Information support of optimization of interaction of natural and technogenic subsystems of the river coastal territory

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The article discusses ways to obtain relevant information on the state of the natural and natural-man-made situation, which is necessary to reduce the risks of natural and man-made emergencies in coastal river areas, to promptly inform the population of an integrated system that includes federal, regional and local information centers. It was noted that to create a systematized database, the factors determining the operating conditions of technogenic systems are considered, which include, first of all, such factors as hydrological, topographical (relief), geological (soil), as well as those changes of these factors, which are determined by human intervention into nature for agricultural land development in coastal areas and other activities. Information is of great importance for the optimal management of river coastal and, above all, border areas. It is a limited and expensive resource of the executive authorities, the management bodies of various production structures, individuals and legal entities that are somehow connected by their activities to the territories located in the coastal, transboundary and border areas. Persons interested in information on the state of the coastal territories with the aim of ensuring efficient and safe activities do not have the same information, therefore its mutual exchange is necessary. In the era of globalization, the main information source is global networks like the Internet, as a single global information space. These trends radically change the approach to the information support of the activities of all governing bodies. The proposal to create an information platform for interaction of owners of data on the natural and natural-technogenic condition in a river coastal area depends on many factors and, above all, the need to process large amounts of data using big data technologies that are used to process large amounts of data in order to obtain new information and which is difficult to handle in the usual ways.

Keywords: *information support, natural, natural and man-made environment, monitoring, databases, collection, processing*

Great prospects for reducing the risks of emergencies of natural and man-made emergencies in the coastal river areas consist of using an integrated system for operational information of the population, including federal, regional and local information centers.

Information on emergency situations, their consequences, the state of radiation, chemical, medical, biological, explosive, fire and environmental safety in these areas should be relevant and timely, based primarily on a systematic, regular data collection, their formation and processing, and further application to predict the situation and develop appropriate management, engineering or other solutions.

Design and then construction of artificial structures (bridge crossings) through watercourses in the river coastal areas, as well as regulatory structures, is a more responsible task than the design of other transport facilities, because already at the beginning of operation, due to the probabilistic nature, they must operate steadily and ensure the impact of calculated hydrological factors.

All the work of the transition, the stability of the bridge and the roadbed approaches under the influence of water flows depends on how the regulatory structures and strengthening perform their functions. When designing a road network, serious attention should be paid to regulatory structures, the cost of which is significant and at bridge crossings in simple conditions reaches 40% of the cost, and in complex - 100% or more. When assessing costs, it is also necessary to keep in mind the high annual maintenance costs, which are especially typical for river crossings with wandering channels, which prevail, for example, on Sakhalin island.

River flow is the interaction of the liquid phase with the solid phase (soil bed), which determines the channel process. The channel process causes a change in the shape of the banks of the river bed, the formation of floodplain old rivers, the movement of islands.

The channel process is influenced by a number of factors that determine the type of river and, first of all, its water content, flow rate, type and size of the ground channel and banks, especially the hydrological regime. An important role in the activity of channel processes plays the height of the banks and their forest cover. With the increase in the duration of floods, flow rates, reduction of soil particles, the intensity of channel processes increases. In connection with the noted, it is possible to give a private classification of river types [1, 2].

Plain rivers are characterized by a channel and floodplains at a flow rate of 0.2-0.5 m/s on floodplains accompanied by meander movement. Slopes of flat rivers are small - up to 0.0005.

The foothill rivers are characterized by slopes within 0,0005-0,005 and speeds from 1,5 to 3,0 m / s. the Island type of the channel process overloaded with sediments is characteristic for this type of the rivers.

Mountain rivers are characterized by slopes of 0.005-0.05 and speeds of 2.5-5.0 m/s. Rivers of this type flow in gorges, where flow control, if necessary, is reduced only to the protection of the banks from erosion.

For a proper solution to the regulation of floodplain flow, a real assessment of the condition of trees and shrubs is important.

The main task of regulatory structures - the direction of flow under the bridge-is solved depending on the topographical, hydrological and geological conditions that determine the type of channel process of the crossed river.

