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Table of Contents:

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Integration of Monitoring Systems for Tourist Destinations into National Environmental Monitoring Systems

Yuliya I. KOLTUNOVA
Department of Marketing and Public Administration
Industrial University of Tyumen, Russian Federation
qween200@mail.ru

Aleksandr A. TKACHEV
Department of Marketing and Public Administration
Industrial University of Tyumen, Russian Federation
sever626@mail.ru

Svetlana V. TOLMACHEVA
Department of Marketing and Public Administration
Industrial University of Tyumen, Russian Federation
svtolm@gmail.com

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Abstract:

Monitoring the state of a tourist destination is determined by the fact that each site must not only have an infrastructure of the appropriate type, but also maintain an equilibrium ecological state, which is determined by whether human activities are either minimized or not implemented at all. In the regions of the Arctic, this interaction is also due to the fact that a significant part of eco-tourism is organized in a location dominated by water tourism. In accordance with this, we define the actual formation of a model of monitoring a water body as based on ecological tourism in the Arctic regions. The novelty of the proposed research is determined by such a factor, which forms an assessment of the quality of the environmental monitoring carried out in order to fully realize the possibility of reducing the anthropogenic load. The authors have developed a strategy, model and practical application for ecosystems based on the use of hydro resources. The application of the obtained results is possible in those ecosystems that are exposed to intense effects and may experience a decrease in recreational capacity. The authors show that the developed model can be fully implemented in the territories, which currently can offer tourists rest in hydrozones, but due to the high load they cannot always accept a sufficient number of tourists.

Keywords: ecological monitoring; tourism; water resources; territory; development.

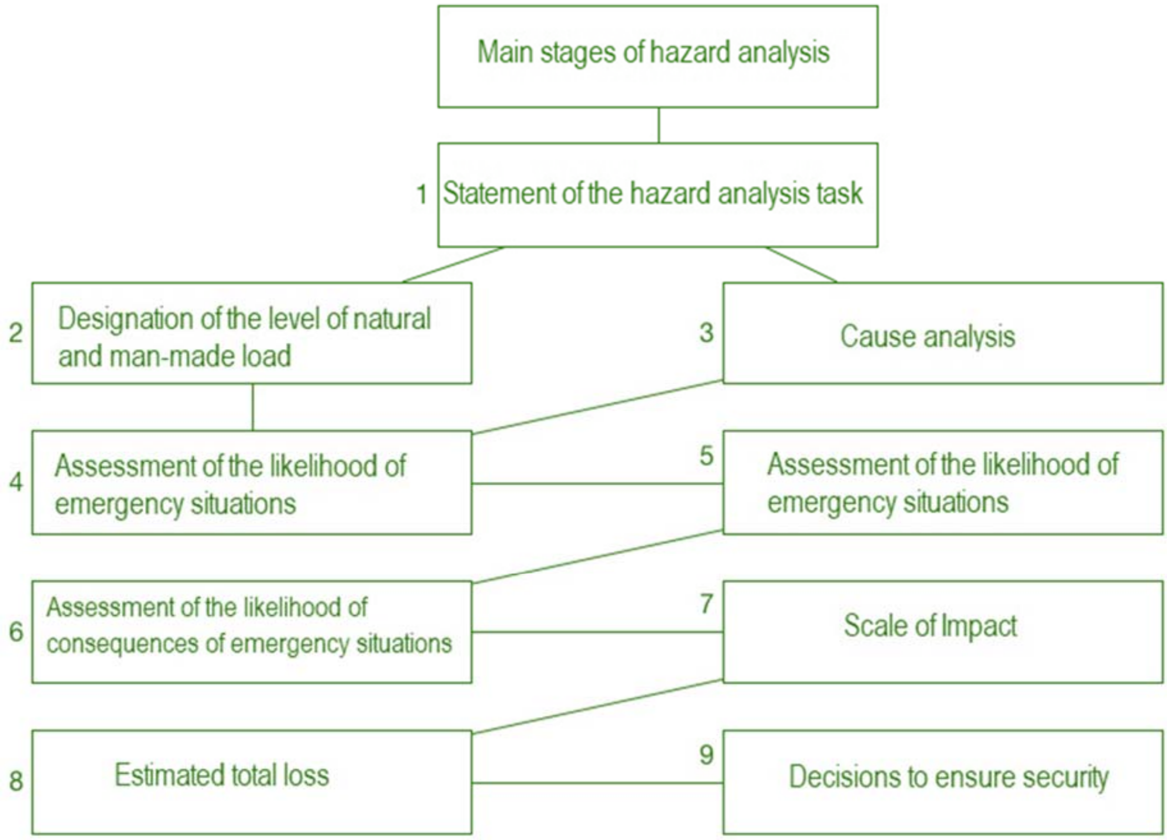
JEL Classification: Q57; Z32.

Introduction

Monitoring the state of the basin of a water body provides for the inclusion in the chain of studies of all factors that in one way or another influence the formation of runoff. The interrelation of a number of functional factors that form the dynamics of the behavior of a water body is the main subject of the occurrence of hydro-ecological hazard (Kuenzi and McNeely 2008). Factors and processes, such as weather conditions, moisture coefficient, geographical features and conditions of functioning of not only a water body, but also a whole hydro-ecosystem, form the subject of study of hydro-ecological hazard. In this regard, the key to an optimal monitoring system is the combination of such factors into a single functional chain, the formation of an algorithm for determining natural and technological hazards (Figure 1). In the course of work, an optimal scheme of stages for assessing the natural and man-made influence in a hydroecosystem is performed, which includes a set of stages for analyzing, determining, assessing the likelihood, extent and acceptability of risks in a hydroecosystem and, as a result, measures to reduce them (Belitskaya 2018).

Working according to such a scheme eliminates the problem of cooperation between departments, since already at the first stage it is possible to determine which jurisdiction falls under one or another emergency situation, and when studying development scenarios, additional structures can be identified that need to be applied in a given situation (Zhao and Li 2006). The main problems that the proposed monitoring system should solve are to improve the coordination scheme of conducting monitoring between various departments, optimizing the network of observation points, expanding the list of indicators and environments (Miller and Hadley 2005; Intima 2017; Villa *et al.* 2017; Moura *et al.* 2018).

