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Assessment of The Current State of Vegetation of Estuaries in The Zone of Dry Steppes of Western Kazakhstan.

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ABSTRACT

The current pace of development of agricultural production, in particular livestock, require maximizing the full potential of irrigation reclamation. In the steppe and semi desert areas of Western Kazakhstan an important role in creating a sustainable food supply, feed production at low cost and the improvement of socio-economic living conditions of the population belongs to the estuary irrigation. Amonge all the irrigational areas in Republic the estuary irrigation consists of more than 30%, and in the Western Kazakhstan - 78%. Research has shown that in modern conditions more than 75 % of all lands with estuary irrigation are not operated properly. The aim of the research is the study of the vegetation condition of estuaries and the rationale of the restoration of land productivity of estuary irrigation with degraded vegetation, resulting from the prolonged interruptions in the flooding. As a result of studies with a use of a remote sensing was the obtaining of data on the extent of use and a vegetation cover condition of the estuary in the zone of dry steppes of Western Kazakhstan in the last 15 years. Violations of the technological regime and the interruption in flooding resulted in a significant deterioration of the ecological state of sections of estuary irrigation, the degeneration of valuable kinds of plants on them and a decrease productivity of natural grass.

Keywords: Estuary irrigation, Flooding, Duration of water standing, Productivity, Herbage, Degradation, Remote sensing, Vegetation index.

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INTRODUCTION

A characteristic feature of the territory of Western Kazakhstan region of the Republic of Kazakhstan is the strong dependence of agricultural production from the drought years. In dry years are sharply reduced grain production and a feed base of livestock. Therefore the agricultural lands in most territories of a region are presented with pastures and hayfields. In the region there is mainly a livestock branch of farming based on the use of natural grasslands and flooded estuaries. This allowed considering the region as one of the promising livestock regions in the economic zoning of the territory of the Republic.

On the territory of the West Kazakhstan region the most common way for soil moisture is the estuary irrigation. Advantages of the estuary irrigation are the ease of design and operation of irrigation systems, low cost of construction works, a possibility of estuary use without a mechanical energy for water lifting, the increase in a domestic water supply, reducing of soil erosions.

An estuary irrigation as a way of using melt and spare water reservoirs was before and still remains as the most available, cheap and very effective method; creates a base for animal feed in areas of unstable moistening and drought. But the nature of agricultural land use of estuary irrigation depends not only on the specifics of agricultural land, but also of the type of estuaries, the depth and duration of flooding, soil and hydrogeological conditions and a salt regime.

System of estuary irrigation in the region is of a basin-wide nature accommodation. It looks like this - the river basins: Ural – 108,0 thousand hectars, Volga – 4.8 thousand hectars, Malyi Uzen and the Bolshoy Uzen – 78,4 thousand hectars, Ulenta – 29.5 thousand hectars, Buldurta – 15,9 thousand hectars, Caldigit – 14.3 thousand hectars, Jaxybai – 6,0 thousand hectars.

Large systems of estuary irrigation of engineering and semi-engineering type that are operating in the region are currently include: the Ural-Kushumskaya watering and irrigation system (WIS) - 87.1 thousand hectares, a Little-Uzenskijj WIS – 44,0 thousand hectares, Big-Uzenskij WIS – 25.9 thousand ha, Caldigajtinskaja WIS - 3.9 hectares, Olentinsky – 10.3 thousand hectares.

Prominent foreign scientists B. A. Shumakov, V. I. Larin, B. B. Shumakov, A. G. Larionov, V. F. Mamin, I. A. Kuznik and many others have dedicated their research to the study of various aspects of the estuary irrigation. In their opinion, the study of the ameliorative condition of estuaries is of great scientific and practical interest, which is essential for the efficient use of natural and artificial estuaries.

B. I. Tuktarov and his disciples noted a decrease the of estuary lands productivity in the recent years because of the sharp deterioration of ecological-meliorative condition of estuaries [1]. According to V. A. Solovyov, the reduction in a local runoff reduces the area of the gulf that is causing occurring at the present time of stepping and a xerophytization of meadows [2].

A quick recovery of grass estuaries that were not flooded with water for many years and were virtually the unproductive saline pastures according to N. I. Yakovenko is possible. A recovery of water availability in these estuaries leads to the appearence of a large number of valuable plants [3]. V. F. Mamin and L. F. Savel'eva pay attention to the necessity of maintaining of high productivity of estuary meadows and a rational use of natural resources. They indicate that geobotanical environment in modern estuaries depends on the anthropogenic factors and reclamation improvement [4].