On the foothill river with a wandering channel and a very intensive riverbed process, the floodplains are practically absent. The channel is a network of constantly changing channels flowing among the sediments carried by the stream.

Streams and alluvial accumulations form the area of the wandering of the evolving channel. It is clear in this case that the opening of the bridge should be less than the wandering zone, so the problem of regulation here is the direction of the flow from the wandering zone to the bridge hole.

The design of bridges, including regulatory structures, is usually performed in two stages: 1) technical design; 2) working drawings. The first stage is accompanied by survey work; the second - topographical and geotechnical works.

To design a system of regulatory structures, it is necessary to collect topographic, hydrological, and other materials characterizing the area of construction. From topographic materials are necessary: a situational-hydrological scheme in order to provide a complex of regulatory structures in a schematic form, as well as large-scale plans for the detailed design of individual structures and their parts.

The situational and hydrological scheme can be made on the basis of cartographic or aerial survey material. In relation to bridge crossings, the size of this scheme is determined by the spill width under design conditions along the axis of the bridge: one and a half width with head and bottom width. This dictates the choice of scale schemes from 1: 50000 with a channel width of more than 500m and up to 1: 5000 with a channel width of 100m or less.

On the situational-hydrological scheme, there should be marked out the islands, existing channels, lakes, old rivers and other elements of the hydrographic network, characteristic marks of the bottom of the channel, channels, lakes, elevations and depressions of the river bed and floodplains. In addition, indicate the direction of the hydrodynamic axis of flow in high water; transport network and designed hydraulic structures.

Evaluate the pace of the main channel wandering and note the intensity and global direction of bed channel deformations.

A geodesic survey of a detailed plan in the direction of the bridge junction is made not less than the width of the flood spill at the calculated level plus 100–300 m up or downstream from the junction axis to a distance of 1–1.5 times the bridge hole, but no less 200 m with a bridge opening up to 1 km. The boundaries of the survey should include the area required for the location of the regulatory structures [3, 4]. Plans for individual structures are tied to the axis of the bridge. Geodetic surveys are performed according to the requirements of regulatory documents.

To design a system of regulatory structures, a number of calculated hydrological parameters are necessary: calculated and maximum floods hydrographs, on the steps of which the corresponding flow rate and level are noted; the values of the velocities and directions of currents in the locations of the regulatory structures; nature of ice drift; type and nature of soils at the base (especially pressure) structures.

As a design sample taken flood, the maximum flow of which has a probability of exceedance, corresponding to the standards. In addition, it is advisable to evaluate the effect of the greatest flood, as is customary on the railways.

Since the survey is difficult to coincide with the actions of the estimated floods, then resort to the schematization of the model, for example, real hydrographs, based on available observations on the river or river-analogue.

When designing regulatory structures, it is necessary to take into account a number of specific features associated with a certain type of river.

The placement of the hole and the amount of flow restriction significantly affects the size of the dams and the type of their fortifications, which affect the channel process along with the relief of the bottom of the bottom, the presence of a channel. When assembling fortifications, designating the dimensions and outlines of the diverting dams, if possible, the head parts should be placed in elevated places where the flow velocity is less.

Also, when designing regulatory structures, the conditions of navigation and rafting and the prospects for their development should be taken into account. In addition, the prospects for the use of the river for economic purposes, as well as the design of hydraulic structures, embankment dams, and amelioration works in the basins of watercourses should be taken into account. Designed regulatory structures should be technically feasible and cost effective.

The design of regulatory structures is based on the results of theoretical and experimental research, as well as the experience of design, construction and operation. However, the variety of conditions that in some complex cases have to be taken into account, necessitates the modeling of control options and the choice of design solutions.

In the field simulation, the study of a similar phenomenon in nature on a smaller-scale object and the establishment of a connection between them replace the study of a phenomenon in nature. Such an approach makes it possible, from the mass of structures, to compare the two closest objects, evaluate the performance of the object under consideration with its counterpart (analogues), and predict channel deformations.

The presence of such a systematized database will make it possible to give a more plausible forecast of local and general erosion in wandering sections of rivers, taking into account the nonstationarity of riverbed deformations.

