About the methodology of geo-risk management in forestry

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Abstract. The article examines the components of risk management, considers industry risks in forestry management. A risk management methodology in forestry is proposed based on a controlled parameter. The preliminary data processing for working with the model is considered.

1. Introduction

In the process of organizing and managing the safety of natural-technical systems, situations often arise when the results of decisions taken do not meet human expectations. An unsatisfactory management result is substantiated by conflicting conclusions. To exclude them, one should use the axiomatic method, which allows one to exclude the groundlessness of reasoning [1].

In order to create conditions guaranteeing the achievement of the goal of activity, a natural-science approach is used in natural-technical systems for management. This approach combines the properties of human thinking, the world and cognition.

Three components are reflected in the following principles.

1) The principle of three-component knowledge:
- component A - abstract representation;
- component B - abstract-concrete representation;
- component C - specific representation (technologies, algorithms).

2) The principle of the integrity of the world. This is a stable, objective connection between the properties of an object and action for a fixed purpose.

3) The principle of knowability of the world. It is implemented by such methods as: decomposition, abstraction, aggregation.

In the process of activity, a person operates with the categories "system", "model" and "purpose", therefore, it is correct to consider and use these categories.

The basis of management is always the decision of a person. A person makes a decision based on a model. Under the object model is understood the description or representation of the object corresponding to the object and allowing to obtain the characteristics of this object. Therefore, a solution is a model of the process with which a person works. A process is an object that works with a fixed purpose. For the synthesis, we use a natural-science approach based on the law of preservation of integrity.

The law of preserving the integrity of the object is a stable repeating association of the properties of the object and the properties of the action for a fixed purpose. WSCO is manifested in the mutual transformation of the properties of the object and the properties of its process for a fixed purpose.
2. Methods and Materials

There are different approaches to making management decisions in forestry [2, 3]. In accordance with the developed natural science approach, each process should be represented by three components corresponding to the properties of "objectivity", "integrity" and "variability" (or the concepts of "object", "goal" and "action", respectively). These three components are located horizontally. On the one hand, they can be interpreted at three different levels of cognition of the world (abstract, abstract-concrete, concrete). This approach determines the presence of three levels vertically. On (figure 1) is a structural diagram of the deployment of the content of the concept of "solution".

![Figure 1](image-data.jpg)

**Figure 1.** The structural diagram of the deployment of the content of the concept of "Solution".

In [4], a parametric model for assessing geo-risk in natural-technical systems was developed, the algorithm of which is shown in figure 2.

Figure 2. The block diagram of the algorithm of the parametric model for geo-risk assessing.

For the correct use of the parametric model, a risk assessment technique based on controlled parameters has been developed.

Consider the main stages of geo-risk assessment based on managed parameters:

1) Domain analysis
2) The formation of the data array
3) Data analysis
4) Data preparation
5) Identification of model parameters
6) Parametric modeling
7) Evaluation of the results
8) Implementation of results when making management decisions.

From each stage, the corresponding tasks follow (table 1), upon completion of which there should be a result, which is the initial data for the next task.

**Table 1.** Decomposition of tasks in the assessment of geo-risks based on controlled parameters.

| Business analysis | Data analysis | Data preparation | Modeling | Decision evaluation | Implementation |
|-------------------|--------------|------------------|----------|---------------------|----------------|
| Definition of business goals | Data collection | Data sampling | Choice of Algorithms | Evaluation of the results | Implementation |
| Assessment of the current situation | Data description | Data cleansing | Test plan | Process evaluation | Monitoring planning |
| Defining analytics goals | Data exploration | Data generation | Model training | Defining next steps | Preparing of report |
| Project Plan Preparation | Data quality check | Data shaping and integration | Model quality assessment | - | Project Review |

For the correctness of the simulation results, it is necessary to perform certain checks, and, if necessary, change the time series as a result of which, completeness, data comparability and conformity of the model used are established.

The developed model does not impose strict requirements on the source data, and this is precisely the key factor. A decision maker can use almost any geodata of his subject area, which is in open or closed access.