Figure 1. Algorithm for assessing the natural and man-made hazard in a hydro-ecosystem



So, according to such a scheme for a model situation of the phenomenon of influence – "Flood" we make a model scheme (Darnay 2016):

- Determining the scale of the flood (carried out by the relevant departments, in this case, the Federal Agency for Water Resources, hydrometeorological center);
- Risk of flooding the area with a flood (carried out by the relevant departments, in this case, the Federal Agency for Water Resources);
- Settlement (local authorities, depending on the assessment of the scale: village, town, city, region);
- Assessment of the scale of the situation according to the zones of flooding of the territories (conducted by the relevant departments, in this case, the Federal Agency for Water Resources);
- Assessment of the development scenario, the extent of damage (conducted by relevant departments, in this case, the Federal Agency for Water Resources, Rosprirodnadzor, local governments);
- Assessment of possible damage (damage to agricultural land, public and private property, human losses);
- Definition of damage zones, localization of damages;
- Assess the consequences and determine their acceptability, search for means and ways to minimize disasters or consequences (adoption of operational reports of the agencies involved);
- Analysis of the received proposals, the formation of an action plan, the distribution of activities by relevant organizations in accordance with instructions for actions in emergency situations.

To solve these tasks, we have created an optimized scheme of stages for assessing the natural and man-made impact in a hydro-ecosystem, which adapts both to environmental components and to phenomena and activities within the system (Long 2019). The system should include the necessary data and schemes for the effective determination and prediction of natural and man-made impact. Thus, the process of impact assessment takes place according to a specific algorithm, following which without extra steps you can come to a logical solution to the problem or take measures to localize it. The proposed scheme allows to identify problems and departments that can form the necessary measures.

1. Literature Review

A weak material and technical base, the lack of an effective monitoring quality assurance system, a low level of information management and data exchange, as well as an inappropriate level of data processing significantly complicates the functioning of the monitoring system and its improvement (Gribust 2018). To improve the monitoring system, which will include all the data and schemes necessary for effective forecasting of the natural and man-made impact, several basic solutions were proposed (Stanciu 2019). As part of this study, climate change analysis was carried out, their correlation with the parameters of surface water bodies and the main categories of consequences of such changes were grouped. Thus, when choosing a monitoring object, the tendency of development of climatic phenomena inherent in the territory under study should be taken into account (Lola *et al.* 2019; Maslennikov *et al.* 2018).

As a result of such changes in climatic factors, the hydrological parameters also change, which are one of the main studied quantities of natural-industrial impact from the side of quantitative indicators. The prediction of climate change plays an important role in the formation of measures that are being developed to prevent and cope with the effects of natural and man-made impacts of various etiologies (van der Straaten 1992).

The next factor not previously studied from the point of view of the basin approach that influences the determination of natural and man-made hazards is the moistening of the basin's territory. The main role in the formation of runoff is precipitation; part of the liquid sediments is absorbed by the land, the rest falls into the watercourse (Briassoulis 2000a). However, not only the quantity of absorbed water factor is important, but also a quality indicator factor (Lei 2014a). The forest cover is able to absorb a significant part of rainwater, moreover, during the fall of acid precipitation, its qualitative condition can significantly deteriorate, which will lead to degradation of vegetation cover and cause significant damage to the hydroecosystem. Violations of the forest cover of the coastal territory of mountain rivers can cause significant damage to the population, because the flow areas of mountain rivers are in especially flood-prone areas. Thus, in determining the risk of the formation of flood phenomena, an important aspect for long-term studies is the study of the wetting of the catchment area and the control of the acidity of rainwater (Briassoulis 2000b; Batyrova *et al.* 2018). The expansion of the monitored parameters will avoid a number of hazards and unforeseen situations and will significantly improve the accuracy of the predicted height of the flood. Such measures will make it possible to take timely measures to prevent and avoid certain consequences of the elements.

Considering the hydro-ecological hazard as a risk that may arise with a combination of natural and man-made factors, one should pay attention to the need for an integrated approach (Yu and Duverger 2019). After all, the threat posed by the flood is not only in the amount of water that passes in a certain area and causes material damage, but also in the influence of the flood on the qualitative state of the water body. For an integrated approach to assessing the natural and man-made impact, it is necessary to consider all aspects of an emergency situation (Ma *et al.* 2018). Hazard analysis and the likelihood of emergency situations include the following main steps:

- statement of the problem of hazard analysis and impact assessment;
- analysis of the hazards and conditions of occurrence of natural and man-made hazards;
- assessment (probability) of emergency situations;
- analysis of conditions and assessment of the likelihood of emergency situations;
- determining the magnitude of the consequences;
- assessment of the likelihood of emergency consequences;

Assessment of the acceptability of natural and man-made impact and decision making to reduce the impact.

2. Materials and Methods

The objectives of the study of natural and man-made impact is to establish the level of risk and risk management by comparing its level with acceptable and the choice of solutions to reduce it. The first priority is to determine the threat to a person, for this it is necessary to allocate the place of residence, enterprises and organizations that fall into the affected area (Vellas and Bécherel 1995; Terleev *et al.* 2019a). Taking into account the peculiarities of the geographical location, terrain and climatic conditions of the area, etc., local councils can establish an acceptable impact for other objects threatened by the impact (except for a person). Other objects that are under threat of influence should also be considered, these are socially important objects, ecosystem elements, property of legal entities and individuals (Lei 2014b; Terleev *et al.* 2019b).

Large social gatherings should be considered as socially important objects (stadiums, cinemas, hospitals, etc.); environmental facilities (reserves, parks, etc.); recreation areas (recreational areas); cultural objects (museums, palaces, architectural monuments, etc.); life support facilities (water treatment plants, power supply facilities, utilities facilities, transportation lines, etc.); location of local government, state administration and other life management bodies (Guo *et al.* 2015; Bolgova *et al.* 2016).

