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LANDSCAPE PLANNING OF THE KAZALY IRRIGATION ARRAY OF SOUTHERN KAZAKHSTAN

Amanzhol KUDERIN
Institute of Geography of Ministry of Education and Science of Kazakhstan, Almaty, Kazakhstan
kuderin@list.ru
Irina SKORINTSEVA
Institute of Geography of Ministry of Education and Science of Kazakhstan, Almaty, Kazakhstan
skorintseva@mail.ru
Tatyana BASSOVA
Institute of Geography of Ministry of Education and Science of Kazakhstan, Almaty, Kazakhstan
tbassova@mail.ru
Victoria KRYLOVA
Institute of Geography of Ministry of Education and Science of Kazakhstan, Almaty, Kazakhstan
v_krylova@inbox.ru
Bella KRASNOYAROVA
Institute for water and environmental problems, Barnaul, Altai Krai, Russian Federation
bella250352@mail.ru

Abstract

The study presents the results on landscape planning of the Kazaly irrigated land located in the lower streamflow of the Syrdaria River. Land degradation (74.1% of the territory) and a revision of the land use is led by the injudicious use of irrigated land (387.6 thousand ha) for agriculture not considering the features of landscape. The results were obtained based on the use of the maps (topographic and land cover), land use patterns (1965-2017), remote sensing data (Landsat 8). The determined structural organization of landscapes irrigated land is represented mainly alluvial plains, the valley complex with the territory 80.4% of the total area of massif. The study gives the analysis of changes dynamics of irrigation areas for 1960-2017 (2.8-22.0 thousand hectares) and qualitative assessment of the condition of agricultural land. The result of the study was complex of maps that contribute to solving problems of agricultural irrigated land management.

Keywords: *landscape planning, natural complex, agricultural land, balanced land use, mapping*

1. INTRODUCTION

Long-term and irrational use of land of southern Kazakhstan in agriculture (especially under regular irrigation) led to the emergence and aggravation of landscape-environmental problems: reduced productivity and sustainability of land, development of degradation processes (soil salinity, water and wind erosion, and etc.). About 150.8 million hectares of agricultural land is various degrees susceptible to various degrees of degradation processes on the territory of Kazakhstan, 38% of them on southern Kazakhstan (Summary analytical report on the state and use of land of the Republic of Kazakhstan for 2017).

One example of irrational agricultural use is Kazaly lands, located in the desert zone in the Kyzylorda region in the territory of southern Kazakhstan (Figure 1).

Figure 1. Kazaly irrigation lands, Kyzylorda region, Kazakhstan.
Source: http://google.com/maps

The large-scale development of the irrigated area in 1980-1995, uncontrolled water extracting from the Syrdarya River disregarding the natural and ecological features of the region led to land degradation.

A lot of farms located in the study area in the pursuit of profit do housekeeping "blindly" based on their own intuition not using scientifically based research on the regulation of agricultural loads on natural complexes. These household farms contribute to the development of land degradation.

About 72% of the territory of irrigated lands susceptible to degradation processes to degradation of the soil cover. The processes of secondary soil salinity affected 48.2% of the irrigated arable land (Summary analytical report on the state and use of land of the Republic of Kazakhstan for 2017). As a result of the secondary soil salinity the areas of irrigated arable land are annually removed from agricultural sector. 2.2 thousand hectares of irrigated land were removed in 2015; 6.4 thousand hectares were transferred to the category of waste land in 2017 (Summary analytical report on the state and use of land of the Republic of Kazakhstan for 2017). There is a decrease of yield of grain, fodder and vegetable-melon crops by 25-38% and also the gross yield of crop production by 32% as a result of a decrease in the productivity of irrigated arable land over the past 9 years. Under current conditions there is an urgent need to develop a landscape planning scheme for an irrigation land that ensure its sustainable development.

2. DATA AND METHODS

2.1 Data sources

In order to estimate the area of degraded land, we used statistical data of the structure of land use (1965-2017), indicators of the qualitative and quantitative state of land (2015-2017) (Summary analytical report on the state and use of land of the Republic of Kazakhstan for 2017), remote sensing data (Landsat 7 and 8) (2017) and field survey materials of the environmental condition of the irrigated land (2015-2017). A topographic map (1: 200,000) (Kazgeodeziya, 2016), soil and vegetation maps (1: 200,000) (Fund materials of the Institute of Geography of the Republic of Kazakhstan, 2015) were used for mapping a landscape of the Kazaly irrigated land.

2.2 Methods

The landscape-resource potential safety and the achievement of a balanced agricultural use of natural resources of the Kazaly irrigation array are possible through the implementation of landscape planning methods. It reflects both landscape-ecological and socio-economic aspects of environmental management and is used for the agricultural management of the territory.

