Criteria of Assessing the Current State of the Kuban River Geosystem

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Abstract. In the current state, delta geosystems should be considered from the standpoint of "sustainable" development. Therefore, the assessment of the current state of a natural object consists of analyzing changes in its basic properties and taking into account its features (the presence of zonal and azonal elements) that occur under the influence of anthropogenic human activity. Such an analysis should include the following types of criteria: criterion showing the nature of the "openness" of the geosystem (environmental factors); criterion reflecting the dynamics of changes in the supply and outflow of water into the geosystem; criterion describing the water exchange and ion exchange of coastal estuaries with the sea, and hydrochemical regime; criterion characterizing the ecological state of the geosystem (biomass stock). The results indicate that fundamental properties of the geosystem are characterized by the openness of the geosystem and azonal elements. When passing the analysis and expert assessment of the current state of the natural environment in the economic use of this territory, it is necessary to pay special attention to changes in the degree of openness (river flow), changes in the structure of the geosystem (landsliding and agricultural development of land).

1. Introduction

The full-fledged use of the Kuban River delta was started only in 1859, the main purpose of which was to organize a water connection between Kuban and Rostov-on-Don, from where bread and other foodstuffs were delivered to Kuban. As a result, Kuban was able to become the main breadbasket of the country itself, but the path of this formation for the entire agriculture, including irrigation of the floodplain of the Lower Kuban, went quite a difficult way [1, 5]. Currently, the state of the delta geosystem must be considered from the perspective of "sustainable" development. The coexistence of man with nature or sustainable development implies ensuring the environmental sustainability of natural and economic sustainability of socio-economic systems [4, 8]. Thus, the assessment of the current state of the natural object under consideration consists in the analysis of changes in its basic properties that occur under the influence of economic activity (Figure 1).
The main difficulty of such an assessment is that the geosystem under consideration contains both zonal and azonal elements (landscapes) and therefore, is very responsive to any changes in historical conditions and, above all, the degree of openness and structure that determine all other properties (integrity, functioning, dynamics and evolution) [3, 2, 7].

2. Materials and methods
When considering the delta geosystem, it is necessary to take into account its features (the presence of zonal and azonal elements), while the evaluation criteria should characterize the fundamental properties of the geosystem as a whole and each element of the natural and man-made complex separately.

A natural and technogenic complex (NTC) is a system, a complex consisting of two main parts, natural and man-made. The word "technogenic" literally means "created with the help of technology", i.e. by man. This word is used mainly to various structures and events. The purpose of the technogenic subsystem is the management of the natural component.

Delta ecosystems, as part of geosystems as a whole, can exist in a state of natural equilibrium, can be reversibly or irreversibly removed from the state of natural equilibrium. The causes of changes in geosystems can be both natural (evolutionary, successional processes – a natural change of biocenoses, manifestations of elements) and anthropogenic (they should be divided into intentional and unintentional, then it is easy to find a place in the classification of changes caused, for example, by an environmental crime - these are guilty (intentional) and negative anthropogenic changes) [6].

Criteria showing the nature of the "openness" of the geosystem (environmental factors) include the interchange of matter and energy with surrounding natural environment, such as:
- accumulation of solar energy and water by the soil in the form of radiation balance and precipitation;
- river (liquid, solid and chemical) flow in the top of the delta of Krasnodar, and on the southern border (small rivers). Accumulation of water and salts with retaining groundwater (pressure supply);
- water and salt exchange with the sea.

The presented criteria reflect the heat and moisture availability of the territory under consideration and can be expressed in terms of the radiation hydrothermal regime "index of dryness".

The main advantage of the "index of dryness" is that it provides an opportunity to take into account not only additional moisture, but also changes in the radiation hydrothermal balance as a result of transformation of the structure of use of the territory [9].

It should be noted that the value of the hydrothermal radiation balance depends on the reflectivity of the surface of the territory, which has had large transformations depending on the type of the underlying surface of the territory [10, 11, 12].

$$R_t = R_0 \frac{(1 - A_x)}{(1 - A_0)}$$  \hspace{1cm} (1)

$R_0$ and $R_t$ – radiation balance of natural and changed surface as a result of economic activity, KJ/ per year;
$A_0$ and $A_1$ – reflectivity of the natural and modified surface (Albedo), a fraction of one.