As elements of the ecosystem, where possible negative impact, should be considered: flora and fauna; aquatic environment (rivers, ponds, sea area); groundwater, including groundwater; other objects of influence. Residential and household buildings can be considered as property of legal entities and individuals; vehicles; cottage and garden plots; cemeteries; buildings, structures and equipment of enterprises; property of industrial enterprises, organizations and institutions; arable land, livestock and other agricultural properties; raw materials and products, in particular, sowing and harvest; other movable and immovable property (Turanlıgil 2016).

In addition, it is necessary to identify other objects that fall into the zone of dangerous influence of the accident. Today there are several methods for determining risk: statistical, probabilistic, expert. Using statistical models to predict the effects of emergencies requires processing a large amount of information. The probabilistic method does not allow to give an objective assessment of the consequences of relatively rare emergency situations, the risk to the population from which is determined by the mathematical expectation of the consequences for a certain time after they occur. The expert method is quite difficult to apply for assessing the safety of an individual object (Roth and Merz 1997).

Therefore, in addition to these risk assessment methods, attention should be paid to the index method, which has several advantages compared with the listed methods. The use of the index approach makes it possible to assess the contribution of one or another factor to the dangerous impact on the environment as a whole or behind individual components of the environment. Today, the assessment of the impact of certain risks is carried out by indices for each component of the environment. It is necessary to establish the relationship of indicators with the level of environmental risk that is formed at a particular object.

3. Results and Discussion

The author has analyzed and systematized the existing methods for assessing the degree of environmental hazard. Thus, specific factors (chemical, physical, biological and landscape transformations) of the region's man-made hazard are analyzed in detail. Introduced man-made hazard index (T). Due to the lack of some data (values of reduction coefficients, not established MPC for some substances, local characteristics of territories, etc.), the author suggested calculating T using the following general formula:

$$T_x = K_t K_p (K_r \Sigma_i K_i M_{ia} + K_b \Sigma L_i M_{ic} + K_v K_z \Sigma N_i M_{io}) \quad (1)$$

where: K_p – coefficient depending on the number of persons who fall under the influence of man-made factors;

K_i – basin coefficient that takes into account the peculiarities of the territories and the ecological and economic conditions for the functioning of water bodies;

L_i, N_i – indicators that take into account the impact on humans and the environment of the mass unit of the i-th hazardous component, respectively.

The main factors affecting the environmental safety of the facility (enterprise, region) are: the amount of harmful components in exhaust gases entering the atmosphere, the volume of polluted wastewater containing harmful components with a concentration of more permissible and polluting the hydrosphere and solid waste (ash and slag, plastic, sludge). It is proposed to assess the degree of environmental hazard by developing a theoretical and experimental substantiation of the predictive stochastic patterns of changes in the vector field of the concentrations of pollutants emitted by a point source. Methods are proposed for solving problems of assessing the quality of surface waters and improving the system for their monitoring. A method is proposed for determining the quantitative influence of the main factors on the total value of the integral indicator of the environmental safety of an object (IIESO), which makes it possible to quantify the environmental status of an object and its impact on regional environmental safety. This indicator varies over time and depends on the degree of implementation of environmental protection measures at individual sites or territories, natural and man-made factors. This allows you to compare objects in terms of their environmental safety. The influence of the above factors is proposed to be quantified on a 100-point scale, and the number of points for a particular factor will depend on the amount of pollution entering the environment. The value of the IIESO object is proposed to be determined by the formula:

$$IIESO = \left[\frac{K_a + K_v + K_{sh} + K_r}{K_p} - \frac{K_z}{K_p} \right] \times 100 \quad (2)$$

where: K_a, K_v, K_{sh}, K_r – pollution factors (atmosphere, hydrosphere, technosphere and contribution of risks), which are defined as $K_i = \frac{M_i}{L_i}$, where M_i – amount of pollutants, tons / year; L_i – limit of pollutants, tons / year; $K_z = \frac{E_z}{TP}$ – coefficient of environmental costs; CC – the cost of commercial products, thousand rubles / year; E_z – total costs of environmental measures, thousand rubles / year. In addition, a total area contamination factor is determined: $K_p = \frac{P_0}{P_c}$, where P_0 – area of object area, P_c – total area of the facility with sanitary protection zone, ha. Due to the calculation of identical indicators, pollution factors are obtained. (K_i), which summarize, which allows to calculate the total indicator of environmental pollution from various factors. Ecological and hygienic diagnostics of the conditions for the reproduction of water resources, watercourses or reservoirs are proposed to be carried out by determining the levels of violation of the conditions for the reproduction of water resources according to environmental and hygienic indicators, followed by a generalization of the estimates for individual blocks, including organoleptic, toxicological and microbiological indicators, followed by a generalized assessment with the definition integral values. To assess the state of surface waters, it is proposed to calculate a complex quality potential index (CQPI). It takes into account the safety factors of organoleptic, physical, chemical, biological, toxicological, and others. Indicators (the relative value of reserve capacity), which are the excess of the allowable values over the actual ones, and the factors of the reserve deficit indicators (the relative value of the reserve deficit), which are calculated as the excess permissible concentrations.