The balance of agricultural sector is determined by the interaction researches that study: natural systems, agricultural environmental management, assessment of natural resource potential, based on the landscape-ecological approach (Zetterberg et al., 2010; Hulse et al., 2016; Adriaensen et al., 2003; Bishop and Lange, 2005; Ozyavuz, 2012; Wang et al., 2012; Paar, 2006). World experience in landscape planning is based on component analysis of natural complexes (Kiryushin, 2011; Orlova, 2014). Landscape management of the territory is the basis of landscape planning, where the main tasks are identification of the possibilities of developing natural complexes, including agricultural production (Brown et al., 2000; Pascual-Hortal and Saura, 2006; Kazakov, 2007).

The study of the Kazaly irrigation array for landscape planning included next stages: inventory of agricultural land use; analysis of natural systems and agricultural production; agricultural impact assessment, landscape and ecological condition; determining the environmental sustainability of natural complexes and parameters of balanced agricultural of natural resources in the existing natural complexes.

Local properties of natural complexes and their morphological parts were aligned at each stage. The leading one was the method of field landscape-ecological mapping (Chupakhin and Andriishin, 1989; Geldyeva and Plokhikh, 2016). Classification construction of a landscape map was based on the historical, genetic and structural approaches of the study of landscape structure (Geldyeva and Veselova, 1992; Drazic et al., 2014). The selection of taxonomic units of natural complexes on the landscape map is based on morphological structural and bioclimatic features. The following system of units is marked on the created landscape map of the Kazaly irrigation array: type - class - subclass - landscape kind– complex of natural boundaries - natural boundary considering the typological classifications of natural complexes of Kazakhstan (Geldyeva et al., 2004). The main mapped unit on the landscape map is natural boundaries. A natural boundary is a morphological part of the natural complex characterized by facies differentiation of lithology, relief morphology, humidity conditions, microclimate conditions and differences in landcover.

The use of methods of remote sensing of land and GIS technologies enabled to determine the level of agricultural impact and manifestation of degradation processes in natural complexes of irrigation land, the optimal ratio of agricultural land areas (arable land, pastures, haymaking, perennial plantings, etc.) (Ozyavuz, 2012; Brown et al., 2000; Vishwakarma et al., 2016).

The assessment of the agricultural impact on the natural complex was based on the integral indicator and was calculated using the equation 1 (Geldyeva et al, 2004):

$$C_v(i) = (W1(i) + W2(i) + ... + Wn(i) \quad (1)$$

where Cv (i) is the integral impact index for the i-th natural complex; Wn(i) is an indicator of the value of the impact n-th factor for the i-th landscape.

Factors of impact were rated on a scale. The integral index was estimated by the sum of the factors, on the basis the levels of agricultural impact are highlighted - weak, medium and strong.

The method for determining the sustainability coefficient (C_{es}) was used to assess the environmental sustainability of natural complexes. It based on the determination and comparison of the areas occupied by various agricultural lands, their positive or negative impact on the environment, which is calculated by the formula 2 (Geldyeva et al., 2004):

$$C_{es} = \frac{\sum_{i=1}^{n} S_{sle}}{\sum_{i=1}^{m} S_{ule}} \tag{2}$$

where S_{sle} - areas occupied by stable landscape elements (forest, trees and shrubs, deposits, hayfields, pastures, perennial grass crops on arable land); S_{ule} - areas occupied by unstable landscape elements (rain-fed and irrigated arable land, private lands, land under construction and amelioration).

The stability of the natural complex was assessed according to the following scale: ≤ 1.0 - unstable condition; 1.01 - 3.00 - weakly stable condition; 3.01 and more – stable condition.

Field survey methods allowed collecting qualitative and quantitative data of the natural complexes condition used for agricultural development and conducting their landscape-ecological assessment (Ozyavuz, 2012; Kiryushin, 2011). The modern landscape environmental condition of natural complexes of agricultural use is assessed according to the indicators presented in Figure 2.

