Information and analytical system for monitoring green spaces

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Abstract. Today the topic of ecology is especially relevant for the residents of the Krasnoyarsk Territory. Many environmental problems have accumulated in the region, and the population is not fully aware of these gaps. In addition, for their solution, for the optimal organization of the activities of various management structures, complex cartographic information is needed. The relevance of the topic being developed is because landscaping and gardening is the most important area of activity of the municipal economy. The tasks of optimizing the urban environment of landscaping, as well as eliminating the consequences of negative impact on the environment, are being solved through the information and analytical system. The goal is to create an information and analytical system for monitoring green spaces, which will allow you to have up-to-date information about the life state of park zones, as well as any landscaping objects added to it.

1. Introduction

With the growth of the city, the development of its industry, the problem of environmental protection, the creation of conditions for human life and activities becomes more and more complex. In recent decades, the negative human impact on the environment and, in particular, on green spaces has increased.

In general, all over the world, significant efforts are being made to green and improve the urban economy. Increased air pollution and dustiness, unfavorable physical and mechanical properties of the soil, asphalt pavement of streets and squares, the presence of underground utilities and structures in the root system zone, additional lighting of plants at night, mechanical damage and intensive use of urban plantings by the population - all this has a constant negative impact on the life of plants in an urban environment and leads to the premature death of trees, long before the onset of natural old age. Industrial production plays a significant role in the process of destruction of the natural environment and deterioration of public health, and, in particular, the chemical industry, which only ranks second among industrial production in terms of the volume of polluted wastewater discharge.

To automate and reduce the time spent on collecting data and analyzing them, to draw up a passport for such objects as: park, square, square, etc., to ensure favorable living conditions for people in the city, as well as for timely care of landscaping objects that have undergone any harmful factors, it is necessary to develop a project that will allow accumulating, systematizing and visualizing information about the current state of landscaping objects.
Now, there are several similar information and control systems for monitoring green spaces, which solve this problem. One of these systems is the "Countree" used in Krasnoyarsk.

The Countree system functions as a smartphone-friendly website. To control the quality of the data, the organizers of the tree accounting conclude a volunteer agreement with each volunteer and provide individual access to the system. For each tree counted in the system, information is saved about who exactly carried out the inventory of the territory enclosed by fences [1].

However, most of these systems for monitoring trees have little functionality, since these systems are not capable of analyzing the collected data. All existing applications for monitoring trees in Russia are only capable of taking inventory of objects.

The main purpose of this work is not only the development of a system not only for the inventory of green spaces. This project will allow tracking up-to-date information about the state of trees, but also displaying data on the vital state of trees periods, sorting trees by species and other characteristics.

The system being developed will also allow displaying charts with various environmental indicators, which will allow analyzing the ongoing environmental situation in the city in real time and timely organizing measures to improve it.

2. Methods

Information and analytical system (IAS) is a system designed to accumulate knowledge and provide data for decision-making based on a comprehensive analysis of information [2] [3].

It should be noted that the IAS is not the only comprehensive integrated system to meet all information needs. Since there may be a desire to get a system of this nature, it is necessary to stipulate the aspect that, due to the great difficulties in real organizations, the probability of its creation is low. IAS of a certain organization rather consists of a number of information systems, each of which serves to make decisions in a specific area. Figure 1 shows the general structure of a single information space [3].

Developed by the IAS "Quality management of urban landscaping objects" consists of two main directions:

- Monitoring the state of urban landscaping facilities
- Quality management of urban greening system

The organization algorithm IAS "Quality management of urban greening objects" is presented in the form of a block diagram in figure 2 [4].
Figure 2. Block diagram of the information and analytical system “Quality management of urban landscaping objects.”

In the developed system for quality management of urban landscaping objects, it is proposed to use a differential method for assessing the quality level of objects.

When determining the quality level by the differential method, an analysis of the comparison of quality indicators of the evaluated object, the base sample and other analogues is carried out. Because of the analysis, it is established whether the level of the base sample as a whole has been reached, by what indicators it has been achieved, what are the differences between the base sample and the analogue.

To assess the quality level by the differential method, the values of the relative quality indicators are determined using the formulas:

\[ q_i = \frac{P_i}{P_{ib}} \]

\[ q_i' = \frac{P_i}{P_{ib}} , i = 1,2,\ldots,n \]

where \( P_i \) is the value of the \( i \)-th quality indicator of the evaluated object; \( P_{ib} \) is the value of the \( i \)-th indicator of the basic sample or analogue; \( n \) is the number of quality indicators of the object.