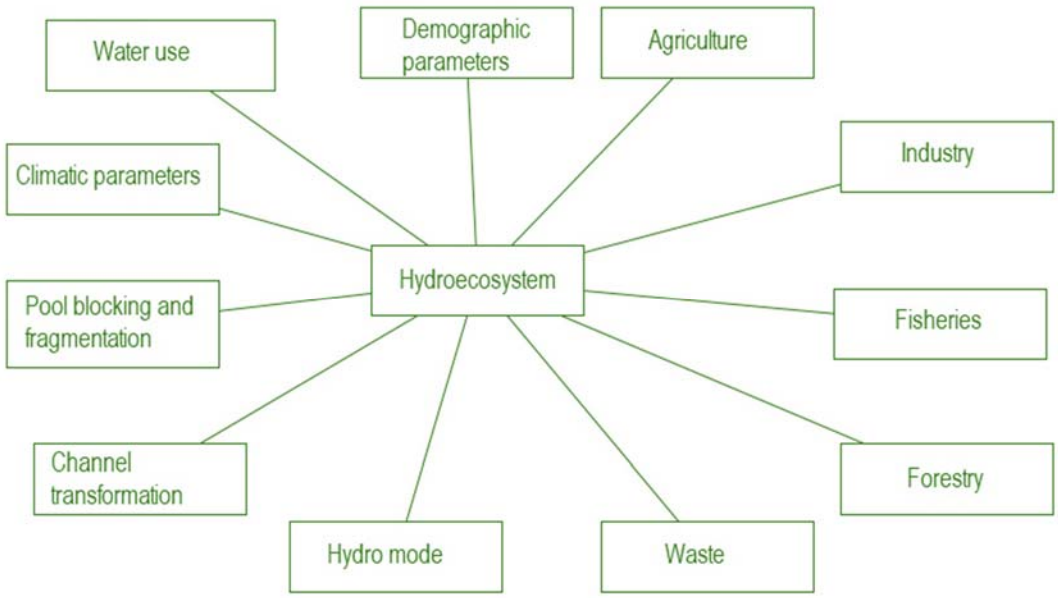
A significant number of researchers associate environmental safety with the concept of "risk". So consider the main types of risks – individual, man-made, environmental, social, economic, partially characterized methods of risk assessment, based mainly on the determination of equipment failures and operator errors. The concept of “risk analysis” should be introduced, which is used for natural factors – natural disasters that affect the state of environmental safety. The main causes that create risks — natural or man-made disasters, industrial production and human activity that affect the state of environmental safety have been studied extensively enough. The corrosion processes of technological devices, pipelines, structures, lead to man-made accidents, create technical risk.

Also, one of the main characteristics of the hydrological regime of rivers is the water level. When anticipating the state of water bodies, the forecast products are highly informative, when water levels are supplied in comparison to their multiyear values in certain seasons of the year – average, maximum, minimum or a certain probability of exceedance. At the same time, there are often differences in the uniformity of multi-year sequences of discharges and water levels. If overflow data are overwhelmingly appropriate to be considered as homogeneous sequences (with the exception of regulated rivers), then with respect to water levels such an approach is not always justified due to changes in the conditions of movement of water masses. These changes are associated with the processes of channel deformations or as a result of the construction of facilities to protect riverine areas from flooding or straightening of the channels.

For each object of analysis, the possibility of the influence of external factors is estimated, based on the characteristics of its location. External influences and their probabilities do not depend on the operating conditions of the object. Therefore, it is determined whether the measures are sufficient to ensure the stability of the object to external influences and reduce negative consequences. A quantitative risk assessment is not performed. A list of possible external influences. Determining the scale of the consequences of natural and man-made hazards includes an analysis of possible impacts on people, property and the environment. In order to assess the possible consequences and the subsequent risk assessment, it is necessary to simulate emergency situations for each of the possible outcomes determined during the development of the situation analysis. All assumptions in assessing the scale in case of uncertainties in the risk assessment process should focus on the worst consequences: if uncertainties arise in the possible values of process parameters, then the worst possible ones are taken to determine the conditions for the occurrence of emergency situations; regarding the probability of weather and climatic conditions, the most unfavorable should be selected for risk assessments; in the case of statistical evaluations, the most unfavorable deviations from the average value are selected with a confidence level equal to more than 0.95; if there are other uncertainties, then other worst assumptions are made under which the worst consequences are most likely. It is recommended to use computer programs and software for emergency modeling, hazard analysis and risk assessment. Methods for calculating and assessing the hazards, consequences and risks that are used in computer programs and software should be justified in accordance with the requirements of the methodology chosen for consideration.

It was established that the occurrence of destructive floods and floods in the studied region is due to a number of natural and anthropogenic factors (Figure 2), the main among which is excessive precipitation (up to 100-300 mm per day) against the background of previous floods, frozen soils, and rapid snowmelt, deforestation, selection of sand and gravel, and the like. Other significant natural factors include the significant steepness of the slopes, the low permeability of the surface, the state of the vegetation and soil cover. Among man-made factors, poor flow regulation, lack of flood reservoirs, imperfect forest management activities, over-plowing, haphazard building, timber dumping, debris and the like are the dominant factors.

Figure 2. Systematization of impacts on the hydroecosystem



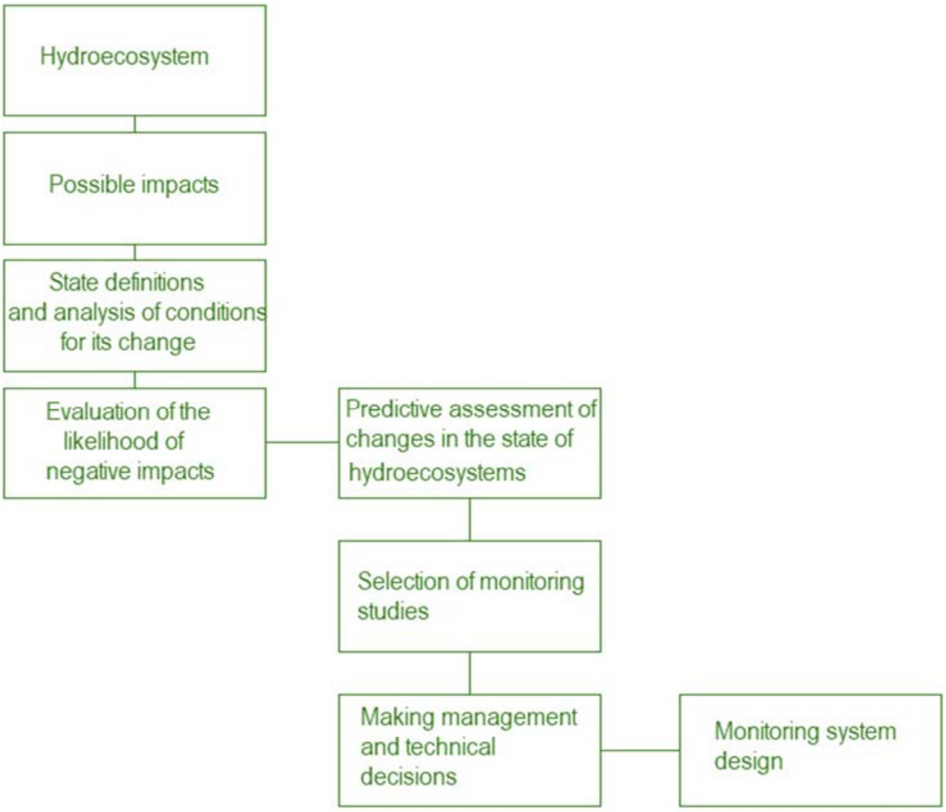
However, the violation of the state of the hydro-ecosystem and its removal from the state of homeostasis can be caused not only by destructive floods and floods. The study of natural and man-made impacts associated with water supply requires further development, improvement and consideration of forecasting capabilities. The use of computer technology will greatly facilitate management in the field of ecology and expand the possibilities of environmental audit of the territory.