In the study of ecological-meliorative condition and of the different modes of flooding at the engineering systems were involved some prominent Russian and Kazakh scientists. In particular, I. M. Fetisov and B. S. Uljanova have investigated the changes in physico-chemical composition of soils with a slight frequency of flooding [5]. However, in modern conditions many engineering estuaries are not flooded or flooded with significant interruptions. This fact leads to the changes of ecological-meliorative condition of lands and the degeneration of the natural grasses in the estuaries [6, 7].

The idea of the research is in the study of the effects of long-term interruptions in flooding on ecological meliorative condition and productivity of estuaries, a search and a rationalisation of science-based ways of their natural and artificial recovery.

METHODS

Studies were conducted in the West Kazakhstan agrarian-technical University named after Zhangir Khan in 2012-2015 (the Republic of Kazakhstan, Uralsk). The objects of research were the areas of estuaries irrigation with degraded vegetation, resulting from prolonged interruptions in the flooding. Experimental studies were carried out on the estuary 49 of Ural-Kushumskaya WIS, including local experiments on cells with numbers 31 and 32, characterized as areas with significant interruptions in flooding.

For the analysis of the areas of flooding estuary sites through space survey the following methods were used: analytical, comparative-geographical, data processing, remote sensing, geoinformation modeling.

Processing of satellite images, the selection of substantive information on the characteristics of the object of study was performed using the software ENVI 4.8.

When performing a work was used the archive of satellite images of low (250 m) resolution (200 images) received by the radiometer MODIS (satellites Terra/Aqua) and multispectral images of medium resolution (30 m) of Landsat satellites over the period from 2000 to 2015. As the baseline data for assessing the vegetation cover of the estuary were used 16-day composite images of NDVI data.

To identify the duration and extent of flooding of the estuary were used pictures taken in the spring (April - mid of June). For assessment and mapping of the vegetation was given a preference for images taken in the period from May to July.

For operations with vector data, for creating of thematic map layers, including attribute, semantic, geographical and graphical information about the object of research was used GIS package ArGIS 10.0.

The primary method for the remote assessment of the estuary was a combined method consisting of a visual method of photo-interpretation and automated image analysis with the use of computer algorithms classification [8].

Recognition of flooded surface of the estuaries on the space survey materials was done in a visual way according to the direct indication of decoding (smooth dark tone image), and using the unsupervised classification algorithm IsoData [9].

Mapping, quantitative and qualitative assessment of the vegetation cover of the estuary were carried out using normalized differential vegetation index NDVI as the most common and the most simple index calculation [10, 11, 12].

The collection and processing of herbarium material, description and analysis of flora were carried out by the conventional geobotanical methods. Was carried out a taxonomical analysis of the flora according to the discount cell and the counting of plant species in each family. Was defined the relationship of plants to the environmental groups. Were carried out the description of the ecological-morphological characteristics of the plants of phytocenosis, biomorphological analysis of vegetation, the analysis of the biomorphological structures of the plants.

Determination of plant density was carried out on sites of 0.25 m^2, evenly spaced around the plot. The counts of the number of plants were carried out before cleaning. A green grass mass were taken into account by the continuous manner, the harvest was weighed from the whole plots and was calculated the yield from 1 ha using a conversion factor to the area. Hay was taken into account by means of the test sheaves. Was selected a trial sheaf of green fodder (at least 4-5 kg) from the meadows with coverige of the entire accounting area. Then the green mass was weighed from the whole area (with the inclusion of the trial bundle). The trial bundles were dried on special racks in a well ventilated area to dry, and then they were weighed. After that were tooken the samples to determine the moisture content of hay in the dry state. Considering the weight of the trial bundle before and after drying was determined the yield of hay in the dry state. Multiplying the yield of green mass of herbs (with taking into account the plots) for yields of hay and conversion factors for the square of 1 hectare and the standard 16 % humidity, was calculated the expected outcome indicator – the yield of hay [13].

RESULTS AND DISCUSSION

The study of water regime of the estuary

Analysis of operational modes of the system of estuary irrigation shows that the geobotanical condition, the fertility of the soil and productivity of herbage depend on the correct determination of optimum rules, timing and duration of flooding.

A comparative analysis of data of remote sensing (RS) areas of the estuary 49 indicates the absence of a regular water support of the estuary, leading to the deterioration of reclamation condition and productivity of the estuary lands. Proceeding from the presented data it is seen that between 2000 and 2015 years a systematic estuary flooding has been produced only in 2000-2002 years. The average square of estuary flooding in these years was 2967 hectares or 76.5 % of the land area. In 2003-2004 the area of flooded land was reduced to an average of 1168 hectares.

