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SCIENTIFIC BASIS FOR THE FORMATION OF A GEODATABASE IN THE DEVELOPMENT OF ASSESSMENT MAPS OF NATURAL AND MAN-MADE HAZARDOUS PROCESSES

Annotation

The formation of a geodatabase serves as a fundamental step in the creation of scientifically grounded assessment maps of natural and man-made hazardous processes. This process involves the systematic collection, integration, and structuring of spatial and attribute data relevant to geomorphological, geological, hydrometeorological, and anthropogenic factors. The scientific foundation lies in the application of geoinformation technologies (GIS), remote sensing data, and spatial analysis methods, enabling the identification, monitoring, and forecasting of hazard-prone areas. The geodatabase supports multi-layered data management, correlation analysis, and scenario modeling, ensuring accurate risk zoning and informed decision-making. This integrated approach enhances the reliability of assessment maps and contributes to sustainable land-use planning and disaster risk reduction strategies.
Keywords: geodatabase, natural hazards, man-made hazards, hazard assessment maps, spatial analysis, remote sensing, risk zoning, data integration, geospatial modeling, disaster risk reduction, multi-layer mapping, geoinformation technologies, environmental monitoring, hazard prediction.

НАУЧНЫЕ ОСНОВЫ ФОРМИРОВАНИЯ ГЕОБАЗЫ ДАННЫХ ПРИ РАЗРАБОТКЕ ОЦЕНОЧНЫХ КАРТ ПРИРОДНЫХ И ТЕХНОГЕННЫХ ОПАСНЫХ ПРОЦЕССОВ

Аннотация

Формирование геобазы данных является одним из ключевых этапов создания научно обоснованных оценочных карт природных и техногенных опасных процессов. Данный процесс включает систематический сбор, интеграцию и структурирование пространственных и атрибутивных данных, характеризующих геоморфологические, геологические, гидрометеорологические и антропогенные факторы. Научная основа формирования геобазы данных базируется на применении геоинформационных технологий (ГИС), данных дистанционного зондирования Земли и методов пространственного анализа, что позволяет выявлять, осуществлять мониторинг и прогнозировать территории, подверженные опасным процессам. Геобаза данных обеспечивает эффективное управление многослойной пространственной информацией, проведение корреляционного анализа и моделирование различных сценариев развития опасных явлений, что способствует повышению точности зонирования рисков и обоснованности принимаемых управленческих решений. Комплексный подход к формированию и использованию геобазы данных повышает достоверность оценочных карт и способствует устойчивому территориальному планированию, а также реализации мер по снижению риска чрезвычайных ситуаций и минимизации их последствий.
Ключевые слова: геобаза данных, природные опасности, техногенные опасности, оценочные карты опасных процессов, пространственный анализ, дистанционное зондирование Земли, зонирование рисков, интеграция данных, геопространственное моделирование, снижение риска бедствий, многослойное картографирование, геоинформационные технологии, экологический мониторинг, прогнозирование опасных процессов.

TABIIY VA TEXNOGEN XAVFLI JARAYONLARNI BAHOLASH XARITALARINI ISHLAB CHIQISHDA GEOMA’LUMOTLAR BAZASINI SHAKLLANTIRISHNING ILMIY ASOSLARI

Annotatsiya

Geoma’lumotlar bazasini shakllantirish tabiiy va texnogen xavfli jarayonlarni baholashga mo‘ljallangan ilmiy asoslangan xaritalarni yaratishning muhim bosqichlaridan biri hisoblanadi. Ushbu jarayon geomorfologik, geologik, gidrometeorologik hamda antropogen omillarga oid fazoviy va atributiv ma’lumotlarni tizimli ravishda yig‘ish, integratsiya qilish va tartiblashtirishni o‘z ichiga oladi. Geoma’lumotlar bazasini shakllantirishning ilmiy asosi geoaxborot texnologiyalari (GAT), Yerni masofadan zondlash