The concept of environmental risk allows us to give a quantitative description of environmental hazards for a wide class of phenomena and processes. It is a quantitative description that is of interest for predicting the natural and man-made impact. So, specific dependencies and trends are traced, which give grounds for improving and deepening the possibilities of integrated forecasting of natural and man-made impact, taking into account not only quantitative, but also a qualitative indicator of influence. After all, when flood and flood events occur, we receive not only external damage, which is caused by the destructive power of water, but also deterioration in quality indicators. And taking into account the fact that a significant part of the population of the Arctic region uses surface water for water consumption, this also implies additional risks of water consumption, which are directly dependent on hydrological phenomena. This once again brings us to the fact that the issue of natural and man-made impact should be approached as a complex indicator. The proposed algorithm allows us to simplify the approach to solving the problem of natural and man-made impact.

Using the scheme of the stages of impact assessment in a hydroecosystem, the period between the influence determination and measures for its liquidation or localization can be shortened significantly. Today the concept of natural and man-made impact is used quite often, however, as a rule, it is used as one of the components of a different indicator, for example, geological, radiological, risk of accidents or any other risk. However, it may be appropriate to take into account the natural and man-made influence not as one of the indicators, but as an independent one, which will allow assessing the threats that may arise and the consequences they may bear.

The creation of spatial dynamic models taking into account all the factors of influence will simplify the selection and improvement of river control and anti-flood measures. The use of computer technology will greatly facilitate management in the field of ecology and expand the possibilities of environmental audit of the territory. Thus, we have developed a methodological diagram of the stages of assessing the impact on the hydroecosystem (Figure 3). This scheme provides a step-by-step study of the hydroecosystem and the impacts that form the risk of water supply. Taking into account possible impacts (Figure 2), the state of the hydroecosystem is determined and the conditions under which it will be violated are analyzed. At the next stage, an assessment of the occurrence of violations and a forecast of further changes in the state of the hydroecosystem are carried out.

Figure 3. Methodological diagram of the stages of assessing the impact on the hydro-ecosystem



Performing such steps provides a choice of effective monitoring studies, improves the process of making managerial and technical decisions and allows you to design an optimal monitoring network. We have proposed a comprehensive method for determining the natural and man-made influence. The method relates to natural and man-made safety, a comprehensive assessment of natural and man-made impact within the basin of a water body, which includes the impact of hydro-regime, the degree of transformation of the aquatic ecosystem, blocking of the basin, fragmentation, ecological state of the basin and the qualitative state of water resources, functioning of aquatic ecosystems. This method of determining the degree of natural and technogenic impact can be used to assess the functioning of the water hydroecosystem in natural conditions and to predict changes in the state of a water body, subject to scenario change. This method of assessing the natural and man-made impact can be used in environmental regulation, environmental assessment, environmental audit in hazard assessment and forecasting of the impact indicator and its various components, the development of water protection measures, planning the development of river systems basins and in forecasting natural and man-made impacts of various genesis. .

According to the key law of nature management, the law of internal dynamic equilibrium – substance, energy, information and dynamic qualities (homeostasis, stability, reliability) of individual natural systems are closely related and any change in these components leads to the development of natural chain reactions in the direction of neutralizing changes or the formation of new systems. At the same time, even a slight change in one of the ecological components can cause irreversible changes in the entire natural system as a whole. In this regard, for the rational management of natural resources in the process of environmental management there is a need for an integral approach to the use of a particular resource and the mandatory environmental regulation of the volume and intensity of its use. Under the conditions of a dysfunction of the components of a hydroecosystem, the task of searching for a critical field of influence arises, which leads to the removal of the hydroecosystem from an equilibrium state (homeostasis).

Today, there is a known method for determining the degree of natural and man-made impact through the determination of the ecological balance coefficient, which consists in the basin approach to determining the hydroecological balance of a territory and includes taking into account such indicators as the percentage of forest land, the percentage of forest land and the percentage of water grounds in the calculation of the ecological balance. However, the method does not provide an assessment of the degree of natural and man-made impact through the limitations of indicators for determining the ecological integrity of a territory by basin approaches, namely: an indicator of surface water quality, an indicator of transformation of aquatic ecosystems, and also not closely related to a water body as a key element of the basin.

We also reviewed a method for assessing the natural and man-made impact of water use of river ecosystems, which includes measuring the volume and intensity of water use of a river ecosystem, the volume of irreversible water use, the volume of wastewater discharges, water quality indicators, changes in quantitative and qualitative indicators of a river ecosystem and technogenic genesis for a certain time, the number of water users who fall under the influence of dangerous events, and a number of people within the basin hydroecosystems values quality building coefficient hydroecosystems and indicators for sustainable, balanced water. Based on the obtained indicators, the value of the complex indicator of the natural and man-made impact of water use is calculated and the degree of the natural and man-made safety of the hydroecosystem for water use is evaluated according to the developed scale. This method is designed to determine the safe level of anthropogenic stress on river ecosystems. However, the limited definition of indicators does not fully determine the degree of natural and man-made influence resulting from the disturbance of the hydroecosystem components and the removal of the hydroecosystem from equilibrium.