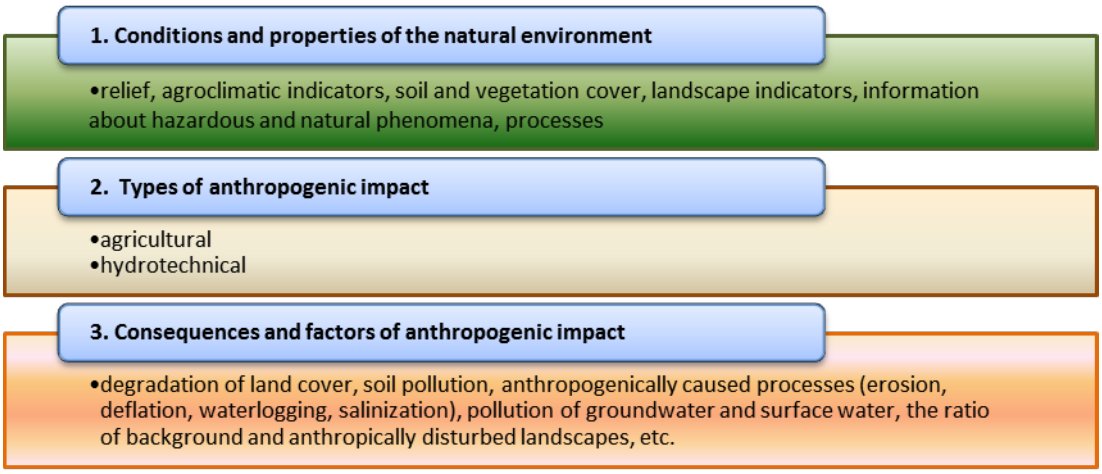


Figure 2. Estimated landscape and environmental indicators.

The level of the landscape and environmental condition was determined for natural complexes of agricultural target considering the character and degree of disturbance of the leading components of the natural complex. The total score of all the above-mentioned indicators was calculated using formula 3 for assess the overall landscape and environmental condition, followed by adjustment for specific types of landscapes.

$$C_{ec} = K_1 + K_2 + \ldots + K_n \tag{3}$$

where C_{ec} – general landscape and environmental condition; K - the criterion of environmental condition; 1 + 2 + ... n - the number of indicators (criteria) for the assessment of the determined parameters of the environmental condition for all assessment groups.

A landscape planning scheme for the Kazaly irrigation array was created for the purposes of balanced agricultural management based on contained research methods. There are zones were highlighted of intensive, moderate and limited agricultural use of the territory, also the zone with the regime of restoration of natural systems, where agricultural use is prohibited. The irrigation area was zoned by functional use with the allocation of protection, buffer, forest protection and water protection zones.

The use these approaches and methods made it possible to consider this region as an open dynamic system that provides balanced agricultural environmental management and solves the problems of land degradation.

3. RESULTS AND DISCUSSION

3.1 Structure of the landscape organization of the territory

Landscape planning of the Kazaly irrigation array is aimed to determine a balanced agricultural use of natural resources, at obtaining the maximum yield of agricultural products and preserving the environmental stability of desert complexes of agricultural use. The natural complexes of the massif were considered from the point of view of their importance for agricultural development during the study.

Landscape map of the Kazaly irrigation array with a scale 1:200000 is a scientific basis for monitoring agricultural use lands in natural complexes (Figure 3). 33 types of Natural boundaries were identified on the map in total. The landscape map is contended an unfolded legend.

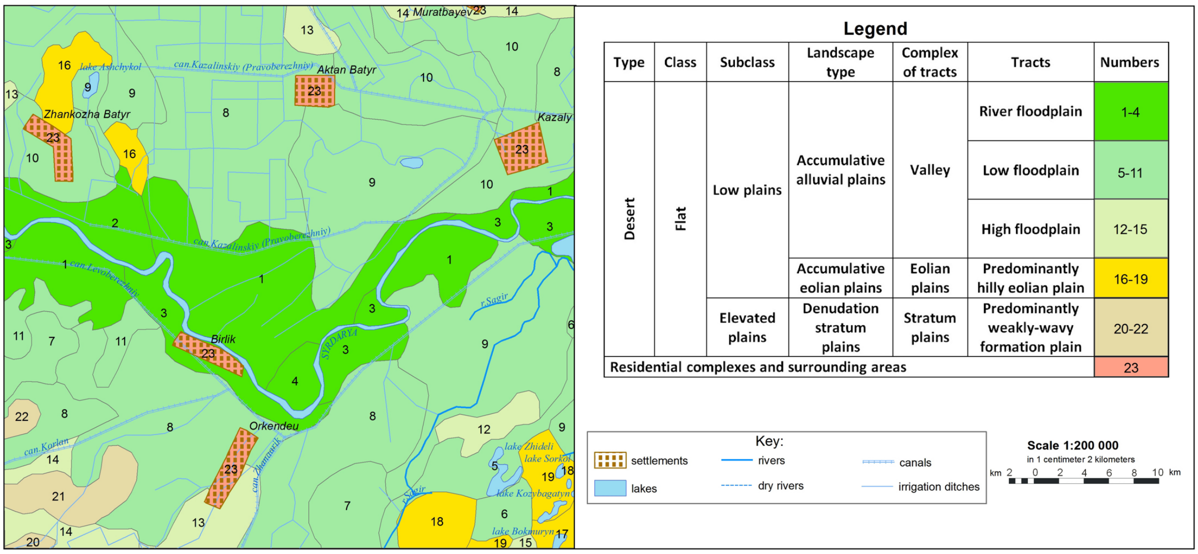


Figure 3. Fragment of the landscape map of the Kazaly irrigation land.

We present a fragment of the unfolded legend to the landscape map of the Kazaly irrigation array:

Natural boundaries of low floodplain

8. Flat wetland floodplain, complicated by oxbows and lakes with carex-phragmites, tubers-scirpus, large-grained vegetation on marsh and meadow-marsh soils, in places with the participation of meadow solonchak.

