98.80	38.79	0.0458	1.59	11.92
Piedmontplainslandscapessubclass						
Bishkek	756	108.70	75.16	0.0416	1.60	12.40
Merke	703	101.50	33.22	0.0415	1.58	7.50
Plainlandscapesclass						
Tolebi	456	98.30	7.43	0.0004	1.59	5.40
Moiynkum	351	88.00	4.58	0.0001	1.61	5.00
Kamkaly-kol	207	81.00	1.21	0.0001	1.41	5.00

As can be seen from Table 7, in the mountain and piedmont of the basin of the rivers Shu, unlike the piedmont plains and plain zones, quite intensive biological cycle ($\overline{B} \to \max,\ Q \to \max$).

Biological productivity ($\overline{B}$), energy consumption for the soil formation process (*Q*), along with the efficiency of the humidification (*HF*), the index of the soil (*S*) and the coefficient of usefulness of climate (*CL*) adequately represents the type of soil and soil fertility in the river basins.Modern state of the watershed areas of the rivers Chu determined significant exploration and functioning in them natural-technogenic complexes, which were shaped by the impact of technogenic factors. Among them significant influence on the watershed impacts of agro-industrial complex, which is accompanied by loss of soil fertility, degradation of grassland, violation of the hydrological and hydrochemical regimes, especially in the lowlands. The main pollution sources are return waters from irrigated agricultural land and waste water from industrial and municipal enterprises of the cities. The comprehensive development of the watershed provides for the creation of environmental infrastructure: enhancement, restoration and preservation of the hydrographic network; introduction of adaptive-landscape farming and land reclamation; hard rationing the maximum permissible level of water demand of agricultural land; the environmentally safe disposal of sewage and return water in the watershed.

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