Geoinformation maintenance of the territory of Chornobilskiy radio-ecological biosphere reserve for monitoring conduction

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SUMMARY

The state and prospects of application of geoinformation systems (GIS) to solve monitoring tasks of nature protected territories of Ukraine are investigated. The results of the first in Ukraine project of geoinformation support of the territory of the Chornobyl Radiation and Ecological Biosphere Reserve (CBR) for monitoring conduction is introduced; it is based on a geospatial database (SDB) of the reserve, which was created using an feature-oriented approach based on national standards of Ukraine DSTU 8774:2018 "Geographical information. Rules for geospatial data modeling" and DSTU ISO 19110: 2017 "Geographic information - Methodology for feature cataloging". An information and reference geoportal of the territory and facilities of the Chornobyl Radiation and Ecological Biosphere Reserve has been created, which makes it possible to provide public access to the current monitoring information of the CBR based on the ArcGISOnline platform to a wide range of users. The use of the developed specialized algorithms of geoinformation analysis and modeling for monitoring of a radiation pollution condition of CBR is offered.

Introduction

The most important task of environmental activities is to preserve and increase the nature reserve fund, as well as the protection of the gene pool of flora and fauna, rare species of plants and animals, landscapes.

After the creation of a protected area, the problem of ensuring the management of this area immediately arises. The most effective practical method of solving this problem is the use of geographic information systems (GIS) and geographic information technologies (GIT), which helps to ensure the activities of nature reserves, as well as allows analysis and modeling of various processes and phenomena in these areas and their mapping.

At the state level, under the aegis of the Ministry of Ecology and Natural Resources of Ukraine, a database of the state cadastre of the nature reserve fund of Ukraine was created, as well as its interactive interpretation in the form of a map (*Nature-Reserve…, n.d.*).

In Ukraine, geoinformation projects (*Nature-Reserve…, n.d.; NPP "Podilsky Tovtry", n.d.; Natural conditions…, n.d.; Chornobyl Radiation…, n.d.*), which are designed to ensure the activities of individual features of the nature reserve fund (NRF) are mostly unsystematic, differ in the approaches and methods used. The main feature of these projects is that they are made in the form of geographic information layers of data, which are presented in the form of digital maps, to solve a specific problem that is not a modern cartographic approach. Digital maps remain inaccessible to a wide range of users, and in some cases even to the administration of the environmental unit and local authorities. The problem is that the whole set of source geoinformation layers of project data, which can be the basis for further development in various areas of the NRF feature, are stored by the authors of the project and, sometimes, in the relevant authority. Electronic data remain inaccessible to a wide range of users, and in some cases even to the administration of the environmental unit and local authorities (*Design of nature reserves…, n.d.*). Therefore, today the urgent task is to substantiate the uniform requirements for the technology of geographic information support of protected areas during their creation, design and operation.

Geoinformation support should be focused on the effective implementation of all functions of the protected area. According to world experience (*Protected areas, n.d.; Protected planet, n.d.*), most of these territories have a similar, regulated by the statutory framework, a list of functions with a priority predominance of some of them. In general, the tasks of protected areas can be reduced to several main functions: environmental, science and research, tourism and recreation, education.

The Chornobyl Radiation and Ecological Biosphere Reserve was founded on the 30th anniversary of the Chernobyl accident on April 26, 2016. In 2016, the reserve was also granted international status and included in the World Network of Biosphere Reserves under the UNESCO "Man and Biosphere" Program.

The area of the reserve, which is located within the Ivankivskyi and Polisskyi districts of Kyivska region, occupies the exclusion zone of the Chornobyl APS, except for the 10-kilometer protection zone of the Chernobyl APS, and represents 226964.7 hectares.

The purpose of the reserve creation is to preserve the natural environment, conduct scientific researches, as well as limited visits by citizens.

The need for such a large-scale structure as the Chornobyl Radiation and Ecological Biosphere Reserve appeared long before April 26, 2016.

