Protection of coastal territories of Russian water reservoirs using land management methods

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Abstract. The article discusses protection methods for coastal areas of large Russian reservoirs from flooding. The object is the Saratov water reservoir which has a significant destructive effect on the adjacent territories. The methods of land monitoring and land management are applied to protect real estate objects from flooding. Recommendations for improving territorial planning schemes of municipalities adjacent to reservoirs are suggested.

1. Introduction
In Russia, the total flood-prone territories is 400 thousand km$^2$ of which up to 50 thousand km$^2$ are annually flooded. Thousands of settlements with a population of about 4.6 million people, economic facilities and more than 7 million hectares of agricultural land are flooded.

Historically, water reservoirs have been located upstream of rivers or in large settlements. As a result of their destruction, settlements are flooded and a significant damage is caused to life and health of residents and economies of regions. In the Far East, Volgograd, Kemerovo Region, the Altai Republic, Khakassia, Tyva, Altai and Krasnoyarsk Krais, large-scale floods caused a multimillion-dollar damage to real estate objects.

In most cases, dam accidents occur during their construction or initial period of operation. During this period, construction defects manifest themselves, the filtration regime and deformations of the structure stabilize. During the next 40–50 years, the state of the structure remains stable, and accidents are not probable. After that, the risk of accidents increases as a result of deformation of building materials.

In Russia, the average age of hydraulic structures is 50 years; analysis of emergencies indicates the need for continuous monitoring and preventing floods. Land management activities play a significant role.

The operation of reservoirs is regulated by two legal acts: the rules for using water resources of reservoirs and the rules for technical operation and improvement of reservoirs.

These documents [1] compiled on the basis of hydrological calculations cannot be used by land surveyors and urban planners, since information on the zones of influence of reservoirs is presented schematically on small-scale maps; there are no data describing boundaries of these zones; there is no information on degrading lands. The lack of areal data on the impact of reservoirs on coastal areas made it impossible to take into account flooding and land degradation in urban planning and land management documents. It is necessary to take into account the influence of zones with special conditions while determining the cadastral value of land. The causes of various damages are the lack of information about restrictions on economic activities (and, accordingly, water protection zones and...
coastal strips) and elaboration of a mechanism to compensate land owners for the damage caused by such restrictions [2, 3]. It has been established that the presence of a water protection zone has an effect on the economic nature of real estate objects located in this zone [4–6].

This article describes methods used for land monitoring and management aimed at planning the use of real estate objects in areas subject to flooding. Recommendations for improving territorial planning schemes of municipalities adjacent to reservoirs are suggested.

2. Materials and methods
The theoretical basis of the study is works of Russian and foreign scientists [7–10], official reports, resolutions, methodological manuals, and federal and regional legal acts.

The research object is the Saratov water reservoir built in 1967–1968 on the Volga river. Its physical parameters are as follows: the length is 357 km, the average width is 5.1 km, the area of the mirror at the normal retaining level is 1,831 km², the length of the coastline at the NLW water is 865 km.

The reservoir was built for hydropower, water supply, fisheries, irrigation, recreation, timber rafting and agriculture. It is located in Ulyanovsk, Samara and Saratov regions.

The Saratov reservoir has a significant destructive effect on the adjacent territories:
- the length of landslide slopes is 570 km, including dangerous areas - 85 km (15% of the coastal perimeter),
- the total bank processing area is about 50 km², the maximum width of the intensive processing zone at different coastal areas is 60–100 m,
- the total length of the coastline is 65 km, the length of the fortified bank is 25 km.
- the area of flooded coastal areas is 180 km² (11% of the mirror area).

On the basis of the comparative statistical analysis of open data, measures of land management aimed at protecting the banks of the reservoir have been ranked by their efficiency.

More than 15 municipal districts adjoin the reservoir. They have general plans for the development of the territory. Measures to combat land degradation are declarative: specific locations of planned erosion control measures in the coastal areas have not been established, and their volumes have not been determined.

The assessment of territorial planning schemes of municipal districts made it possible to supplement sections on the protection of coastal areas.

3. Results and discussion
The construction of shore protection structures has the most significant effect on bank destruction.