From the beginning of 2005 till the end of 2009 the flooding was absent. Were flooded only plots that were located in the Northern part of the estuary. The average underflooding area of the estuary in this period amounted to 228 ha with the area of flooding - not more than 384 hectares. In the period of 2013-2015 years, the flooded area of the estuary has increased significantly: in 2013 was covered 570,6 ha, in 2014 – 1080,5 ha and in 2015 the underflooded area was 698,6 ha (figure 1).

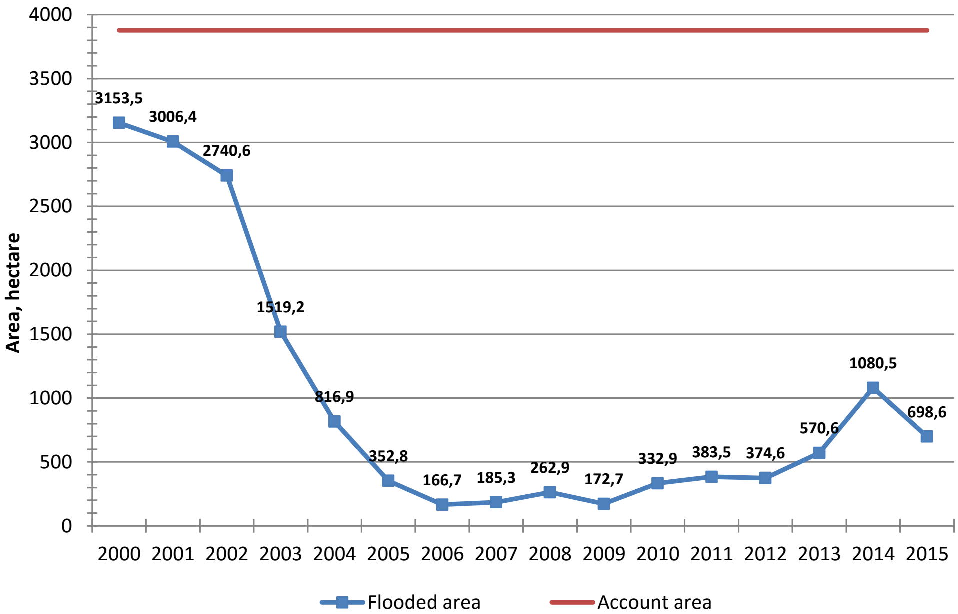

Figure 1 – The dynamics of the area of flooding of the estuary 49 for 2000-2015 years by the ERS data

The cyclical flooding of the experimental plots was consistent with the overall dynamics of the flooding of the estuary. Breaks in flooding of the cell 31 were observed in the period from 2003 to 2009. Flooding at the level of 50-60 percent of the area was produced in 2010-2014 years. Breaks in flooding of the cell 32 were observed in the period from 2003 to 2013 years. The renewed flooding of the cell began in 2014 year.

Analyzing the timetable of the flooding of estuary, defined according to the remote sensing, we can conclude that the technique of flooding of the estuary was generally consistent with the optimal timing. The flooding starting was observed during the passage of the spring flood (third decade of March – first decade of April), and the duration of water standing in the estuary was in average 32-48 days. Deviations were observed only in 2015, when the beginning of the flooding of estuaries coincided with the third decade of May, and the duration of flooding was about 20-25 days.

The duration of water standing in the cell 31 was up of 15-18 days, which corresponds to the irrigation norm 2500-3000 m3/ha. In the cell 32 a duration of water standing was less than 15 days, where the application rate was about 2000 m3/ha.

Assessment of the vegetation cover of the estuary by the remote sensing.

Photographs taken during a vegetation period in 2015 (figure 2, 3), demonstrated a significant difference in the herbage of the estuary in areas with the absence and the presence of flooding. The coloration and density of vegetation gave an indication of the good condition of the natural grass at the site of irrigation.

Figure 2 – Natural grass with plot of cell of the flooded estuary

For a site of cell of the estuary, where there was no water supply for a considerable period of time, is characteristic a rare herbage of a poor quality. The performance of such sites is in the several times lower in a comparison with the flooded area.

Figure 3 – Natural grass of the not flooded cell site

Dynamics of changes in land area of the estuary occupied by vegetation with index NDVI of different ranges for the period 2000-2015, are shown in figures 4 and 5.