The Chornobyl Radiation and Ecological Biosphere Reserve was established by the Decree of the President of Ukraine of April 26th, 2016 - №174 / 2016 "On the establishment of the Chornobyl Radiation and Ecological Biosphere Reserve". This document defines "creation in Ivankivskyi and Polisskyi districts of Kyivska region within the exclusion zone and the zone of unconditional (compulsory) resettlement of the territory that was radioactively contaminated as a result of the Chornobyl disaster, the Chornobyl Radiation and Ecological Biosphere Reserve" (Fig. 1).

The purpose of this article is to study the features of geoinformation support of the Chernobyl Radiation and Ecological Biosphere Reserve for GIS monitoring.

Method and Theory

The research is based on the theory of databases and uses the principles of feature-oriented modeling to create a database of geospatial data GIS CBR as the core of geoinformation support for monitoring of protected areas.

Results

The authors of the article recommend using the principles of the geoinformation approach for geoinformation support of the territory of the Chornobyl Radiation and Ecological Biosphere Reserve.

Among the principles of geoinformation approach there are the use of geospatial databases, the advantages of which are: minimization of data redundancy; unification of data organization is achieved through the use of application schemes developed on the basis of international standards and national standards of Ukraine in the sphere of geographic information / geomatics; integrity and protection against unauthorized access, which determines the compliance of database information with its internal structure and given rules, the independence of data structures from software, the independence of software from data structures (*SOU..., 2014; DSTU ISO..., 2017*).

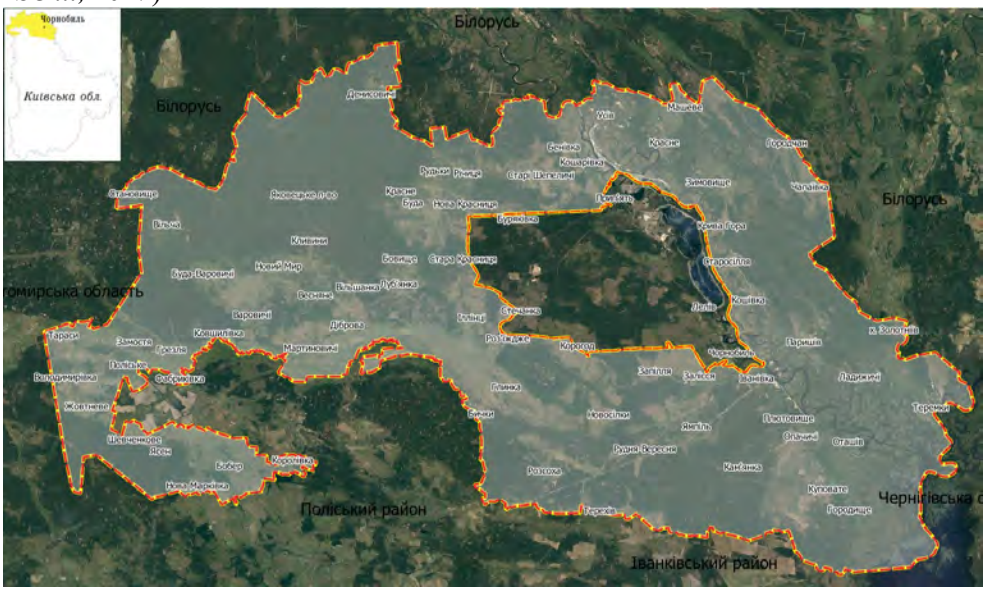

Figure 1 *Territory of the Chornobyl Radiation and Ecological Biosphere Reserve*

The geospatial database for GIS CBR for GIS monitoring conduction was created using an "feature-oriented approach", which defines the basic entities (classes) of the system which is being designed and establishes associations and operations to these classes. This SDB provides effective access to information, systematization of different types and origins of data, geoinformation analysis and modeling, ensuring the needed level of interaction between different users.