ma’lumotlari hamda fazoviy tahlil usullarini qo‘llashga tayanadi. Bu esa xavfli jarayonlar ta’siriga moyil hududlarni aniqlash, monitoring qilish va prognozlash imkonini beradi. Geoma’lumotlar bazasi ko‘p qatlamli fazoviy ma’lumotlarni samarali boshqarish, korrelyatsion tahlil o‘tkazish va turli ssenariylarni modellashtirishni ta’minlaydi. Natijada xavf darajalarini aniq zonalashtirish va asoslangan boshqaruv qarorlarini qabul qilish imkoniyati yaratiladi. Bunday integratsiyalashgan yondashuv baholash xaritalarining ishonchliligini oshiradi hamda yer resurslaridan barqaror foydalanishni rejalashtirish, favqulodda vaziyatlar xavfini kamaytirish va ularning salbiy oqibatlarini minimallashtirishga xizmat qiladi.
Kalit so‘zlar: geoma’lumotlar bazasi, tabiiy xavflar, texnogen xavflar, xavfli jarayonlarni baholash xaritalari, fazoviy tahlil, Yerni masofadan zondlash, xavflarni zonalashtirish, ma’lumotlarni integratsiya qilish, geofazoviy modellashtirish, ofatlar xavfini kamaytirish, ko‘p qatlamli xaritalashtirish, geoaxborot texnologiyalari, atrof-muhit monitoringi, xavfli jarayonlarni prognozlash.

Introduction. In recent decades, the increasing frequency and intensity of natural and man-made hazardous processes have underscored the urgent need for effective risk assessment and management strategies. The spatial complexity and interdependence of geological, geomorphological, hydrological, climatic, and anthropogenic factors necessitate a comprehensive, data-driven approach for monitoring and evaluating these hazards. One of the most effective tools in this context is the geodatabase - a structured system for collecting, storing, managing, and analyzing spatial and attribute data.

The formation of a geodatabase represents a critical foundation in the development of assessment maps aimed at identifying risk-prone areas, predicting potential threats, and guiding sustainable land-use planning. Through the integration of GIS technologies, remote sensing data, and advanced spatial analysis techniques, geodatabases enable researchers and decision-makers to visualize multi-factor hazard zones and to conduct correlation analyses between various environmental and anthropogenic indicators.

This study is focused on establishing the scientific and methodological framework for creating a geodatabase tailored to the needs of hazard assessment mapping. The aim is to enhance the accuracy, relevance, and practical applicability of such maps in both urban and rural contexts, thereby supporting disaster risk reduction, environmental protection, and regional development planning.

Methods. The methodology for forming a scientifically grounded geodatabase in the development of assessment maps of natural and man-made hazardous processes is based on a multi-stage, interdisciplinary approach integrating geospatial technologies, data science, and hazard analysis. The key methodological steps are outlined below. 1. Data Collection and Preprocessing: a). Acquisition of spatial data from remote sensing (satellite imagery, aerial photography), topographic maps, and field surveys, b). Collection of statistical and historical data on the occurrence and impact of natural (earthquakes, landslides, floods) and man-made (industrial accidents, pollution) hazards. 2. Spatial Analysis and Modeling: a) Application of geostatistical methods (e.g., interpolation, Kriging, correlation analysis) to identify hazard-prone zones, b) Use of multi-criteria decision analysis (MCDA) and weighted overlay techniques to assess vulnerability and hazard intensity, c) Incorporation of temporal data for dynamic modeling and forecasting of hazard development.

Results and discussion. According to scholars, GIS technologies have evolved into a universal, open platform closely interconnected with the spatial knowledge of essential infrastructure components. In the prevention of natural and man-made hazardous processes and the proper organization of evacuation, relevant data is collected.