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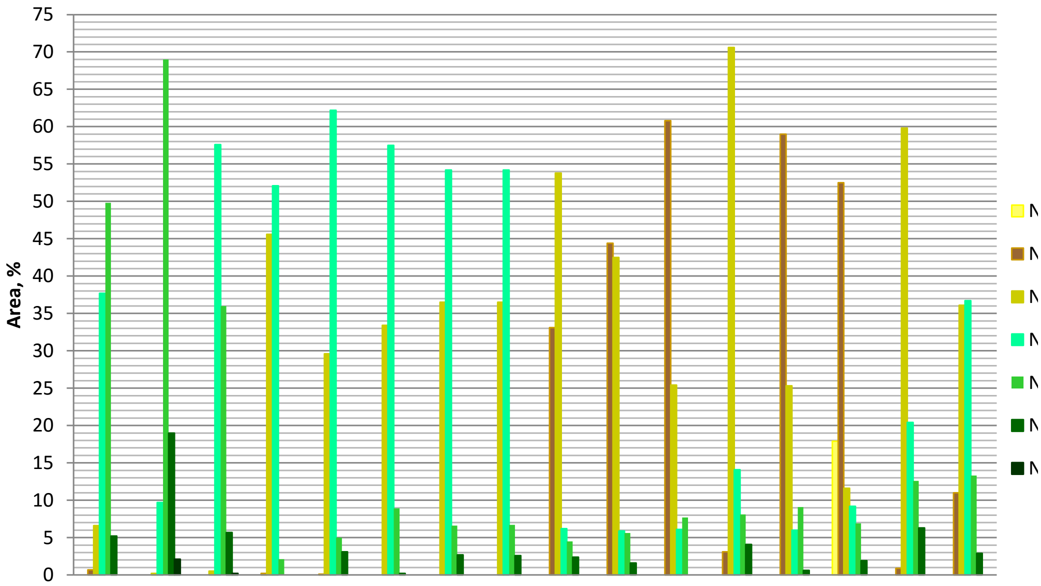

Figure 4 – A distribution graph of the land area of the estuary occupied by vegetation with index NDVI of different ranges for the period 2000-2015

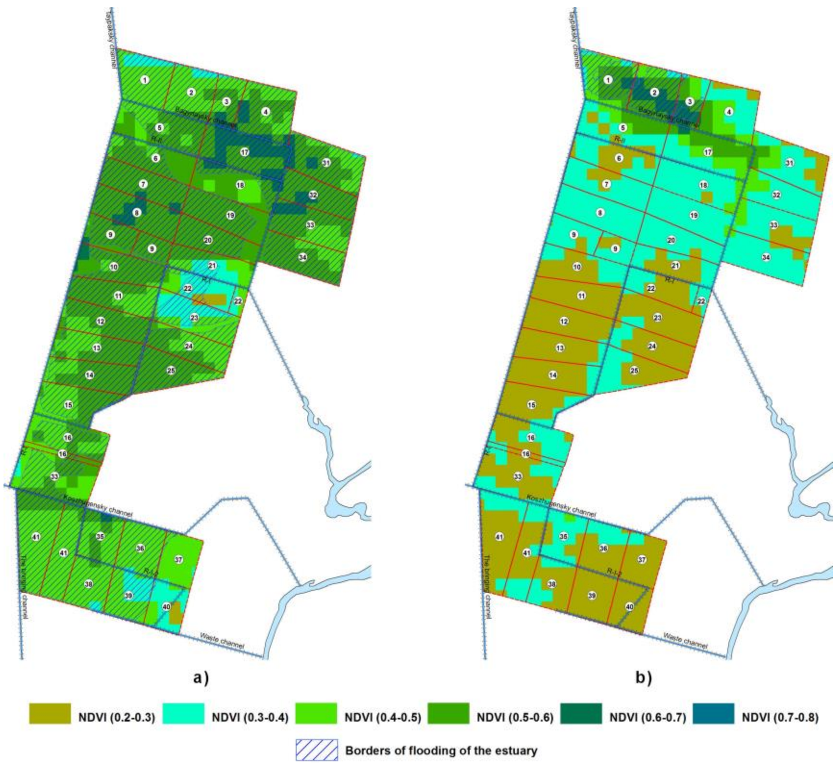

Figure 5 – Chart of the sinking of the estuary 49 and the distribution of biomass using the NDVI index for remote sensing data: a) 2000; b) 2009.