The factors that determine the operating conditions of regulatory structures include, first of all, natural factors such as hydrological, topographic (relief), geological (soil), as well as those changes in these factors that are determined by anthropogenic interference with nature for agricultural land development, communications, construction and environmental activities.

Consider first the influence of the genesis of floods on the operating conditions of the bridge. Due to the rapid movement of the rain flood wave, the flood forecast can only be short-term. Therefore, it is impossible to have an idea in advance of when and how high the flood will pass. Due to intensive ups and downs, and short standing of maximum levels of rain floods - water struggle during their passage is ineffective.

The flood from snowmelt is verified quite accurately in time and can be corrected due to the slow rise of the levels and the long duration of the maximum level. During this time, you can work out the concept of water control and stock up on necessary materials.

Thus, information is of great importance for the optimal management of river coastal and, above all, border areas, and especially for making transboundary decisions. It is a limited and expensive resource of executive authorities, authorities of various production structures, individuals and legal entities, which are somehow connected by their activities to territories located in coastal, trans-boundary and border areas.

The relationship of information with goals and decisions is presented in table 1.

Table 1-Relationship of the nature of the information to the completeness of the decision

Status of information	Complete	Incomplete	
Decision	With certainty	With risk	With uncertainty
Objective expectations	Unequivocal	Quasi- unequivocal	ambiguous
Subjective feelings	confidence	uncertainty	

Persons interested in information on the state of coastal areas in order to ensure effective and safe activities do not have the same information because of its distribution, therefore its exchange or communication is necessary.

In the era of globalization, it is customary to rely on informatization based on global networks such as the Internet, on a single global information space. These trends are fundamentally changing the approaches to information support of all management bodies.

In this regard, the implementation of the concept of sustainable development of river coastal areas, which required a change in the natural management paradigm and reorientation to rapidly renewable resources, should be based on the use of new information technologies to develop and make management decisions [5, 6]. High-end science information technologies, expert systems with artificial intelligence for accounting and conservation of biodiversity and bio-resources are becoming relevant. In addition, ecological and biogeographic knowledge is now the most popular and natural users, i.e. those to whom they previously only prevented the development of natural resources.

In order to implement the strategy of sustainable coastal environmental management In the Far Eastern region, developing environmental policy and justifying the forecast of environmental and economic development, making management decisions using methods to reduce anthropogenic pressure on the environment, the authors propose to use expert systems with artificial intelligence, the coastal basin-territorial principle of information analysis and creating various simulation models.

The use of the basin organization (in contrast to the administrative-territorial principle of information analysis) in information technologies is the most promising, however, statistical information (data on physical-geographical, ecological-economic, natural-resource, labor, etc. components), as a rule, is provided by administrative districts, which, on the one hand, greatly simplifies the calculations, but, on the other hand, for river coastal-border-transboundary territories becomes unacceptable. Increasing demands for the efficiency of information in the management of the coastal territory as an economic and natural object necessitates the creation of network technologies that are being developed in accordance with the requirements of modern conditions for the functioning of management bodies. Management of natural processes should be based on reliable information about past, present and future states of natural and anthropogenic subsystems.

Information systems, as well as the information system for monitoring anthropogenic changes, are an integral part of the management system, human interaction with the environment (environmental management system), since information about the existing state of the environment and its trends should be used as a basis for developing conservation measures and taken into account when planning the development of the coastal area. The results of the assessment of the existing and projected state of the coastal area, in turn, make it possible to clarify the requirements for the subsystem of observations (this is the scientific basis for monitoring, justification of the composition, structure of the network and methods of observations) [7].

Using detailed information about the state of river coastal areas as an object of monitoring it is possible to determine the optimal conditions for the implementation of various types of economic activities and take measures to reduce their adverse effects on people's livelihood.

The problem of pollution of the Amur River appeared already in the middle of the twentieth century. The accident at the chemical plant and the release of benzene in 2005 on the Songhua River (China) showed the absence of a modern effective mechanism for solving transboundary problems in the basin and served as the basis for the development of cooperation between the two countries in the field of environmental protection to solve the problem of creating joint mechanisms for the protection and use of natural resources coastal areas of the river basin.