Of the two formulas given above, the one is selected at which an increase in the relative quality indicator corresponds to an increase in the quality of the object. Based on the results of calculating the relative indicators, conclusions are drawn about the quality level of the evaluated object. If all the values of the relative indicators are greater than or equal to one, the quality level of the evaluated object is higher or equal to the level of the base sample. If all values of relative indicators are less than one, the quality level of the evaluated object is below the level of the base sample.

In cases where part of the values of relative indicators is greater than or equal to one, and part is less than one, it is not possible to make an unambiguous conclusion about the quality level of the object being evaluated. In such cases, a mixed method of assessing the quality level is used. In this case, it becomes necessary to determine the parameters (coefficients) of weight and complex quality indicators [4].

An integrated method for assessing the quality level of objects. When using this method, the quality level of the assessed object is characterized by one generalized (complex) indicator, which is a function of single indicators. In this case, the complex indicator is the average weighted arithmetic quality indicator, determined by the formula:
\[ Q = \sum_{i=1}^{n} m_i(Q) q_i \]  

(3)

where \( m_i(Q) \) — parameters (coefficients) of the importance of quality indicators,

\( q_i \) — relative quality indicators for a promising (basic) object or analogues.

Based on the results of calculations, the following conclusions can be drawn:

- at \( Q \geq 1 \) — the quality, level of the evaluated object is higher or equal to the quality level of the base object or analogue;
- at \( Q \leq 1 \) — the quality, level of the evaluated object is lower than the quality level of the base object or analogue.

Determination of the parameters (coefficients) of the importance of quality indicators.

In accordance with the practice of assessing the level of quality and the recommendations of regulatory documents, the values of the parameters (coefficients) of weight can be determined by the following methods:

- The method of cost regression dependences.
- By the method of limit and nominal values.
- Equivalent Relationship Method.
- Expert method.

It should be noted that the first three methods are widely used in assessing the quality level of industrial products. The expert method for determining the parameters of the importance of indicators is based on the use of the opinions of experts. The expert method should be used only in cases where the weight parameters cannot be determined by the first three methods. The analysis of the content of the methods and the data used in this case shows that the method of limiting and nominal values can be used to determine the parameters (coefficients) of the weight of indicators of the quality of objects of urban green spaces [5]. This method is based on the use of the known limit values of quality indicators of objects that determine the requirements for them. Average statistical values of indicators are taken as nominal values. The numerical values of the weight parameters when using the method of limiting and nominal values are determined by the formula:

\[ m_i(Q) = \frac{1}{\sum_{i=1}^{n} \frac{1}{P_{ni}-P_{pr}}} \]  

(4)

where \( m_i(Q) \) - weighting parameters of quality indicators,

\( P_{ni} \) — the nominal value of the \( i \) – th quality indicator,

\( P_{pr} \) — limit value \( i \) – th quality indicator.

If, when determining the weight parameters, the condition \( \sum_{i=1}^{n} m_i(Q) = 1 \), and then these parameters are called the weighting factors of the unit quality indicators.
3. Results

Created on the basis of the developed UML use-case diagram (figure 3) [6], the ER-diagram of the database is capable of storing the entire amount of data for the future IAS [7]. Includes the following tables (figure 4).

![Figure 3. UML use case diagram.](image)

![Figure 4. Database diagram.](image)

In order for the developed IAS to be user-friendly and to have the most complete functionality, it is necessary to adhere to the following requirements:

- simple and intuitive interface to increase the speed of the user's work by reducing the time of thinking;
• reducing the number of human errors by reducing the requirements for vigilance, increasing the intelligibility and visibility of indicators, blocking potentially dangerous user actions until confirmation of the correctness of the action is obtained;
• the user interface should contain tips, informational messages, help documentation.

Based on the above criteria, the interface of the future information systems was developed. The user should not feel tension when working in this system [8].

The main menu of the page is a city map on which landscaping objects are located in the form of markers. By selecting a marker on the map in the place where the landscaping object is located, you can edit it (figure 5). You can also add new objects by pre-defining a point on the map.

Figure 5. IAS main page interface.

4. Conclusion
In the course of the work performed, an information and analytical system for monitoring park zones was designed, which will automate the process of collecting information about the greening objects of the city of Krasnoyarsk and perform an analysis of the environmental situation. This system will make it much easier to analyze the situation, draw up maps and passports of objects, and make decisions regarding park zones. And also a layout of the interface of the information management system was developed and a database was designed.

In the future, it is planned to create wider functionality and the ability for users to customize the system for themselves: add the markers they need on the maps, data filtering, tabular access to the list of trees, as well as a moderator panel, which would allow more extensive and convenient work with data.

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