Table 1. Reflectivity of various types of surfaces.

| Type of surface   | A          | Type of surface   | A          |
|------------------|------------|------------------|------------|
| Water            | 0.06 … 0.1 | Fresh grass      | 0.22 … 0.26|
| Chernozem        | 0.08       | Grains           | 0.15 … 0.25|
| Dry Chernozem    | 0.14       | Dry grass,       | 0.19       |
| Dark soil        | 0.1 … 0.15 | Rice field       | 0.12       |
| Dry soil         | 0.22 … 0.32| Reeds            | 0.1        |

The second set of criteria reflects the dynamics of changes in the supply and outflow of water to the geosystem, as well as solid and chemical substances. When describing natural conditions (not affected by human anthropogenic activity), the values for the flow of the Kuban River up to 1942, i.e. before the commissioning of the Tikhovsky reservoir, absorbed by the Krasnodar reservoir [13], are taken. The average annual flow of the Kuban River in the alignment of the city Krasnodar is 12.48 km$^3$ per year, the outflow to sea is 9.28 km$^3$ per year, (Table 2).

The third set of criteria describes the water exchange and ion exchange of coastal estuaries with sea, and the hydrochemical regime, including the inflow of sea water and the outflow of river water from the estuaries. As a result, we can state significant deviations in the values for the series of groups of coastal estuaries. The salinity of water in the coastal estuaries varies widely from 0.7 to 10 g/l, on average 2.2 g/l, the coefficient of variation = 1.11 [14, 15].

The biomass reserve is taken as a parameter that characterizes the ecological state of the geosystem. The biomass reserve reliably describes the characteristics of ecological stability of the geosystem both in natural conditions and under anthropogenic influence, since the anthropogenic human impact affects, first of all, the total biomass reserves, sharply reducing them.

The criterion is formulated based on the assumption of the existence of a "pyramid of energy", according to which, more or less the same amount of energy (10 %) passes from one trophic level to another [16, 17].

A decrease in the value of the criterion means that some species will disappear, which means a decrease in species diversity, total biomass reserves and, accordingly, a decrease in the ecological stability of natural and man-made complexes and the geosystem as a whole [18].

In different natural zones, the structure of delta geosystems has its own peculiarities and differences, but the general scheme of their formation is more or less the same.

For NTC-1 and NTC-2, the main changes are associated with a violation of the natural and hydrothermal regime and soil formation conditions [19]. Violation of the hydrothermal regime occurs due to plowing and agricultural production (including land irrigation).Violation of soil formation conditions is associated with a change in the flooding regime, which is caused by the digging of the riverbed, i.e., a change in the volume of runoff at the top of the delta.

The changes are due to a violation of water exchange with sea and the hydrochemical regime of estuaries as a result of a decrease in the volume of runoff (level regime of coastal estuaries does not change at a constant sea horizon) for NTC-3 [20, 21].

Thus, the change in the properties of components of delta geosystems is mainly due to changes in hydrothermal and hydrochemical regimes.

But for a full-fledged analysis of the state of natural environment and the trend of its change, the presented criteria will not be enough. It is necessary to define a number of criteria describing the state of individual components of the geosystem-biota and soil [23, 24, 25].

For biota, such criteria for individual natural and man-made complexes will be the annual increase in biomass (productivity), litterfall, i.e. the volume of biomass return to the soil and the ratio of annual biomass growth to litterfall [26, 27].
The main and determining parameter of soil fertility is biomass reserves, humus reserves and the content of water-soluble salts (salinity) (Table 2).

**Table 2.** Natural values of criterion for the geosystems of the Kuban River delta and its separate NTC.

| Criterion of condition’s assessment | NTC 1 | NTC 2 | NTC 3 |
|------------------------------------|-------|-------|-------|
| Property of openness of geosystems  |       |       |       |
| Average annual flow of the Kuban River, km³ | 12.48 | 12.08 | 9.28  |
| Water mineralization in the coastal estuaries, h/l |       |       | 2.2   |
| R                                  | 1.2   | 0.57-0.72 |       |
| Biota                              |       |       |       |
| N, t/ha per year                   | 12.0  | 21.6  |       |
| O, t/ha per year                   | 41    | 71.5  |       |
| N / O                              | 0.29  | 0.3…0.47 |       |
| Soil                               |       |       |       |
| Humus reserves, t/ha               | 650   | 400   |       |
| Silting, %                         | 0.3…1 |       |       |

**3. Conclusion**

The results obtained (Table 2) indicate that the fundamental properties of the geosystem, including environmental sustainability, are characterized by the openness of the geosystem and azonal elements (NTC-2 swamplands, estuaries). These elements, in turn, are determined by the specifics of the hydrological regime of the Kuban River (flow volume, spills, flooding).

Summing up, it should be noted that when conducting a comprehensive analysis and assessment of the current state of natural environment in the economic use of the territory, it is necessary to pay special attention to changes in the degree of openness (river flow) and changes in the structure of the geosystem (landsliding and agricultural development of land).

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