The order of the Ministry of natural resources and ecology of the Russian Federation of October 8, 2014 adopted "Guidelines for the implementation of state monitoring of water bodies in terms of observations of the state of the river bottom, banks, the state and mode of use of water protection zones and changes in the morphometric characteristics of water bodies or their parts", which provide:

- regular monitoring of the state of the river bottom, banks, the state and mode of use of water protection zones, changes in the morphometric characteristics of water bodies or their parts;
- collection, processing and storage of data obtained from observations.

The composition of the observed and measured parameters, the frequency of observations and surveys, forms and methods of processing of observations should be linked to the scale of the water body and the intensity of natural and anthropogenic transformations of riverbeds.

Monitoring methods include:

- expeditionary visual and instrumental examinations;
- geodetic methods;
- remote sensing methods.

For individual water bodies, the water situation on which has specific features, combinations of different methods in different sequences can be used. The main results of remote sensing are space and aerial photographs of water protection zones, coastlines and water areas, as well as materials for remote sensing data processing: transformed images, photographic plans with special thematic content and other materials.

In the implementation of monitoring, observations are made of: changes in the position of the coastline; dynamics, causes of changes in the coastline; consequences and potential danger of changes in the coastline; the presence of foreign objects in the riverbed. The list of observed parameters and the frequency of their determination are given in table 2.

Table 2 - The list of observed parameters and the frequency of their determination

The basis for monitoring the condition of the bottom, shores, changes in the morphometric characteristics of coastal areas	Type of observation	Observation parameters	Frequency of observations
River bottom, banks, morphometry			
Planned clearing of channels; landslides, erosion processes, etc.	The condition of the bottom of the water body	1. Characteristic channel forms 2. The change in elevation of the river bottom, ΔZ, m 3. Foreign objects on the bottom, location: a) type of object; b) size; c) potential danger; 4. Sediment load (degree of silting)	1 time per year during the summer-autumn low-water

The basis for monitoring the condition of the bottom, shores, changes in the morphometric characteristics of coastal areas	**Type of observation**	**Observation parameters**	**Frequency of observations**
	The state of the coastline, the deformation of the banks	1.Coastline position 2.Changes in the coastline over the observation period, ΔX, m 3.The area of flooded areas ΔS, m^2, 4.Area of wetlands S, m^2 5.and its change ΔS, m^2	1 time in 5 years during the summer low water period
Areas of rivers where there is a narrowing of the river bed due to hydraulic structures, bridge structures			
Threat of flooding	The condition of the bottom and banks of the water body	1. Foreign objects at the bottom, location: a) type of object; b) size; c) potential danger. 2. The presence of islands; 3. The area of plots under shrub and tree vegetation.	Once a year during the fall low water period
Water protection zone, river coastal territory (authors' proposals)			
Threat of flooding	State of river coastal area	a) civil engineering objects b) engineering infrastructure objects c) objects of cultural heritage d) protected areas	Once a year during the summer-autumn low flow period

To collect information, it is necessary to monitor coastal and transboundary basin areas. To do this, it is necessary to develop a monitoring strategy that is consistent with statistical data and innovative technologies, local capabilities, required accuracy and results using the above guidelines.

The authors believe that the method of collecting information, its analysis and processing should include the following steps (Fig. 1):

1) analysis of initial (stock) materials on the state and use of land in riverside coastal-border-transboundary territories;

2) Selection of the most informative indicators for monitoring riverside coastal-border-transboundary territories based on a geo-ecological assessment of the territory and the danger of natural and man-made regional risks;

3) determination of methods for selecting monitoring indicators, development of approaches to collecting information in accordance with local conditions, use of remote sensing data (aerospace surveys, data obtained from unmanned aerial vehicles);

4) collection of information on additional indicators using modern innovative technologies for obtaining and processing information on the state of land and water resources; verification and analysis of all selected indicators for the objects of the RCA;

5) creation of a database of completed studies by combining and unifying all the materials received so that the results can be obtained promptly at the request of the portal user;

6) creation of a server for primary processing of information on the basis of incoming requests from ordinary users of the portal, creating an RCA geoportal and metadata portal, including modules for monitoring transboundary territories, coastal territories, banks, waters, engineering structures, biological resources, etc.