On the basis of the collected Internet data, a database on the implemented analogue objects, the volume of prevented bank processing, m/year and the cost of one meter of bank protection measures has been created. The linear functional dependence of the cost of bank protection (y) on the bank processing (x) has the form y = 79.784 + 51.285 * x. On its basis, you can build a financial forecast.

On the basis of these calculations, the feasibility of bank protection works in 12 settlements of Samara Region was determined (Figure 1). The total length of bank protection is 39 kilometers, of which 22 kilometers is a new construction object.

Taking into account the ongoing processes in the territories adjacent to the Saratov reservoir, the types of coastal fortifications were ranked according to their effectiveness, taking into account the volume of capital investment: relatively cheap sloping coastal fortifications, stripes, the most expensive resistant belt and retaining walls. Resistant belts are expedient for protection of settlements, while sloping coastal fortifications are used on the inter-settlement territories.

Additional measures to strengthen the slope were recommended: replanting slopes, seeding slopes with special plants or surface trimming with natural turf; rock dumping and erection of additional mounts at its junction with e coastal shoals; alluvium of gentle sandy beaches; maintenance and protection of existing forest plantations and shrubs on the slopes and in adjacent reservoir areas; special water-intercepting upland shafts and channels.
Figure 1. The scheme of the bank protection facilities of the Saratov water reservoir in Samara region

In case of flooding of adjacent territories, it is recommended to develop working projects for land drainage taking into account two main areas of agricultural application of the zones:

1) radical or superficial improvement of forage lands planting appropriate herbs;
2) drainage followed by creation of meadow and arable land plots (this direction is beneficial for large and compact areas over 100 hectares).

The agricultural use of shallow waters makes it possible to develop agriculture and animal husbandry in the areas adjacent to the reservoir (cheap fodder production due to natural aquatic vegetation and cultivation of moisture-loving crops - wild rice, canary). These lands can be used to collect fodder hydrophytes (reed, water manna, aloe telorez, pierced and brilliant and rutus spiky). These plants are highly productive, occupy large areas and have excellent fodder qualities.

For the further rational use of adjacent lands, it was proposed to develop land management measures:
1. Special survey, identification and assessment of the size of flooded territories, bank processing, compilation of thematic maps using GIS systems;
2. Ecological and economic, agro-ecological and ecological-landscape zoning (zoning);
3. Inter-farm land management, rational reformation of the municipal land fund;
4. Development of measures for improving natural landscapes, restoring and improving soil fertility, eliminating waterlogging.

The construction of bank protection structures is carried out within the boundaries of the water protection zone. To construct them, a draft water protection zone and a coastal protective zone of the reservoir are being developed. The width of the water protection zone and coastal protective strip is determined in accordance with Article 65 of the Water Code of the Russian Federation. The boundaries of the water protection zone and coastal protective strip of the reservoir, their coordinates and reference points are described. The lack of information about the boundaries of zones causes various damages, because the lack of information on the exact location of land (the real estate cadastre) and information on restricted application of lands, boundaries of special zones (the border register) have a direct impact on the value of economic regulators of land management.

Thus, the structure and composition of the cadastral value are influenced by various pricing factors (restrictions on the application of the object located in the water protection zone). The results of studies have shown that there is a negative relationship between the cost and the presence of water protection zones. It is obvious that using the mechanism of redistribution of land payments at the stage of cadastral value formation, it is possible to compensate for losses arising from restrictions on the use of land in special areas.
The availability of this information will be useful for those who carry out assessment activities taking into account the influence of special zones on the total value of real estate objects. It will help reduce damages caused by the lack of information on water protection zones in the unified state register of real estate objects when calculating the cadastral value of special land plots. It can also be used when making decisions on the withdrawal or repurchase of these objects.

4. Conclusion
The aspects of land management activities carried out in areas affected by reservoirs showed the need for their integrated application in land management schemes taking into environmental and economic damage. These materials will reduce the damage caused by the lack of information in the state information registers, have a direct impact on the establishment of various types of land payments and contribute to the sustainable land use.

It was proved that bank destruction can be stopped by building bank protection facilities. Protective belts can be built for protecting settlements while sloping coastal fortifications can protect inter-settlement territories. The recommendations for improving the territorial planning of municipal areas by adding sections on the protection of coastal areas were provided. These measures will contribute to the rational socio-economic development of territories, the effective use of flood-prone areas and reduce possible damage to real estate objects.

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