On the other hand, the method of protection against flooding by regulating the river flow, covering the formation of the reservoir accumulated by the construction of a dam at the place of creation of reservoirs, also complements the natural and man-made impact under investigation. For example, prior to the construction of a dam, the maximum allowable discharge of water that does not cause a flood in the main river's stream is determined, as well as the flow of water that does not cause a flood in the beds of one of its tributaries, after which no less than 2 dams are installed on each tributary, where each dam has a gateway, the size of which is calculated from the conditions for ensuring the transmission of water, the flow rate of which does not exceed the above-mentioned maximum allowable flow rate for each inflow. This method ensures that only the estimated amount of water from each inflow is supplied and that the water in front of dams in temporary reservoirs exceeds the estimated flow rate. This increases the effectiveness of flood protection even under adverse meteorological conditions, but it provides only technical measures to control the channel and does not take into account environmental indicators that would allow rational use of the territory and determine future impacts. Therefore, this approach was taken into account when introducing the indicator of transformation of aquatic ecosystems, because any technical activity affects the channel processes of the basin.

To improve the method of determining the natural and technogenic influence developed by us, a study on the prediction of the spring flood coefficient was also taken into account. In connection with this method, depending on the module of the runoff and the runoff layer, the sum of factors is determined, such as: catchment area, relative bogs, relative forest cover, relative plowing, which are used to calculate the spring flood coefficient. Taking into account the given physiographic characteristics, this method allows to calculate the parameters of the maximum flow, but does not take into account many factors that affect the degree of risk that may arise in conditions of natural and man-made hazards. Since in our time the pressure on water bodies and hydroecosystems is due to various factors, the definition of each of them is irrational, and the assessment of the degree of natural and man-made impact without taking into account a complex of factors is unreliable. That is why, given the analyzed studies, the study posed the task of developing a method for determining the degree of natural and man-made influence by determining the integral indicator of a complex natural and man-made influence and assessing by its value the degree of natural and man-made influence on the totality of natural and man-made factors. This will allow to more fully assess the state of the basin hydroecosystem, reliably determine the likelihood of its violation and, accordingly, apply a set of measures to reduce the impact of negative impacts on the hydroecosystem more substantively.

The protection and rational use of water is of particular interest for a comprehensive assessment of the ecological state of surface waters, as well as the parameters under whose influence this state is formed. Development and implementation of preventive environmental measures based on probable environmental information will significantly improve the environmental situation in the Arctic region. In this regard, an important part of measures to improve the quality of surface waters is the introduction into water protection practices of an integrated system for assessing the ecological status of aquatic ecosystems, which contains basic parameters, flow regulation, flow indicators, indicators of the degree of fragmentation and blockage of the basin, as well as basic conditions for the functioning of a water body.

The proposed calculation indicator R_{he} is a relative value, which depends on the level of anthropogenic load and natural processes, and the phenomena occurring within the basin hydroecosystem. The proposed degree of natural and man-made impact should be assessed on the following scale:

$R_{he}<0,2$ – reference state – the range of environmental factors most favorable for the functioning of a hydro-ecosystem;

$0,2<R_{he}<0,4$ – зона оптимума – low damage range without causing hydroecosystem disturbances;

$0,4<R_{he}<0,6$ – pessimum zone – a range of environmental factors that are unfavorable to the functioning of a hydroecosystem;

$0,6<R_{he}<0,8$ – crisis zone – a range with a high level of damage to the hydro-ecosystem, the state of the ecosystem is dangerous;

$R_{he}>0,8$ – ecological disaster zone – a range with a very high level of damage to the hydroecosystem, the state of the ecosystem is critical.

The obtained degree of impact for a specific basin unit, according to the dynamism of all components, can be used to assess the degree of environmental impact of analogous objects. The introduction of a specially developed scale for assessing the natural and man-made impact will provide an opportunity to use a simple priority setting method, where certain areas or sections of a hydroecosystem that meet certain standards of environmental quality, without further intervention, can be considered reference, and other areas of hydroecosystems can be ranked and assessed, depending on the degree of natural and man-made impact. During the implementation of this method, indicators of hydro-mode measurement, indicators of transformation of aquatic ecosystems, indicators of blocking of the basin, indicators of fragmentation, coefficient of ecological imbalance, coefficient of water quality are determined.

The hydromeasurement measurement indicators cover the useful volume of reservoirs, for which they use data from the technical characteristics of the reservoirs, calculate the total useful volume of all reservoirs above the site, from observation posts and hydro-ecological reference books, use the average five-year flow data, calculate the degree of flow regulation at the site, from the topokart data, deciphering satellite images determine the area of the floodplain on the site, calculate the change in floodplain ecosystems on the site, and on the basis of the obtained x data, the index IMPflood as changing floodplain ecosystems in the script.

The index of transformation of aquatic ecosystems due to flooding (IMPres) is determined as follows: from the technical characteristics of the reservoir, data are used to determine the maximum area of the reservoir, then the total area of all reservoirs is calculated above the estimated section in a specific scenario using topographic data and GIS calculations, cross-section profiles.

On the basis of the obtained data, the indicator of transformation of aquatic ecosystems (IMPres) is calculated as the ratio of the area of the reservoir (or reservoirs) to the area of all aquatic ecosystems above the boundary. The basin blocking rate (IMPblock) is determined on the basis of a calculation using GIS modeling, the area of the river basin's sections above a certain range, blocked above the dams built according to the scenario (n), and the area of the basin above this range. The indicator (IMPblock) is calculated as the percentage of water intake blocked by dams above the alignment. To determine the fragmentation index (IMPfrgm), data from GIS modeling and calculation of the area of parts of the river basin into which the basin is fragmented by dams in the scenario and the total area of the main river basin are used.