Based on the considered actions, a comprehensive system of support for management decisions aimed at preventing natural and man-made emergencies for the river coastal area (RCA) in the Far Eastern region is proposed.

The main methods of monitoring the RRT include: expert opinions, remote data collection, statistical data study, in-situ monitoring, study of sampling by water levels in the rivers of the basin (based on natural criteria, expert opinions of natural users and land users), modeling and much more.

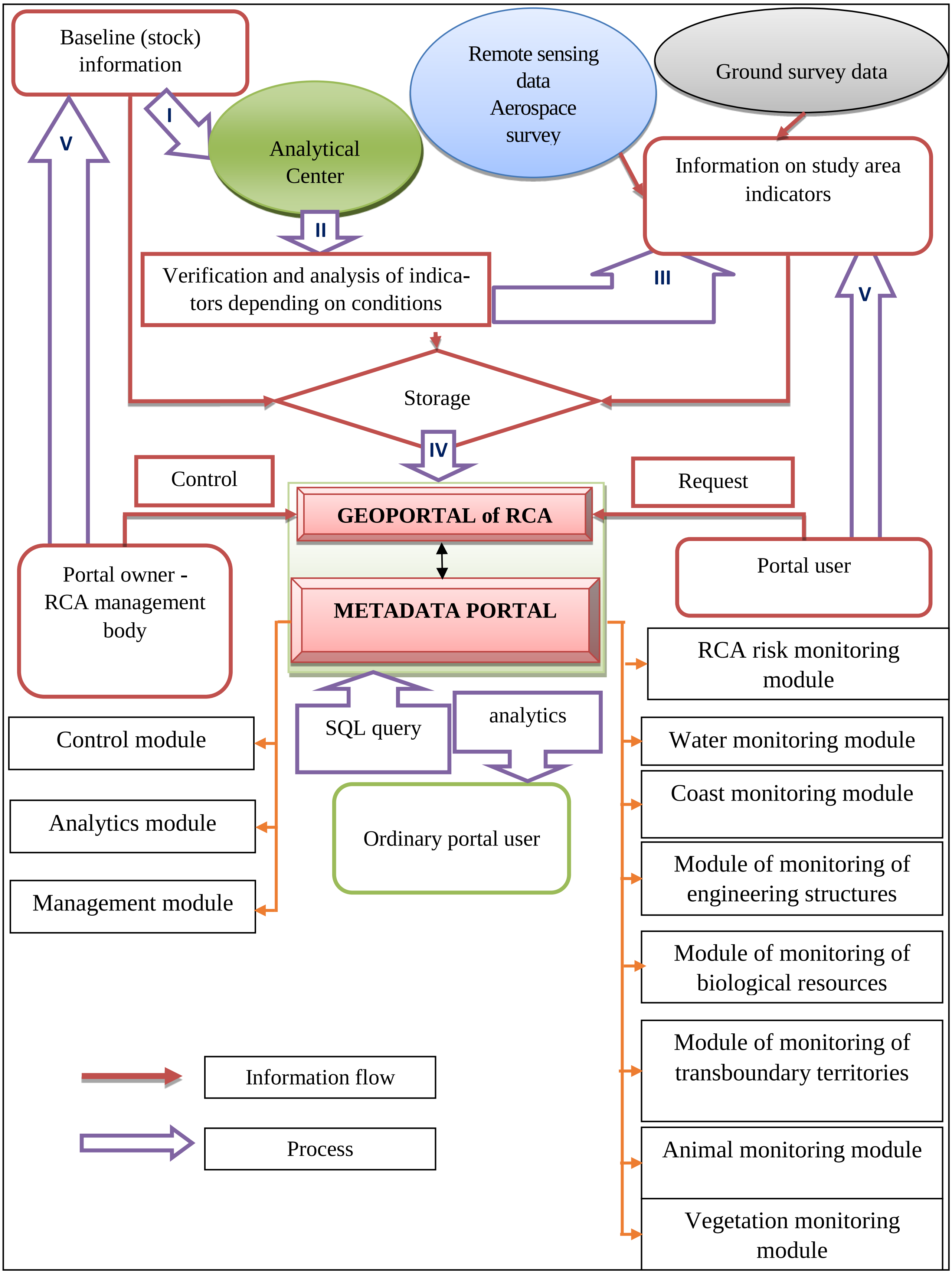

Figure 1-Algorithm for selection and evaluation of indicators for monitoring of river coastal areas

The development of river coastal areas depends on many factors, among which we can note such as: 1) currently there is no developed program for the development of river coastal territory; 2) there is a great competition between the various owners of natural resources located in this territory; 3) there is ambiguity in the formalization of the boundaries of the river coastal territory etc.

Based on this, there is a need to develop, improve and optimize the interaction of natural and man-made subsystems of the coastal natural and technical system, which in the first place should be based on the information base about the object under study, which is obtained by monitoring the environment, land, the use of modern methods and methods of obtaining and updating information about the state and use of coastal areas, taking into account natural and man-made regional risks. Assessment and design of the management decision is based on reliable and timely information about the state of the river coastal area. This requires:

- improvement of the coastal area monitoring system based on its complexity and taking into account regional natural and technological risks;
- create an inventory of river of coastal areas;
- improvement of the regulatory and legislative base of information support for monitoring and cadastre of coastal areas;
- improvement of the system of indicators for monitoring river coastal areas and indicators of accounting and cadastre in the information system of river coastal areas;
- ensuring comparability and convertibility of river coastal monitoring data from different sources;
- improvement of the system of supervision and control over the use and ecological status of river coastal areas;
- establishment and forecasting of the zone of ecological disaster, the zone of risk of development of catastrophic floods on the basis of application of complex data on a condition of the coastal territory to design on protection, elimination and the prevention of the negative phenomena in RCA.

