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IMPORTANT IMPORTANCE AND SOLUTIONS OF MAPPING AREAS OF HIGH TECHNOGENIC RISK IN SOUTHWESTERN UZBEKISTAN

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Abstract

This article examines the methods of identifying and mapping zones of high technogenic risk in the southwestern regions of Uzbekistan, their problems and significance. These zones have arisen as a result of the rapid development of industry, exploitation of natural resources and environmental degradation, posing a serious threat to infrastructure, agriculture and human life. The study uses modern geoinformation technologies - GIS (geographic information systems), satellite imagery, drone (UAV) data and spatial modeling tools to identify risk zones, analyze their ecological footprints and integrate this data into the state cadastral system. The proposed methodological approach serves to make scientifically based decisions on environmental management and emergency risk reduction.

Keywords: Technogenic risk, GIS, drone mapping, satellite imagery, spatial analysis, digital cadastral system, Uzbekistan.

Introduction

In recent years, in Uzbekistan, especially in the South-Western region, against the background of industrial expansion, improper exploitation of land resources and climate change, technogenic hazards have been increasing. This situation has a negative impact on the environment, public health and economic stability, especially in the Kashkadarya and Surkhandarya regions and areas close to the Aral Sea. Technogenic hazards include factors ranging from earthquakes to industrial waste, mining operations, groundwater pollution, and the spread of radioactive substances. Effective management measures can be developed by identifying these risk factors, assessing their territorial distribution and analyzing them by location. In this regard, mapping areas with high technogenic risk, that is, identifying risk zones using geoinformation technologies and displaying them on maps, is one of the urgent issues. Such an approach serves not only to visually represent risk factors, but also to make strategic decisions aimed at reducing risk. Such cartographic analyses are also considered an important tool in preventing emergencies, planning infrastructure projects from a safety perspective, and maintaining ecological balance. This article provides a comprehensive analysis of the methods for identifying areas of technogenic risk, mapping them, and solutions to existing problems using the example of Southwestern Uzbekistan.

Main Part:

Technogenic hazards have increased sharply in the southwestern regions of Uzbekistan, particularly in the Kashkadarya and Surkhandarya regions, with the expansion of industry, mining and energy sectors. These regions are close to the Kyzylkum desert and the Gissar mountain range, and natural factors such as severe drought, low-fertility soils and seismic activity, combined with human activities, further increase environmental hazards. In recent decades, the rapid development of infrastructure such as oil and gas pipelines, cement plants and mining activities has dramatically changed the natural landscape and ecological balance of these regions. As a result of the accumulation of industrial waste, mining, deforestation and depletion of groundwater reserves, these areas are becoming increasingly vulnerable to man-made disasters, in particular, subsidence, soil erosion, water pollution and even local seismic events. The expansion of urban development and the intensification of agriculture further exacerbate this vulnerability. In many cases, the use of land resources is carried out without environmental expertise, which leads to an increase in risk factors for nearby settlements and ecosystems. In the face of such a sharp increase in risks, there is a growing need for powerful tools that can provide fast, accurate and comprehensive solutions for their effective management. One of the most effective strategies for managing man-made risks is the introduction of advanced geoinformation technologies. Geographic information systems (GIS) and remote sensing (RS) tools together allow for the collection, analysis and visualization of spatial data. These technologies will greatly assist researchers and policymakers in understanding landscape dynamics, monitoring the distribution of hazard zones, assessing their impacts, and planning mitigation measures. There is also a political need to integrate hazard mapping into national land use strategies, especially cadastral systems. Such integration will enable risk-informed land development initiatives to be planned and critical information to be communicated to stakeholders, from government agencies to private landowners. This paper proposes a practical roadmap for mapping hazard zones and incorporating them into digital cadastral systems as an effective and evidence-based approach to managing hazard zones. There is a critical need for a geoinformation approach that combines satellite imagery, GIS technologies, and real-time field data to identify, assess, and visualize hazard zones. This paper develops a scientific and practical framework for managing hazard zones by identifying hazard zones and integrating them into a digital cadastral system.