The following was developed – conceptual and logical geoinformation models using the unified modeling language UML, as well as a catalog of features and attributes of GIS CBR based on national standards of Ukraine DSTU 8774: 2018 "Geographic information". Rules for modeling geospatial data" and

DSTU ISO 19110: 2017 "Geographic information – Methodology for feature cataloging" (*SOU..., 2014; Karpinskyi, Lazorenko-Hevel, 2020*), which provides effective access to information, use of methods of geoinformation analysis, integration of geospatial data.

The designed conceptual model consists of entities, their attributes and relationships between them. In total, the model has 33 classes of features and 35 connections between them. The names of feature classes and their attributes are displayed in Ukrainian to summarize the content of information that will be indicated in these classes.

On the designed conceptual model the features are generalized:

- "Roads", "Railways" and "Bridge constructions" in the class "Railways, features of street and road network and bridge constructions";
- "Hydrographic features (polygonal and linear)", "Sources", "Anti-fire reservoirs" in the class "Features of hydrography and hydrographic network";
- "Flora", "Vegetation groups", "Vegetation" in the class "Vegetation".

Controlling checkpoints (CCP) and auto-barriers are associated with roads, border signs with borders, power plants with power lines.

All classes of features are part of the quarters through the connection "composition". The composition lies in the impossibility of the existence of features of the reserve outside the quarters.

"Quarters" interact with the reserve territory through "aggregation", while "Reserve territory" interacts with Kyivska region through this connection. The choice of "aggregation" connection is explained by the fact that

quarters are part of the reserve territory, but they can exist separately (e.g. if a decision is made to liquidate the reserve, the quarters may exist separately or become part of the forestry.). The same applies to aggregation between the reserve territory and the Kyivska region.

A prerequisite for designing a logical model of a geospatial database is the development of a catalog of features and attributes. According to the conceptual model, the SDB should contain 33 features.

When developing the SDB, the structuring of geographical information was carried out in accordance with the standard of the Ministry of Agrarian Policy of Ukraine SOU 71.12-37-949: 2014 "Database of topographic data. Catalog of features and attributes" (*On approval…, 2005; On the establishment…, 2016*). From this standard for designing a database of geospatial data were obtained 12 classes of features and their attributes: "Settlements", "Boundaries", "Boundary signs", "Power plants", "Power lines", "Roads", "Railways", "Bridge structures", "Hydrographic features (polygonal and linear)", "Sources", "Fire reservoirs".

Other features and attributes that are absent in the mentioned standard were designed independently, as they are necessary for geo-information support of monitoring of the CBR territory.

In the logical model, real-world features were classified in accordance with the standard DSTU ISO 19110: 2017 "Geographic information – Methodology for feature cataloging" (*DSTU ISO…, 2017*) and according to the designed catalog of features and attributes.

Experimental implementation of a geospatial database

The experimental implementation of SDB was carried out in the software ArcGIS 10.2 (Fig. 2) in the form of a file database of geodata.

Geoportal project

The geoportal of the reserve territory was implemented using the cloud service ArcGIS Online. This service allows you to convert web layers from *.mxd project file.

The geoportal includes layers: "Borders", "Roads", "Railways", "Hydrography", "Functional zoning", "Radiation status", "Tourist routes".