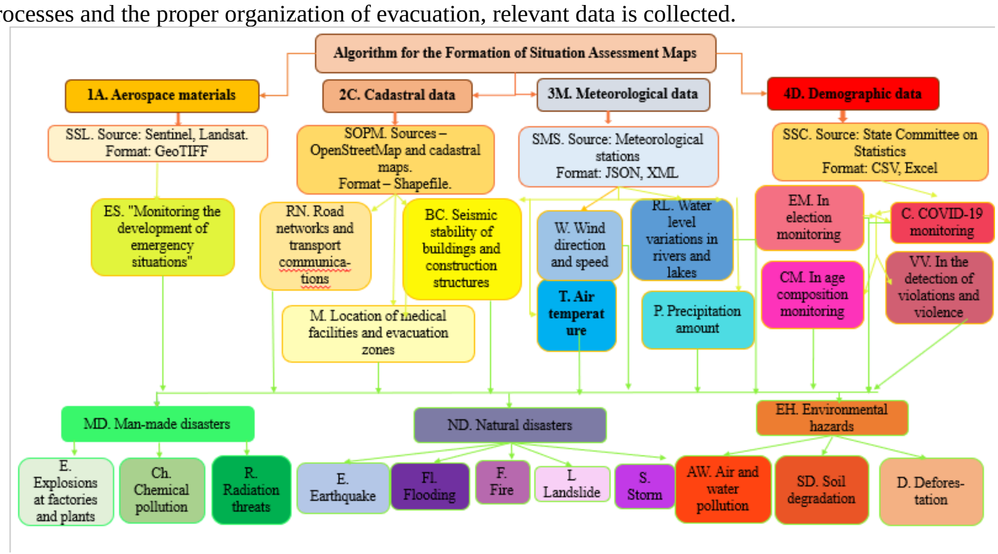

Figure 1. Algorithm for Structuring the Content of Situation Assessment Maps.

The developed algorithm not only enables deep analysis through the integration of the collected data, but also provides a foundation for visualizing this information across thematic layers.

According to the algorithm for structuring the content of situation assessment maps, the evaluation of natural, technological, and environmental hazards is carried out through the integration of various data sources and analytical elements. This algorithm facilitates the collection, processing, and thematic integration of the data necessary for the assessment and analysis of emergency situations.

The primary objective of developing this algorithm is to support the creation of maps that are used to analyze the likelihood of occurrence and spread of hazards, as well as to design appropriate mitigation measures. The creation of such maps involves the compilation of data from aerospace, cadastral, meteorological, and demographic sources. These data provide the basis for analyzing emergency situations, identifying the interrelations among features related to technological disasters, natural hazards, and environmental threats.

The algorithm enhances the process of hazard assessment mapping by leveraging multi-source data and an interdisciplinary approach. This approach contributes to the comprehensive analysis, forecasting, and decision-making processes related to natural and man-made hazards.

According to the data from the situation assessment map generation algorithm, no single process occurs in isolation; rather, it results from the influence of multiple factors and the interrelation of several simultaneous conditions. This can be described using a correlation function.

In the comprehensive analysis of natural and man-made processes, the correlation between events and phenomena was calculated to enable the forecasting of technogenic factors, natural disasters, and environmental hazards. The development of this correlation required the management of a wide range of data.

To manage these data effectively, neural activity models were utilized. By regulating the behavior of neural networks, it became possible to forecast technogenic factors, natural disasters, and environmental threats in advance.

In this context, a scientific approach based on identifying the integration between hazards, natural and technogenic factors, and their spatial distribution was implemented through the mathematical modeling of data flows.

In mathematical modeling, correlation analysis methods are widely used to identify relationships between datasets. These methods are particularly significant for determining the relationships between influencing factors and outcomes (such as yield, effectiveness, etc.). For the purpose of forecasting technogenic factors, natural disasters, and environmental hazards, the data flows associated with hazardous processes were analyzed using Pearson correlation.

The Pearson correlation coefficient [9; pp. 9–12] was used to determine the degree of linear association between two variables, based on the standard formula.

$$r = \frac{\sum(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum(x_i-\bar{x})^2(y_i-\bar{y})^2}} \quad (1)$$

$$\sum(x_i-\bar{x})(y_i-\bar{y}) \quad (2)$$

$$\sqrt{\sum(x_i-\bar{x})^2} \quad (3)$$

r ∈ [-1, 1]

r = 1 – indicates a perfect direct (positive) linear correlation;

r = –1 – indicates a perfect inverse (negative) linear correlation;

r = 0 – indicates no linear correlation.

Here, xi and yi represent the values of two variables (zi may denote a third variable, etc.), and x̄ and ȳ denote their respective mean values.