Relevance of the problem and level of research:

The study is focused on the southwestern part of Uzbekistan - in particular, the districts of Dehqanabad, Nishon, Guzar in the Kashkadarya region and Sherabad and Sariosiyo in the Surkhandarya region. These districts were selected as areas where resource exploitation has increased due to the rapid development of industry and its pressure on the environment, but where environmental control is weak. These areas were identified as the main objects for the study due to their geological complexity, the risk of human activity, and their ecological sensitivity. The study area includes semi-desert and full desert zones. These areas have sparse vegetation cover, loess soils, and dry steppe ecosystems. The area is close to the Gissar mountain range and the Kyzylkum desert, and is a transitional zone between mountainous and desert reliefs. Most of the territory is rugged, with elevations ranging from 300 to 1,500 meters,

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especially in the foothills. Seasonal rivers, temporary streams, and artificial irrigation networks play a major role in water supply, but many areas suffer from water scarcity and inefficient irrigation. In terms of climate, the region has a rather sharply continental climate, with temperatures exceeding 45°C in summer and sometimes dropping to -10°C in winter. Annual precipitation is low, ranging from 200 to 350 mm, and is unevenly distributed, leading to periodic droughts and soil degradation. Dust storms and strong drying winds are also common, further increasing the risk of erosion and air pollution.

The industrial landscape of the region includes oil and gas fields (especially the Shurtan gas complex), cement plants, and several open pit mines. These activities contribute significantly to environmental degradation through land cover change, deforestation, and chemical contamination of soil and water resources. Improper waste disposal and outdated infrastructure further exacerbate the risk of environmental pollution. In terms of human habitation, many rural residents live in or near anthropogenic hazard zones. They rely primarily on agriculture and livestock for their livelihoods. However, degradation of cropland and pollution of water resources are leading to a decline in agricultural productivity, further weakening the population. In addition, major transportation routes, such as regional highways and railways, that pass through the region make anthropogenic hazard assessment a particularly pressing issue in public safety and infrastructure planning. Considering the above factors, the selected study area is a relevant example for the application of GIS and remote sensing methodologies in the identification and management of man-made hazards. This area has a complex interaction of natural and anthropogenic factors, which simultaneously creates both a challenge and an opportunity for testing and implementing geoinformation technologies for sustainable land resource management and risk reduction. The issue of mapping man-made hazards using geoinformation technologies is receiving increasing attention in the scientific literature, not only globally, but also in the Central Asian region. Many studies emphasize the important role of GIS (Geographic Information Systems) and remote sensing technologies in identifying hazards, risk modeling, and land resource management. Platonov et al. (2013) conducted a significant study on mapping soil salinity in the Syrdarya region based on multi-temporal satellite images. Their results showed how effective geoinformation methods are in accurately and systematically tracking spatial changes in degraded areas. Similarly, Akramkhanov and Vlek (2011) conducted a study on salinity risk assessment using artificial intelligence (neural networks) and remote sensing, justifying the potential of machine learning methods in environmental monitoring. Research by Sultanov et al. (2021) examined the economic aspects of intensive horticulture development in arid regions of Uzbekistan, demonstrating how GIS planning is closely linked to agricultural policy. Mamatkulov et al. (2021) used GIS and remote sensing technologies to predict cotton yields in high- and low-yield areas, which indirectly contributes to the mapping of man-made hazards by identifying ecological stress zones.

Internationally, Jim et al. (2020) analyzed the effectiveness of NDVI and SAVI indices in monitoring vegetation cover in semi-arid regions, while Leng et al. (2021) studied the impact of agriculture on water quality in the Aral Sea basin. These studies support the use of vegetation indices and water quality indicators as proxy indicators in assessing anthropogenic impacts.