9. Flat gently sloping floodplain complicated watercourses, canals and ditches with sedge and reed, reed-forb-grass, shrub, licorice, halophytic grass vegetation with irrigated and saltwort-sornotravnyh fallow land in the meadow and marsh, sometimes dries, alluvial -land soils, meadow and secondary saline soils.

10. Flat weakly sloping floodplain complicated by sinks and lakes with reed-grass-large-grass, shrub, small-grass-saltwort vegetation on meadow-marsh, sometimes drying soils, alluvial-meadow soils and saline saline.

It was determined that the structure of the natural complexes of the Kazaly irrigation lands is attributable to paleogeographic, geological, geomorphological, orographic, climatic conditions and the diversity of land and vegetation cover. The main factors of differentiation of agricultural use in the territory are the features of the relief and soil and vegetation cover in the context of landscape planning. Table 1 shows the structure of the landscape organization of the Kazaly irrigation lands.

Table 1. Structure of the landscape organization of the Kazaly irrigation lands

Landscape type	Complex of natural boundaries	Characteristics of the complex of natural boundaries
Accumulative alluvial plain	Valley complex	It is composed of sand, loam, sandy loam, gravel and pebble with large-grass, riparian, grasslands, salinity-halophyte grass vegetation on meadow-marsh, alluvial-meadow soils and salt marsh. It includes: - the river floodplain (legend numbers 1-5); - the low floodplain (legend numbers 6-12); - the high floodplain (legend numbers 13-22)
Accumulative eolian plain	Complex of the eolian plain	It is composed of sand, sandy loam with ephemeral-wormwood with shrubs and meadow grasses on the sands. It includes the predominantly hilly aeolian plains (legend numbers 23-27)
Denudation stratum plain	Complex of the stratum plain	It is composed of clay, loam, sandy loam with keyreuk-wormwood, boylych vegetation on gray-brown and takyr-like soils. It includes the undulating plains (legend numbers 28-31)
Takyr		It is composed of clay, mostly devoid of vegetation (legend number 32)

There are natural boundaries of river valley, aeolian and stratum plains characterized by relatively high level of landscape diversity and significant frequency of occurrence in the landscape structure of the Kazaly irrigation array. The most interesting are the natural complexes of valleys, aeolian and partly stratum plains for the aggregate of natural factors that form the resource potential by agricultural use of natural resources.

A cartographic analysis of the structural organization of landscapes of the Kazaly irrigation array showed that landscapes of alluvial plains are represented by a valley complex of natural boundaries (22 types of natural complexes). It is occupied 80.4% of the total area of the array. Valley complex is distributed in the central, northern and southeastern part of the irrigation lands. The soil and landscape conditions of the valley complexes are quite dynamic and are largely determined by the water regime of the Syrdariya River.

Nature boundaries are distinguished within the valley complex: the river floodplain (9.5% of the irrigated area), low floodplain (33.2%) and high floodplain (37.8%).

A quantitative analysis of the landscape structure of the irrigation array was used as a basis for landscape planning objectives of agricultural use. It includes: counting the types of natural complexes, their area and repeatability, the area of individual groups of the natural boundaries and their share of the total area of the array. It made possible to calculate the coefficients of landscape fragmentation and complexity of landscape design (Table 2).

Table 2. Quantitative characteristics of the structural organization of natural complexes of the Kazaly irrigation array

Indicators \ Natural boundaries	River flood-plain	Low flood-plain	High flood-plain	Hillocky aeolian plain	Slightly undulating stratum plain	Average value
Area of natural boundaries, km^2 (S)	372	1301,7	1481,7	378,7	388,7	785
The fraction of the total area of the array, %	9,5	33,2	37,8	9,6	9,9	20
Number of types of natural boundaries (m)	5	7	10	5	4	6
Number of selected contours (n)	28	44	65	43	37	44
The average number of contours per one natural boundaries (p=n/m)	5,6	6,3	6,5	8,6	9,2	7,3
Average contour area (S_0=S/n), km^2	13,3	29,5	22,8	8,8	10,5	17,8
Index of frequency of occurrence of the natural boundaries of this group in the region ($W=m/m_{total}$)	0,16	0,23	0,32	0,16	0,13	0,19
Coefficient of landscape fragmentation, in fractions of a unit ($K_{lf}=1 – S_0/S$)	0,974	0,977	0,984	0,973	0,972	0,977
Landscape design complexity factor (K_{cf}=p-n/S-S_0)	5,52	6,26	6,45	4,89	3,52	5,3

The calculation of the contour average area in a particular natural boundary allowed for planning to develop a balanced size of irrigated areas and areas for grazing. The index of the frequency of occurrence certain natural boundaries within the Kazaly irrigation lands can be used for determination of the spatial distribution of agricultural units and establish the fractional distribution of irrigated arable land and other types of agricultural land. The highest frequency index is characteristic for low and high floodplain (0.23 and 0.32, respectively) and the lowest for slightly undulating stratum plain is 0.13.