According to the estimated data for the period under review there have been significant changes in the vegetation cover of the examined object. If during 2000-2002, almost all of the territory of the estuary (in average 98 %) were occupied by areas with medium and high NDVI values (greater than 0.4), with a natural grass of good quality, then from 2003 to 2007 there was a tendency of increasing vegetation cover plots with smaller values of the index (below 0.4), complising to the irregular herbage with low grass growth density. On average, they occupied 36% of the territory of the total area of the estuary.

In the period from 2008 to 2013 is noted a maximum of the estuary areas with low values of the index, the average area of which amounted to 79% of the considered territory. The reverse processes in the direction of increasing of values of the index, became traceable in 2014-2015 years. Land areas with medium and high NDVI values consisted at an average of 46,0% and with a minimum value - 54 %, respectively.

Thus, the analysis of the vegetation of the estuary, estimated through the NDVI index, indirectly confirmed the relationship between the absence and the presence of flooding of the estuary.

Study of geobotanical composition and productivity of vegetation cover of estuaries areas

A vegetation cover is closely related to the environment, and it is impossible to know the regularities of its structure and distribution without taking into account the various ecological and geographical relations of the vegetable organisms and of their groups.

The results of studying the vegetation cover of the estuary cages 31 and 32 of 49 Uralo-Kushumskaya IBS (irrigation bypass system) show that on the experimental plot in the zone of sufficient moisture in the vegetation are dominating cereals, such as meadow fescue (Festuca pratensis huds), meadow foxtail (Alopecurus pratensis), Kentucky bluegrass (Poa pratensis), quack grass (Elytrigia repens), comb-shaped Wheatgrass (Agropuron pectiniforme).

Among them is also often found from the sedge the Bulboschoenus sea (Bulboschoenus maritimus Pala). On test plots, the projective cover of vegetation is 70-95 %. The height of the plant varies from 40 to 120 cm.

In areas with lack of moisture in the vegetation of the estuary are dominating the xerophytic plants, such as white-tomentose wormwood (Artemisia hololeuca), Lessing wormwood (Artemisia Lessingiana Bess), mugwort (Artemisia vulgaris L), stag sand.

In the floristic composition of the studied estuary were identified 40 plant species belonging to 10 families. In the estuary areas with sufficient moisture was allocated a cereal-sedge-forb association.

The most numerous representatives were among the following families: cereals of 11 species, Asteraceae – 7 species; sedge – 4 types; legumes – 3 species; crucials – 3 species; Labiatae – 3 types; Rosanne – 2 species; Plantaginaceae, Convolvulaceae, Cermakhoveae, Euphorbiaceae and Chenopodiaceae - 1 species.

The results showed that in the studied area are dominating mesophytaes and xeromesophytes – 35 %, xerophytes – 12,5 %, hygromesophyte – 7.5 %, hygrophytes – 10 %.

Analysis of life forms of the studied area showed the presence of two biomorphological structures of the plants: perennials – 87,5 %, and the annuals are on the second place - 12.5 %.

A biomorphological analysis of the vegetation confirms that the dominant group is the hemicryptophytes - 57.5 % (23 species), on the second place – geophytes 30 % (12 species), terofits – 10 % (4 species) and hamefits 2,5 % (1 species).

In the not flooded areas a hay yield is very low (2,0-7,0 h/ha) and in the flooded areas a yield is relatively high: 43.6-44.6 h/ha. In the not flooded ares a significant irregularity of herbage is combined with a different grass growth density. In some places occur gaps virtually without plants. Taking into account a significant difference between the yield of the not flooded and flooded areas and between the various interruptions in flooding (cell 31 and cell 32) the excess was only by 1,0 h/ha. One of the reasons may be the insignificant difference in the duration of the breaks (9 and 12 years), similar values of flooding norms, the composition of the crops on plots and other relief-meliorative conditions.

Thus, the results showed that the main factor influencing the yield of natural grasses in the estuaries of the dry steppe zone of Western Kazakhstan is the presence of periodic flooding areas. Comparison of the species composition of flooded and unflooded plots shows a significant difference of herbage in the same cells. In the areas with a stable hydration to a greater extent there are the most valuable plants for feeding. Of course, the productivity of estuaries is directly associated with the agrochemical and agrophysical properties, and also with the meliorative condition of soils of estuaries. A uniform distribution of water in the estuary provides a high yield of natural herbage.

CONCLUSION

Thus, in the dry steppe zone of Western Kazakhstan the analysis of operational modes of the estuary areas shows that the geobotanical diversity and productivity of natural grass depend on the observing of the periodicity of flooding.

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