The creation of the river coastal territory geographic information system (GIS RCA) will provide all interested users with the necessary amount of information on the state and use of the river coastal territory, represented by thematic cartographic materials, diagrams, graphs, will allow for information exchange with the funds of the state real estate cadastre, the Unified state register of rights to real estate and transactions with it, cadastres and registers of natural resources and information systems of other economic entities [8, 9].

Thus, GIS RCA is an integrated information system based on a set of reliable information about the state and dynamics of the use of the river coastal area. In this regard, the precise allocation and mapping of floodplain areas, the assessment of the main floodplain massifs, the study of the scale and extent of their possible degradation are of particular importance. On the basis of satellite images and topographic maps Egidarev E. G. conducted studies of the impact of hydroelectric power on the surrounding area in the Amur river basin, highlighted the high floodplain of the Amur and its large tributaries, which have a catchment area of more than 10,000 km^2. The total area of the floodplain-channel complex in the valleys of the large watercourses of the Amur basin is 80 341 km^2 [10]. Taking into account the location of existing hydrotechnical facilities in the basin, it was found that in 2013 the transformation of natural flow occurs to varying degrees on the watercourses, forming half of all floodplain areas with a total area of 42,752 km^2 [11]. Modern methods of obtaining spatial information allow a high degree of accuracy and in a short time to conduct research and perform mapping and modeling on any territory of interest.

In accordance with the federal law of July 27, 2006, No. 149-FZ (current edition, 2016) “On information, information technologies and information protection” GIS RCA should: be compatible with the common information space of the Russian Federation; create conditions for efficiently ensuring the satisfaction of the needs of citizens, state authorities and local governments in the information of state information resources.

To the copyright holders of GIS RCA, the authors propose to consider the structural unit created at the interregional level - at the district level.

The authors propose the formation of the information system of the river coastal territory (GIS RCA) of the Far Eastern region, which is a systematized, constantly updated database of natural and man-made objects, which is the river coastal territory.