3.2 Dynamics of irrigated areas (1960-2017 years)

The Kazaly irrigation lands cover an area of 387.6 thousand hectares, 300 thousand hectares of them suitable for irrigation. Currently only 22.0 thousand hectares of land are irrigated regularly. In the general structure of agricultural land of irrigated array, pastures account for 60.6%, irrigated arable land 35.7%, hayfields 0.8% and a deposit of 2.9% of its territory (Summary analytical report on the state and use of land of the Republic of Kazakhstan for 2017). The period from 1965-1985 is characterized by a rapid increase in the area of irrigated lands; they amounted to 32.5 thousand hectares by the end of 1985. At the same time, the annual increase in irrigated land was 1.2 thousand hectares. From 1985 to 2017, there was a decrease in the growth rate of irrigated lands from 32.5 thousand hectares to 22.0 thousand hectares (Figure 4) (Agriculture of Kyzylorda region of Kazakhstan, 2017).

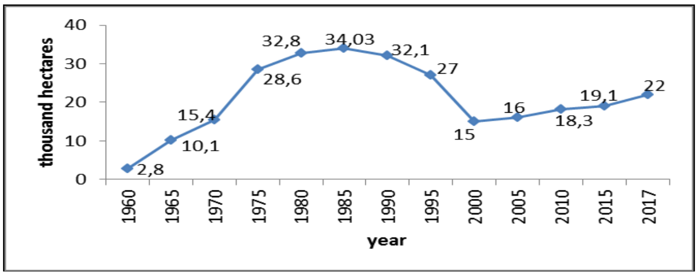


Figure 4. Dynamics of irrigated lands of the Kazaly irrigation array, thousand hectares.
Source: http://old.stat.gov.kz/faces/kyzylorda

About 89% of the territory of the array is used for agricultural production. The main agricultural crop is rice; it occupies 75% of the region sown area. An analysis of data for the 50 year period on rice crops, average yield and gross harvest showed that in recent years there has been a sharp decline in this production. If in 1985 the average yield of rice was 50.2 centers per hectare, by 2017 it decreased and amounted to 24.5 centers per hectare (Figure 5) (Agriculture of Kyzylorda region of Kazakhstan, 2017).

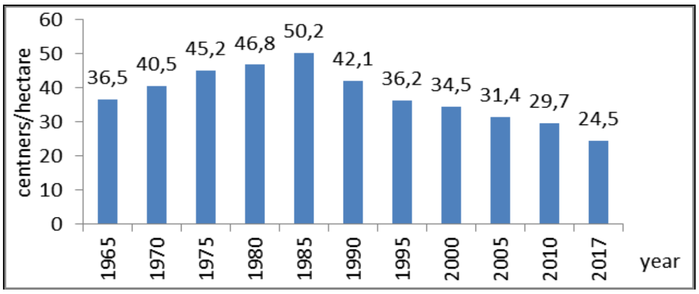


Figure 5. Dynamics of rice yield on the Kazaly irrigation lands.
Source: http://old.stat.gov.kz/faces/kyzylorda

3.3 Landscape and ecology condition of the agriculture lands

The assessment of agricultural impact on natural complexes allowed identifying the main environmental problems of the irrigation array and was a necessary step in the development of a landscape planning scheme. It has been established that 8% of the array territory is subject to a weak level of agricultural impact. This territory covers a complex the slightly undulating stratum plain and hilly aeolian plains, which are mainly occupied with livestock grazing. About 25% of the territory of natural complexes of high and low floodplains is subject to the average level of impact; this territory is used as pastures and hayfields. Pasture load here is 60-75 heads of sheep and goats per 100 hectares of land. 67% of the territory of the array has a high level of exposure. There is a high pasture load (more than 145 sheep per 100 hectares of pasture land) in the valley complex (river, low and high floodplains), where irrigated lands are concentrated.

This region has undergone irreversible environmental changes associated with agricultural use of natural resources and ill-considered water management policies of 1975-1985 in terms of landscape and ecology. The agricultural development of the array under conditions of an unregulated water consumption system, as well as underreporting of the structural organization and internal interrelationships of natural complexes under pasture and irrigation impacts, predetermined the development of degradation processes and deterioration of the ecological and land reclamation conditions of the array (Table 3) (Geldyeva et al., 2004).

The analysis of the qualitative condition of the natural complexes of agricultural use of the array showed that there is an annual loss of productivity of agricultural lands due to the loss of soil fertility (salinity, loss of humus, etc.).