To determine the coefficient of environmental imbalance Kedb using the data of GIS modeling and calculation of the percentage of arable land, the percentage of forest land, the percentage of water areas, the percentage of wetlands, as well as the data of the forecast coefficient of spring flood friendliness. The coefficient of conformity of water quality (FCQ) is determined on the basis of calculations of an integrated quality potential index. CQPI calculations include the so-called safety factors of indicators (relative reserve power), calculated as the excess of allowable values over actual values (concentrations, units, points, quantity, etc.) and subtract the factors of reserve deficit indicators (relative value of reserve deficit), which is calculated as an excess of concentrations (or other measurements) over the permissible values (in the same units). The result is divided by the number of indicators used:

$$CQPI = \frac{1}{n}\sum_{i=1}^{n} x_i$$

$$x_i = \begin{cases} \dfrac{WQS_i}{C_i} \, если \, \dfrac{WQS_i}{C_i} > 1 \\ \dfrac{C_i}{WQS_i} \, если \, \dfrac{WQS_i}{C_i} < 1 \end{cases} \tag{3}$$

where: WQSi – water quality standard for a specific indicator, that is, permissible (limit values) indicators of the physicochemical and biological state of waters and their properties that meet the requirements of fisheries reservoirs;
Ci – the actual water quality value for the i-th indicator;
n is the number of indicators.

The result is divided by the number of indicators used and subsequently find its ratio with the indicators of the optimum, determines the proportion of deviations from the norm. The integral indicator of the complex natural and technogenic impact (Rhe) is calculated on the basis of the formula developed by the author:

$$R_{he} = \sqrt[6]{IMPflood \times IM\,\mathrm{Pr}es \times IMPblock \times IMPfrgm \times Kedb \times FCQ} \tag{4}$$

where: IMPflood – change in the hydrological regime and ecosystems of the floodplains in the downstream dams, up to the mouth;
IMPres – transformation of aquatic ecosystems due to flooding;
IMPblock – blocking the river basin, in particular the intersection of the migration routes of biological species;
IMPfrgm – fragmentation of the basin – the degree of division of the basin into separate sections by dams, expressed as the percentage of lost paths along the river network;
Kedb – coefficient of environmental imbalance of the river basin or its section;
FCQ – water quality ratio.

The solution of the problem was based on the mathematical processing of an array of statistical data on the results of surface water analysis, passport data of the river basin and the determination of parameters using GIS technologies. Thus, after statistical data processing of the river basin and carrying out comparative analyzes for the river basin, the results obtained are grouped and entered into a consolidated database (Table 1), on the basis of which a complex indicator of natural and man-made impact was obtained R_{he}. The developed method allows to assess the situation of the basin. In this case, the hydroecological norm is the minimum optimal value that does not go beyond the limits of the reactions of the device for maintaining homeostasis.

Based on the interrelation of causes and consequences of the occurrence of natural and man-made impacts, the proposed approach contains structural indicators that make it possible to fully assess the possible impact and, by replacing indicators, determine the dynamics of changes in the behavior of a hydroecosystem. The main fundamental task within the framework of the indicated research is the substantiation and development of a rapid assessment methodology for the development of hydrological potential of river basins, which covers a comparative analysis of various development scenarios for determining favorable indicators and values that minimize environmental losses from activities. The proposed method is particularly relevant in the basin of arctic rivers, which has a high undeveloped hydro-ecological potential and needs to preserve the ecosystems and biota of rivers.

Characterization and analysis of all potential activities in large river basins will allow scientific, environmental, public organizations and the expert community to formulate more reasonable proposals for drawing up and adjusting regional development strategies, schemes for the protection and use of water resources, schemes for locating energy facilities, corporate and departmental plans, and investment programs. The prospect of development and expansion of the concept of natural and man-made impact is the ability to attract more of the studied parameters, which will allow to adapt this method to the features of each watercourse. For example, in the described method, we use the hydro mode measurement indicator, which takes into account the reservoirs on the river, during the study of the water body, take into account the features inherent in the selected structural unit and cannot be ignored during economic activities.

Table 1. Parameters for determining the complex indicator of natural and man-made impact R_{he}

Indicator	Index, indicator code	Units	Script or source formula	Initial data
1. Hydro mode measurement indicator				
Useful volume of reservoirs (adjustable reservoir capacity)	LV	million m^3	-	Technical characteristics of reservoirs, GIS modeling
The total net volume of all reservoirs above the site (in the scenario)	LV_*acc_n*	million m^3	ΣLV	Calculation
The average stack on the site for the last 5 years of observation	Wx5	million m^3		From observation posts, hydrological reference books
The degree of adjustment (change) runoff on the site (x)	Alt x	condition. %	$\frac{LV}{Wx5} \times 100\%$	Calculation
Floodplain area on the site (x)	S_flx	km^2		Topographic maps, decryption of maps
Changes in floodplain ecosystems on site (x)	IF_*X*		$\frac{Sfi \times LV\_acc}{Wx5}$	Calculation
Changes in floodplain ecosystems in the scenario (n) – the sum of the values of all modified sections of floodplains	IMP_flood	%	$\frac{(\Sigma IF)xn}{\Sigma S\_fix} / 100$	Calculation
2. Transformation index of aquatic ecosystems				
Maximum reservoir area	R_A	km^2		Technical characteristics of reservoirs, GIS
The total area of all reservoirs above the range in this scenario (n)	SWO	km^2		Calculation in GIS, maps
The area of all water bodies of the river basin is higher than the design section (x) together with the reservoir and in the scenario (n)	SWR_{xn}	km^2		Topographic maps, GIS calculation
The ratio of the area of reservoirs (a) to the area of all aquatic ecosystems is higher from the site (in the scenario)	IMP_res_{xn}	%	$\frac{R\_A\_acc_{xn}}{SWR_{xn}} \times 100\%$	Calculation
3. Pool blocking rate				
The area of the river basin's sections above this section (x) blocked above the dams built according to the scenario (n)	$SB\_dam\_up_{xn}$	km^2		GIS modeling and calculations