$\bar{x}$= (4+3+2+1)/4=2,5.

$\bar{y}$ =0,25+0,25)/4=0,46.

xi	yi	xi-x	yi-y	(xi-x) (yi-y)	(xi-x)2	(yi-y)2
4	1	1,5	0,54	0,81	2,25	0,292
3	0,33	0,5	-0,13	-0,065	0,25	0,017
2	0,25	-0,5	-0,21	0,105	0,25	0,04
1	0,25	-1,5	-0,21	0,105	2,25	0,04

∑ (xi-x) (yi-y) =0,81-0,065+0,105+0,105 = 0,955.

∑ (xi-x)2 = 2,25+0,25+0,25+2,25 = 5.

∑ (yi-y)2 = 0,292+0,017+0,04+0,04 = 0,3885.

r = 0,955/√ 5*0,3885 ≈ 0,68.

The obtained result was r = 0.68, indicating a direct proportional correlation. When various types of data (xi) were collected and correlated based on their characteristics (yi), it was revealed that technogenic factors, natural disasters, and environmental hazard processes exhibit a tendency to increase. This relationship is illustrated as shown in (Figure 2)

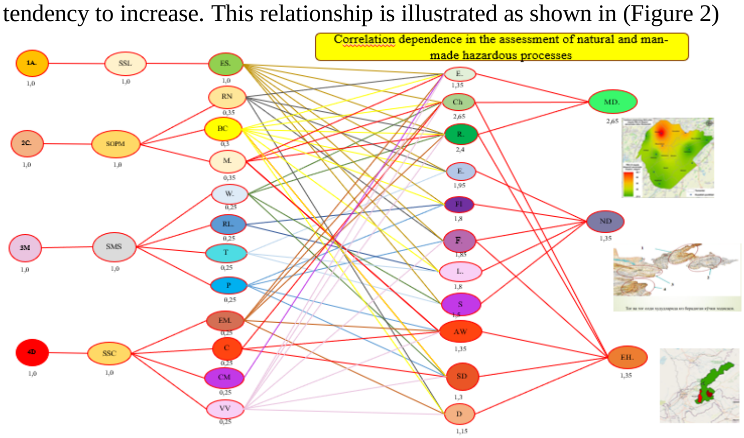

Figure 2. Correlational Relationship in the Assessment of Natural and Technogenic Hazardous Processes

Natural and technogenic hazardous processes have a direct impact on the health of every individual in our country and on future generations.

In the prevention of technogenic factors, natural disasters, and environmental hazards, the use of statistical sources, visualization of their impact zones and epicenters through mapping, situation assessment, and process visualization creates a foundation for preventing many negative consequences and for developing timely and optimal solutions.

The correlational method for assessing natural and technogenic hazardous processes primarily supports geoecological analysis, the assessment and forecasting of natural disasters, the modeling of hazardous zones, and the automation of decision-making processes. This method visually represents the correlational relationships between various data sources and types of hazards.

Such analytical tools are considered highly effective in GIS-based analysis, modeling, and forecasting. From a scientific standpoint, this model serves to perform integrated risk assessments based on interrelated factors.

Based on the mathematical modeling of data flows, a geo-factor-based integral correlational analysis model has been developed for forecasting and assessing natural and technogenic hazardous processes.

A geo-factor-based integral correlational analysis model has been developed, aimed at forecasting natural and technogenic hazardous processes through the mathematical modeling of data flows. This model enables the assessment of technogenic and natural disasters, as well as environmental hazard levels, and facilitates comprehensive forecasting by identifying interrelationships among various geophysical, geomorphological, and anthropogenic factors.

Conclusions and recommendations. Based on mathematical modeling of data flows, a geofactor-based integrated correlation model was developed to assess and forecast natural and technogenic hazardous processes. The model provides a framework for determining the relationships between geophysical, geomorphological, and anthropogenic factors, allowing for a comprehensive evaluation of the mechanisms governing hazardous process development. As a result, it improves the accuracy and effectiveness of forecasting the spatial and temporal evolution of natural and technogenic hazards.

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