The humus content of the irrigation array soils is low and varies in the arable horizon from 0.51 to 2.6%. Soils have different degrees of salinity; there is distinguish soils of sulphate-chloride, sulphate, sulphate-soda and chloride types of salinity. The medium salinity soils prevail that occupy an area of 64.3%, slightly saline, respectively, 22.6% and strongly saline 13.1% (Geldyeva et al., 2004; Karlykhanov et al., 2016).

"Nomadic agriculture" is practiced as a result of the processes of secondary salinity on irrigated land; the main idea of it is developed new areas for irrigation and old ones are abandoned annually. Erosion processes are also widely developed and are represented by plane and linear erosion. Planar water erosion is manifested in the form of erosion of the surface soil horizons, which reduces the content of humus in the soil. 54.1% of the land area of the irrigation array was to a varying degree affected by water and wind erosion in 2017.

Table 3. Dynamics of development of land degradation of the Kazaly irrigation array, %

Natural complexes	Stages of development of irrigation array, years		
	1960-1975	1976-1995	1995-2015
Increase in the area of saline soils, year			
1The valley complexes	4	6-10	42
2 The complex of the eolian plain	3	4-7	20
3 The complex of the stratum plain	2	3-6	25
Growth of eroded areas, year			
1 The valley complexes	1	2- 4	5-7
2 The complex of the eolian plain	less than1	1-3	2-4
3 The complex of the stratum plain	1,5	2-3	4-6
Reduction of humus in soils, year			
1 The valley complexes	0,8	3-5	11-15
2 The complex of the eolian plain	0,2	1-3	4-6
3 The complex of the stratum plain	0,6	2-3	5-7

It was established that about 42.2 thousand hectares of arable land were removed from agricultural use in the irrigation lands from 1980 to 2015. Losses from the withdrawal of these lands amounted to 12002.5 thousand dollars, while losses from a decrease in yields (rice, vegetable melons and forage crops) are determined at 950.0 thousand dollars.

Significant part of the irrigation array is used for livestock grazing. In recent years, there has been an increase in the number of sheep and goats. The number of sheep and goats in farms increased by 2.5 times and amounted to 72.5 thousand compared with 2010 (Agriculture of Kyzylorda region of Kazakhstan, 2017). Unsystematic use of pastures under grazing and irregular pasture loads led to the degradation of pasture vegetation especially around settlements.

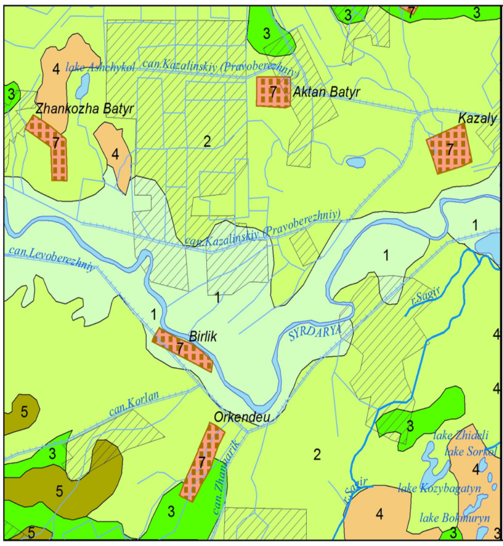
It was established the species composition of the grass stand on all types of pastures in the massif deteriorated for 1960–2017. Particularly the greatest transformations were the grain (Agropyron fragile, A.desertorum Stipa sareptana), which, when grazing, transformed into wormwood and shrub, and, with strong grazing became grassy. So their area decreased by 3.9 times (from 60.1 to 15.4 thousand hectares) from 1980 to 2015 (Ogar, 1998; Summary analytical report on the state and use of land of the Republic of Kazakhstan, 2017).

A qualitative reorganization of plant communities took place as a result of changes in the hydrological regime of the Syrdarya River and excessive mowing on the region. The floodplain meadows were on the verge of extinction: mono-dominant thickets from Phragmites australis transformed into (Inula britanica, Lythrum saliracia, Glycyrrhisa glabra) reed and grass communities (Acroptilon repens, Pluchea caspia, Chenopodium album, Polygonum patilum, Xantium strumarium). The area of reed grasslands has decreased by 6-7 times, the yield has decreased to the level of pasture yields and is 1.5-2.0 centers per hectare since 1960 (Novikova et al., 2001; Summary analytical report on the state and use of land of the Republic of Kazakhstan, 2017). The area of reed grass (Calamagrostis epigeius), licorice (Glycyrrhisa glabra) and grass-forb grass communities has decreased throughout 70-75%.

The character of changes and the sustainability of natural complexes depend on their properties, type and degree of agricultural impact. According to the degree of resistance of natural complexes to agricultural impact, the following were identified: resistant (a complex of the stratum plain); weakly resistant (a complex of the eolian plain) and unstable (the valley complex) natural complexes of the irrigation array. The share of sustainable natural complexes is 9.9%, weakly resistant 9.7% and unstable 80.4% in the total area of the array. The assessment of the stability of landscapes to agricultural impacts allowed us to identify areas with unstable or weakly resistant natural complexes that require special care of agricultural activities implementation within them and, accordingly, areas where natural complexes are able to withstand large agricultural loads.