Idicator	Index, indicator code	Units	Script or source formula	Initial data
Basin area above this range (x)	SB_up_x	km2		GIS modeling and calculations
Blockage of the river basin, in particular the intersection of the migration routes of biological species	IMP_block_n	km2	$\frac{SB\_dam\_up_{xn}}{SB\_up_x}$	Calculation
4. Fragmentation rate				
Area of parts of a river basin that are fragmented by a dam basin in a scenario	I, II, …, n	km2		
The total area of the main river basin	SB	km2		
Pool fragmentation	IMP_fgrm	%	$\left(1-\frac{\sqrt[2]{(I^2+II^2n}}{SB\_up_x}\right)/100$	
5. Environmental imbalance factor				
Percentage of arable land	Sal	%		GIS modeling and calculations
Percentage of arable land	Sf	%		GIS modeling and calculations
Percentage of arable land	Sw	%		GIS modeling and calculations
Percentage of wetland area	Ss	%		GIS modeling and calculations
Environmental imbalance factor	Kedb	%	$Kedb = Sal / Sf + Sw + Ss$	Calculations
6. Water quality factor				
Comprehensive quality potential index	CQPI		$CQPI = \sum \frac{FCQ_i}{C_i}$	
Water quality ratio	FCQ	%	$4 / CQPI$	4 indicators of optimum

Technical anti-flood facilities are part of the economic infrastructure as are roads and telecommunications. Trying to build new anti-flood facilities or reservoirs, one should not underestimate the final effects and the need to maintain existing facilities in good condition. Only the implementation of a set of measures that covers natural water retention, technical installations, preventive measures to reduce risks, the determination of the risk of residual impacts and individual preventive measures can lead to an improvement in flood protection. Therefore, it is necessary to compare the willingness to change with how you can achieve your goals.

Conclusion

The reservoirs in the river basin are certainly an important component of the hydro-ecosystem, therefore the basin approach when using the proposed method is the determining lever for a comprehensive and reasonable assessment of the natural and man-made impact within the selected basin. This element of the basin is introduced into the formula using the ratio that determines the change in floodplain ecosystems in the study area. The concept of environmental impact allows us to give a quantitative description for a wide class of phenomena and processes associated with environmental hazards. It is this level of impact assessment that is of interest for determining and predicting natural and man-made influence. The widespread use of methods for predicting the impact can be the key to the sustainable development of the region, since due to the timely prevention of unwanted technological impact, you can take the necessary measures to localize the problem or reduce its consequences.

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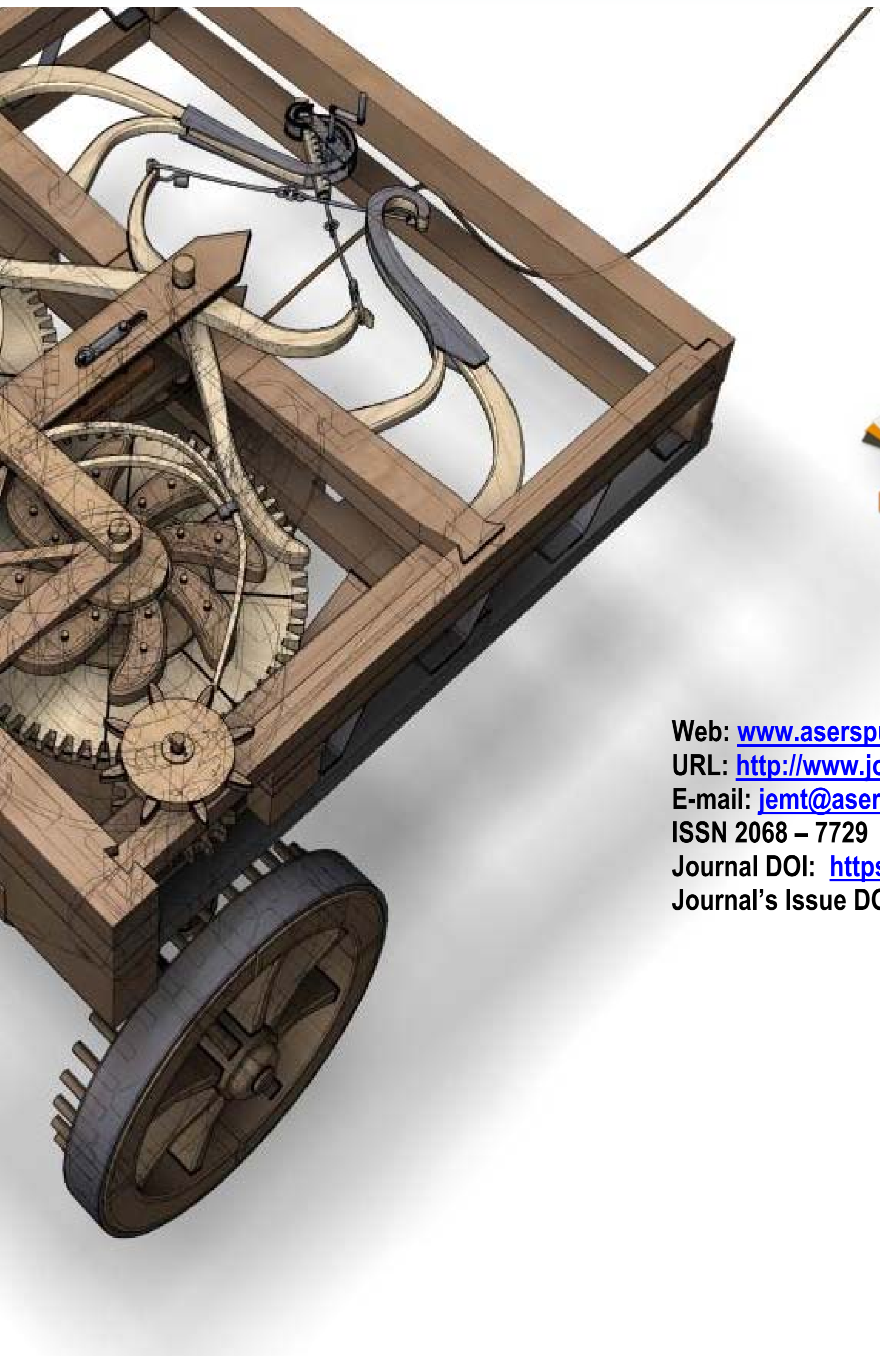

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