Formation of information base of GIS RCA is based on materials of monitoring of environment and condition of lands; on data of the state real estate cadastre; cadastres and registers of natural resources; the state register of the rights to real estate and transactions with it. Information exchange of relevant information between the owners of such information on the state of the river coastal territory should be carried out through the Unified Information Center, taking into account information on the status of transboundary territories. This is the obligation to obtain the necessary information to fully assess the condition of the river coastal territory and predict its condition.

Information in the GIS RCA is formed by thematic blocks: legal, cartographic, economic.

Baseline GIS RCA data is based on basic cartographic material, data on land users, users of natural resources, data on water, land, forest, mineral resources, bio resources, wildlife, engineering structures. Each database block (DB) consists of a coordinate grid description, including a complete set of information units. There are 11 such blocks in the GIS; among the generally accepted blocks, the “RCA Risks” and “Transboundary Territories” blocks deserve special attention, which include data on regional natural and man-made risks and information on international transboundary territories, which play a special role in monitoring, assessment and forecasting state of man-made objects and natural territories.

The block describing the risks of a riverine coastal area includes data on the boundaries of the RCA, taking into account areas with a special regime of land use, as reflected in the state real estate cadastre. The table "land resources" contains a comprehensive description of the soil cover of RCA in accordance with the accepted classification.

The cartographic basis of GIS RCA can be represented as a digital spatial model using 3D technologies. As sources of information for creation of digital model of the district, it is necessary to use topographic maps, materials of aerospace and photo shootings, materials of topographic and geodetic works, data from surveys of the river and sea bottom, materials of remote sensing presented in uniform coordinate system.

Table 3 presents the generally accepted characteristics and a brief description of the set of geodata of GIS RCA by their belonging to the cadastre or registry with the author's additions.

Table 3 - A set of geodata presented in GIS RCA

Cadastral affiliation	Resource type	Characteristic
State real estate cadastre	Capital construction	Cadastral number, inventory number, name, address (location), purpose, number of storeys, availability, commissioning, ownership, cadastral value
	Administrative-territorial division	The name of the administrative-territorial unit, a description of the boundaries
	Points of the state geodetic network	Network class, point ID, name, coordinate description
	Road network	Name, road class, category, number of lanes, lane width, type of coverage
Forest Registry	Forest resources	Allocation number, block number, area, perimeter, stand composition, forest type, type of forest conditions, information about the owner
Water Registry	Surface water	Cadastral code of the water site, length, description of boundary sections, catchment area, water quality class, control status, type of use, chemical and bacteriological analysis results, property
	Groundwater, water use	Cadastral code of the water site, absolute well mark, purpose, water quality class, flow rate, type of use, results of chemical and bacteriological analysis
State Natural cadastres	Land resources	Categories of land, structure of agricultural land, structure of acreage, proportion of pastures and forage, perennial planta-

	Land plots of the coastal territory	Land plots of the sea and river bottom covered by surface waters, their location, area, type of land, type of use, cadas-
	Climatic resources	Extreme and average temperatures, precipitation, solar radiation, the duration of the frost-free period, the relevance of the
	State of the environment	Results of measurements of soil quality parameters, water use objects, atmospheric air by ecological monitoring stations
Federal State Statistics Service	Economic and geographical characteristics	Average wages, wages per person per month, unemployment rate, regional subsistence level, provision of housing, medical care, density of the transport network, relevance of the information
Unified State Register of Rights to Immovable Property and Transactions with It (USRR)	Database of legal information on the property	Property name, area, types of previously verified transactions, cadastral number; address of the location of the property; information about the owner and type of rights; information on restrictions, arrests and encumbrances; real estate lawsuits

The introduction of elements of GIS RCA at the present stage can be ensured within the framework of the current state program of the Russian Federation "Information Society (2011-2020), approved by the decree of the Government of the Russian Federation of October 20, 2010 N 1815-p", which defines the main priorities of strategic development in Information and communication technology.

GIS RCA will allow to coordinate and direct the efforts of public authorities, subjects of the Federation of the far Eastern region, local authorities, economic entities and citizens to improve the information management of river coastal areas, taking into account regional natural and technological risks and the international transboundary features of the Amur basin.

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