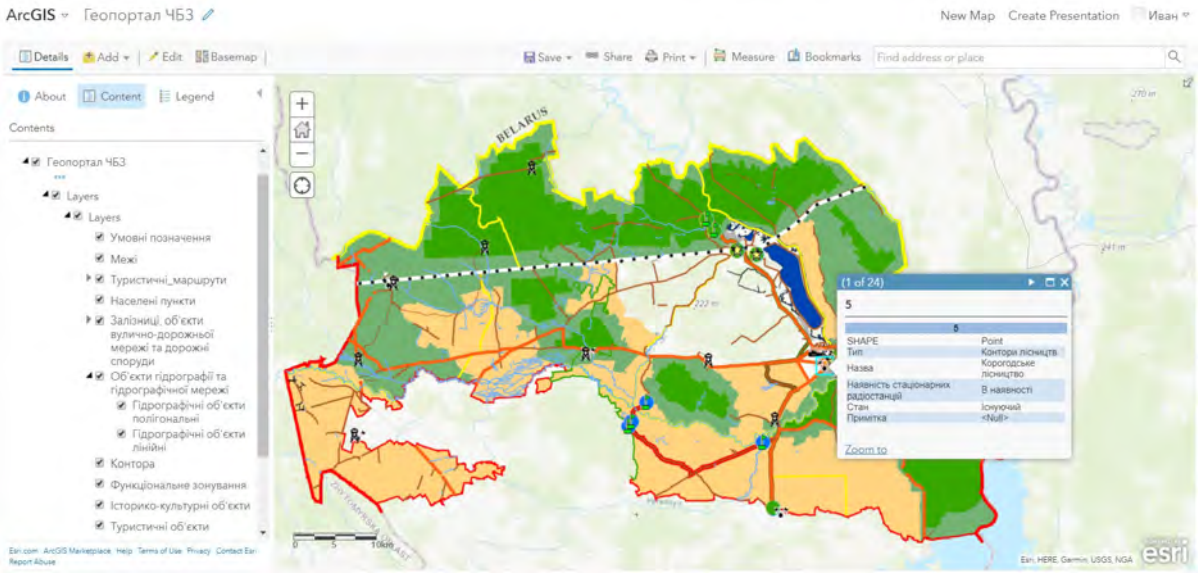

Figure 2 *Researched implementation of SDB*

Development of algorithms for specialized functions

In the process of GIS support, automated algorithms were developed to solve the following tasks: design of tourist routes; designing possible consequences of catastrophes; providing geoinformation support during the elimination of forest fires (design of optimal routes from forest fire stations to the place of forest fire, taking into account the terrain and areas with high levels of radiation, which must be bypassed and first of all to prevent the spread of fire); development of measures for the implementation of environmental, anti-erosion, landslide and anti-fire works, restoration of disturbed natural complexes; comprehensive assessment of the reserve territory; conducting scientifically substantiated functional zoning of the reserve territory;

development of proposals for the construction and reconstruction of facilities necessary to ensure the activities of the reserve (taking into account the terrain and the state of radiation pollution).
Algorithms are developed by creating ModelBuilder models using overlay operations and tools Spatial Analyst, Network Analyst, Statistics Tools.

Conclusions

Peculiarities of geoinformation support of the Chornobyl Radiation and Ecological Biosphere Reserve for GIS monitoring are: keeping up-to-date and unifying different types and origins of data on a single digital topographic basis, ensuring the required level of interaction between different local government authorities, other enterprises and institutions which ensure the viability of the reserve.
Problems solved with the help of GIS CBR:
- creation and maintenance of up-to-date cartographic materials (boundaries of the reserve, current state of use of the territory, natural landscapes, vegetation, distribution of rare and endangered species of flora, fauna, plant communities, functional zoning, afforestation of the reserve; location of historical, cultural and recreational areas features, ecological trails and tourist routes; fire-fighting landscaping, project plan);
- planning of nature reserve territory; organization of economically, socially and ecologically effective management of the reserve; development of measures for environmental monitoring; monitoring of the state of radiation pollution of the reserve territory; making management decisions, issuing data on hard media; visualization of the reserve territory; design of tourist routes; designing possible consequences of catastrophes; providing geoinformation support during forest fire fighting; development of measures for the implementation of environmental, anti-erosion, landslide and fire works, restoration of disturbed natural complexes; comprehensive assessment of the territory of the reserve, its economic use and reserves of natural resources, landscape diversity, historical and cultural sites, the state of engineering and transport infrastructure; conducting scientifically substantiated functional zoning of the reserve territory; development of proposals for the construction and reconstruction of facilities necessary to ensure the activities of the reserve.

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