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From the perspective of integration into the cadastral system, Aslanov et al. (2023) studied the issue of monitoring land use in the peri-urban areas of Tashkent city and integrating cadastral maps using geoinformation tools. Their study highlighted the need to integrate cadastral activities with environmental data flows, thereby improving spatial management. Despite the progress in this area, in-depth and comprehensive studies of man-made hazard zones, especially those with high industrial loads, are still limited. In most scientific literature, hazard factors are often studied separately (e.g., salinity, drought, erosion), and their consideration as interconnected multi-hazard systems is not sufficiently established. In addition, the issue of integrating hazard information into digital cadastral systems has been addressed in few studies, although this is of great importance for practical land management and planning.
This study aims to fill these gaps by integrating hazard modeling and cadastral data management. This approach builds on the methodologies developed in previous studies and applies them to a new geographic and thematic context – the southwestern anthropogenic hazard zones of Uzbekistan. This approach will thus serve as a basis for creating a replicable model for other arid and industrially intensive regions.
Objectives and tasks One of the most important results of the study is that it has successfully demonstrated the feasibility of integrating hazard data into the existing cadastral system of Uzbekistan. This integration allows spatial data on hazard data to be collected in a single system, along with land ownership, use rights, and property boundaries. Based on a standardized scheme, each identified hazard zone was characterized by the following attributes: hazard type, date of identification, data source (satellite, UAV, or field measurement), and intensity level. This approach ensures that data is stored in the same format and facilitates interoperability between government databases.
Incorporating hazard information into cadastral maps has significant implications for management and planning processes. Land use classification becomes more accurate and contextualized in areas subject to industrial pressure or environmental degradation. This increases the accuracy of land allocation decisions and allows for resource allocation while minimizing risk. Emergency management systems also benefit from this integration, as real-time spatial information can improve preparedness, response, and recovery efforts. However, several practical challenges need to be overcome to maximize the effectiveness of this approach. While UAV (drone) monitoring is very useful for obtaining high-resolution images, its performance can be limited by adverse weather conditions, such as dust storms or strong winds, which are common in the study area. In addition, in many rural areas, outdated or unclear cadastral documents make it difficult to identify and map risk zones. The lack of sufficiently qualified personnel in the use of GIS tools in local governments hinders the full use of spatial data in planning and policymaking.
To address these challenges, it is important to invest in building technical capacity, conducting thorough field surveys to update the cadastral database, and expanding UAV coverage. Through such measures, the integration of geohazard zones into cadastral systems can become a key tool for sustainable land management in hazardous areas in Uzbekistan. Based on the results and analysis obtained in this study, a number of strategic recommendations are put forward to improve the effective management of technogenic hazard zones in the territory of South-West

Uzbekistan. These recommendations aim to strengthen technical capacity, inter-institutional cooperation, data quality, and the preparedness of local communities through geoinformation approaches.

First, it is important to establish a centralized and open-access geohazard geoportal, managed by the State Land Committee of Uzbekistan or relevant government agencies. This portal will serve as a national platform for storing, viewing and updating spatial data on man-made hazards. Such a platform will ensure openness, enhance information exchange between different government agencies, and support public and private stakeholders in planning and emergency preparedness.

Secondly, UAV-based monitoring should be established on a regular basis. This should include field observations at least twice a year, which will allow for the identification of seasonal changes and emerging new hazards. High-resolution, near-real-time images obtained using UAVs are a very important tool for monitoring dynamic hazards such as erosion, industrial expansion, or illegal dumping.

Third, GIS training programs should be expanded at the regional and local levels. Certificate programs in hazard mapping, GIS software use, and environmental modeling should be introduced in collaboration with universities, technical colleges, and research institutions. In addition, special practical workshops should be organized for government officials, planners, and emergency service representatives.

Fourth, the legislative framework should be strengthened. That is, risk information must be formally taken into account in land allocation, urban development plans, and environmental assessment processes. This includes including man-made risk layers in official cadastral systems and making risk assessments a mandatory requirement in any construction or land allocation decisions. To regulate this process, clear guidelines and standards should be developed regarding data accuracy, classification, and reporting formats.

Fifth, pilot projects should be launched in areas with high levels of man-made risk. These projects will allow testing the possibilities of integrating real-time risk monitoring with mobile applications and participatory GIS approaches. Involving local populations in the process will increase the efficiency of data collection, raise public awareness and encourage a proactive approach to disaster risk reduction. Finally, international cooperation and financing mechanisms should be developed. This will support investments in long-term geo-information infrastructure, scientific and innovative research and resilience planning. Partnerships with global institutions such as the United Nations Development Programme (UNDP), the World Bank or regional scientific networks can provide technical expertise and financial support and allow successful models to be scaled up.

Conclusion

By implementing these recommendations, Uzbekistan's capacity to identify, monitor, and mitigate man-made hazards will be significantly strengthened. This will ensure that spatial data becomes a key factor in sustainable development and land management in the region. Mapping man-made hazard zones based on GIS and remote sensing technologies is an effective and scientifically sound solution for environmental management in South-West Uzbekistan. This study shows that integrating hazard zone data into cadastral systems supports sustainable development, strengthens risk management, and increases public safety.

Future research should focus on applying this methodology to other regions, introducing predictive modeling based on machine learning, and improving real-time hazard notification through mobile applications and public monitoring.

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