3.4 Balanced agricultural environmental management of the territory

A balanced structure of agricultural use of the Kazaly irrigation array was developed on the basis of the resilience of natural complexes to agricultural impact (Figure 6).



Legend

Landscape / group of tracts	Balanced ecological parameters in landscapes. Share of lands in the landscape from the area of the massif, %					Landscape area, km²	№ tract type
	Irrigated land from the area of agricultural lands	Perennial grasses from arable land area	Fodders from the area of agricultural lands	Field shelter-belts from the area of irrigated arable lands	Natural landscapes in the total area of the territory		
Type - desert. Class: plain landscapes. Subclass – low-lying plains, elevated plains							
I Landscapes of accumulative alluvial plains							
A. Valley complex of tracts composed of sands, loams, sandy loams, gravel and pebble							
River floodplain	15	50	50	15	60	366,6	1
Low floodplain	15	45	50	10	65	1285,5	2
High floodplain	20	40	55	10	65	1467,8	3
II Landscapes of accumulative eolian plains							
B. Complex of tracts of the eolian plain composed of sands, sandy loams							
Eolian plain	-	-	50	-	70	376,0	4
III Landscapes of accumulative denudation plains							
C. Complex of tracts of formation plain composed of clays, loams, sandy loams							
Weakly-wavy formation plain	10	40	60	10	50	380,6	5

Key: settlements; lakes; rivers; dry rivers; canals; ditch; irrigated arrable land; takyrs; residential complexes and surrounding areas

Scale 1:200 000 in 1 centimeter 2 kilometers

Figure 6. Fragment of a map of balanced agricultural environmental management of the Kazaly irrigation array.

It was established that balanced using of natural resources on the irrigation array is solved by increasing the share of environment-stabilizing land (forest plantations, natural pastures and hayfields) in the total structure of agricultural land to 75% of the array and reducing the area of irrigated arable land to 10% of the agricultural land. The balanced structure of agricultural land is subdivided depending on the agricultural development of natural complexes as follows: in a valley complex (river floodplain, low and high floodplain) the area of irrigated arable land should be about 15-20%, forage lands - up to 55%; in the complex of the stratum plain (slightly undulating plain), the area of irrigated arable land should be 10%, the area of forage lands - 60% of the area of all agricultural land. It is necessary to exclude from use under irrigated arable land the complexes of the aeolian plain.

3.5 Landscape planning of the Kazaly irrigation array

A landscape planning scheme was developed based on assessments of the landscape structure of the Kazaly irrigation array, its landscape-ecological state, the sustainability of natural complexes to agricultural impact, the development of a balanced structure of agricultural land. It focuses on sustainable agricultural management and restoration of natural resource potential (Figure 7).

The color gamut reflects the differentiation of natural complexes according to the intensity of agricultural development on the landscape planning scheme: intensive; moderate; moderate by subject to the implementation of water management and agro-technical measures; using in conservation mode (reserves and cores); limited (buffer zone) use; failure to use for restoration with subsequent transfer to the category of limited use (environmental stress zone); territory with the regime of restoration of natural complexes. Numbers denote nature boundaries and types of their functional use.

It was established that 21% of its total area of the Kazaly irrigation array confined to the natural complexes of the river floodplain can be used in an intensive mode. The allocation of this territory implies that the organization of agricultural environmental management here is associated with the lowest risk of disturbing the natural balance of the territory.