The main steps in preparing the data are:
1. Representation of the process under study
2. Analysis and identification of regular components that depend on time
3. Analysis of the implementation, after removing the legitimate components
4. The construction of the autocorrelation function, to determine the possible depth of the forecast
5. Bringing to the required data structure

3. Results and Discussion

First of all, to determine the possibility of working with specific geodata, you need to check them for stationarity and normality of the distribution.

For this, we will use the Student t-test. We put forward the null hypothesis about the randomness or stationarity of the series and the absence of a time trend, an alternative hypothesis is not the randomness of the series and the presence of a temporary trend i.e. dynamism.

In general, a hypothesis test is performed using the t-test, which is calculated by the formula (1):

\[
t = \frac{\bar{X}_1 - \bar{X}_2}{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)^{0.5}}
\]

We can interpret the calculated value based on the properties of the t-criterion, based on which it can be argued that at the significance level \(a > 0.05\), the null hypothesis is accepted, otherwise not. Graphically (figure 3), the level of significance can be represented as an area of rejection and acceptance.
The second condition for the source data is the normality of the distribution. The probability distribution shows the probability of all possible implementations of the variable. Each distribution depends on the parameters that characterize the distribution. Normally distributed (figure 4), is called a random variable whose probability density has the form:

\[
\frac{1}{\sqrt{2\pi s}} \exp \left( -\frac{1}{2} \left( \frac{x - \bar{X}}{s} \right)^2 \right), \tag{2}
\]

Depending on the values of the arithmetic mean and standard deviation, the normal distribution graph can look like:

\[\text{Figure 3. Graphical representation of the acceptance area.}\]

\[\text{Figure 4. Normal distribution graph.}\]

As a test for the normality of the distribution, we will use the Shapiro-Wilk test, which has the form:
\[
W = \frac{1}{s^2} \left[ \sum_{i=1}^{n} a_{n-i+1} \left( x_{n-i+1} - \bar{x} \right) \right]^2, \quad (3)
\]

where,
\[
s^2 = \sum_{i=1}^{n} \left( x_i - \bar{x} \right)^2 \quad (4)
\]
\[
\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i \quad (5)
\]

To determine the depth of the forecast, it is required to construct the autocorrelation function of the initial series. Autocorrelation of a random process describes the relationship between the values of the process at different points in time. In the case when the process is continuous, autocorrelation is determined by the formula:
\[
R(t, s) = \frac{E[(X_t - \mu)(X_s - \mu)]}{\sigma_t \sigma_s} \quad (6)
\]

For a discrete process \(X_1, X_2, \ldots, X_n\), autocorrelation is calculated by the following formula:
\[
\hat{R}(k) = \frac{1}{(n-k)s^2} \sum_{i=1}^{n-k} (X_i - \mu)(X_{i+k} - \mu), \quad (7)
\]

To achieve the most accurate forecast results, the forecast depth is determined from the value of the correlation coefficient. In this case, we are interested in a noticeable, high and very high correlation, in this case the model shows the most accurate indicators.

4. Conclusion
Geo-risk management and the search for the optimal managerial solution is implemented in the dependence “territory - economy - natural environment”, the main role in it is played by the process of ensuring the safety of socio-economic systems under the influence of external factors [5]. The proposed methodology is distinguished by a combination of graphical, analytical and statistical methods for assessing risks based on controlled parameters. The developed technique allows you to:
- carry out verification and conversion of primary data,
- form an array of data with specified properties,
- maximize comparability of simulation results.

Thus, for optimal risk and possible damage management, it is necessary to design and develop information systems for decision support based on geographic information technologies, including:
- a) distributed databases of dependencies of forecasted and actual meteorological parameters,
- b) data on the possible economic and social consequences of managerial decisions, while preventing and eliminating the consequences of adverse events.

The developed approach to risk management allows you to optimize the process of making a managerial decision that satisfies the objective function - to reduce the relative economic damage, depending on the natural factors of the study area, and will contribute to the positive dynamics of the financial and economic activities of the region.

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