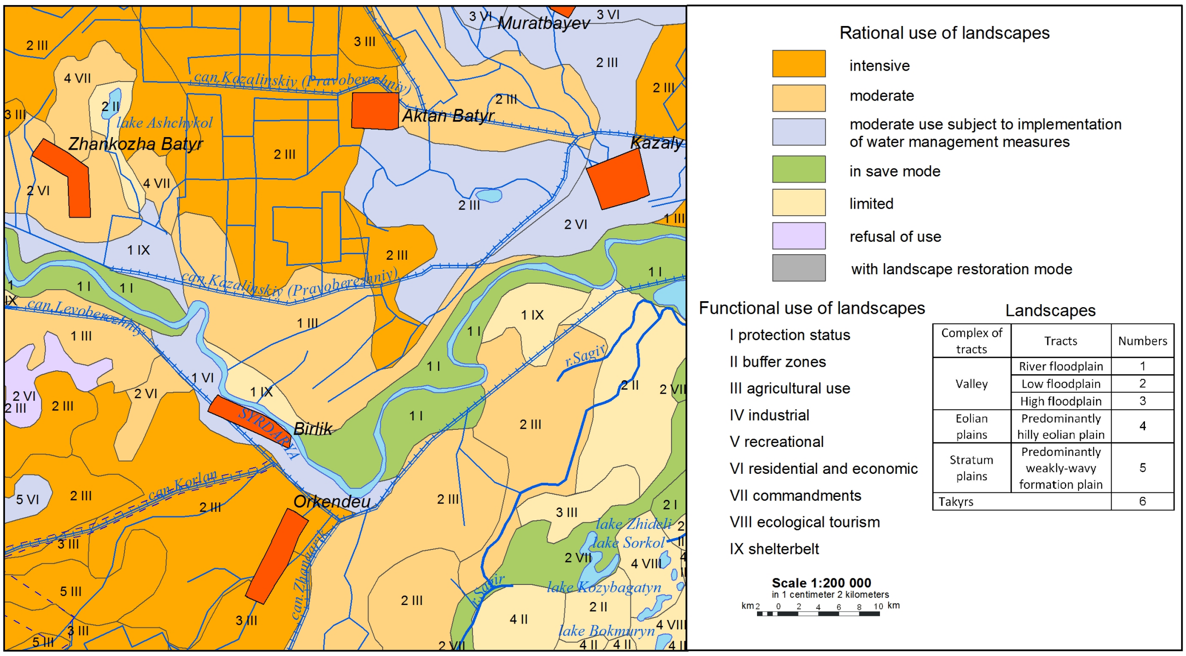


Figure 7. Fragment of a map of landscape planning scheme of the Kazaly irrigation array.

Fourteen percent of the territory covering the valley complex (river, low and high floodplain) corresponds for moderate use of land for agricultural development. 19% of the area of the array is provided the moderate use subject to agro-technical and water management activities are carried out on irrigated lands.

The use of valley complexes (river, low and high floodplain) in conservation mode is assumed on 12% of the area of the array. Conservation regime means the introduction of significant restrictions on the forms and intensity of exploitation of natural complexes to ensure their natural development under conditions that exclude almost all forms of agricultural impact (their selective use is acceptable for pastures with adherence to livestock grazing).

Limited use (buffer zones) is recommended for 22% of the total area of the array. Refusal of agricultural use of the array territory is necessary in the natural complexes of the low and high floodplains, which occupy 6% of the array area. The area of significantly disturbed landscapes of the high floodplain in the restoration mode should be about 6% of the territory of the array. First of all, it is areas of farmland degraded, saline, knocked out (disturbed) by livestock, etc.

The ways of solving the ecological and economic problems of agricultural use of the Kazaly irrigation array were proposed on the basis of the carried out landscape planning: the preferential development of irrigated agriculture on the river floodplain; hard rationed livestock grazing on the eolian plain; rationalization of the territorial structure in accordance with the landscape organization of the territory; an increase in the area of natural forage lands, primarily due to the removal of low-yielding, degraded and saline lands from arable lands; an increase in the share of perennial grasses in crop rotations at least up to 30% of arable land; bringing the livestock load in accordance with the recommended standards for natural systems; introduction of methods for the ecological optimization of natural complexes, etc.

4. CONCLUSIONS

The current system of agricultural use of the Kazaly irrigation array (located in the territory of southern Kazakhstan) cannot ensure a significant increase in the production of agricultural products and compliance with the ecologically acceptable principles of management. In this regard, a fundamentally new approach to agricultural environmental management was implemented in order to preserve and reproduce the natural resource potential of the territory and stabilize the production of high quantity and quality of agricultural products.

The research of the creation of a landscape planning scheme for the Kazaly irrigation array was aimed to determine its territorial use, taking into account the natural resource potential, to achieve sustainable development of the territory. The use of the information contained in the created landscape map and data on landscape diversity is the basis for landscape planning of the irrigation array. The qualitative and quantitative analysis of the spatial landscape structure of the study area allowed us to establish the patterns of distribution of natural complexes and to evaluate their current landscape-ecological state, necessary for landscape planning.

A survey of the irrigation area of the array allowed us to assess the condition of agricultural land and isolate natural complexes according to the degree of resistance to agricultural impact.

The developed landscape-ecological criteria for balanced agricultural use of the irrigation array are a system of actions that have the main goal - the preservation of the natural resource potential and the environmental sustainability of the territory.

The cartographic models for the territory of the Kazaly irrigation array: a landscape map, a balanced agricultural use map and a landscape planning scheme help solve problems in the management of agricultural use of natural resources and create optimal conditions for the reproduction of the main components of the environment.

The proposed landscape planning scheme was taken as the basis for developing a strategy for the balanced management of desert regions of Kazakhstan.

The obtained results of the study can be qualified as a major achievement in the development of a constructive geography direction in the field of landscape planning, ecologically balanced agricultural use of natural resources to ensure the sustainable development of desert regions of irrigated agriculture in southern Kazakhstan.

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