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Geoinformation toolkit for risk assessment of karst processes development

I. Chepurnyi, V. Podholov, T. Chepurna, *B. Karpinskyi (*Ivano-Frankivsk National Technical University of Oil and Gas*)

SUMMARY

The research is devoted to the creation of geoinformation tools for karst risk assessment for the territory of Vinnitsa region. Risk assessment was carried out by taking into account population density and the damage of the territory by karst processes. The geoinformation toolkit is based on a modern GIS - QGIS tool using Python programming language. The assessment of the damage to the territory by karst processes and the assessment of the karst hazard of the territory of the Vinnytsia region were carried out for two territorial levels - the level of administrative districts and the level of territorial communities (village, settlement, city councils). The possibility of automated construction of population density maps, invasion of the territory by karst processes, risks of karst hazard on the example of administrative-territorial units of Vinnitsa region is realized.

Introduction

On the territory of Ukraine hazardous geological processes are widespread, activation of which leads to emergencies with considerable material losses. The development of these processes is related to the peculiarities of the natural conditions of the territory - geological, geomorphological, hydrogeological, hydrometeorological and technogenic component. The main hazardous geological processes within the territory of Ukraine are landslides, karst, flooding, erosion, mudflows and subsidence over mining, etc. (Information Yearbook..., 2019). Measuring the impact of these processes on the safety of life of the population is the risk of development of these processes, the calculation of which is made taking into account the population density and the infestation of territories by certain types of hazardous geological processes. The main tool that allows modeling of risk assessment of the development of hazardous geological processes is geographical information systems (GIS). The purpose of these studies was to create a geoinformation tool for karst risk assessment for the Vinnytsia region.

Method and/or Theory

Karst processes risk assessment is described in the works on complex EGP risk assessment (Bychenok at al., 2008; Ivanyuta, 2015) and involves taking into account the area of karst manifestation, which is often accepted as karst development probability, and certain coefficients that depend from the purpose of evaluation.

In particular, (Bychenok at al., 2008), life risk assessments in the area of hazardous exogenous geological processes are determined according to the state of the territory and its population density.

Here it is noted that for rural settlements within which the development of hazardous exogenous geological processes is close to the natural mode of development due to the lack of systems of engineering protection and significant level of anthropogenic impacts, the total risk of life and economical risk is calculated as the product of population density on the probabilities of development of hazardous exogenous geological processes.

In (Kasiyanchuk, 2015; 2016; Podholov, 2017), the principles of risk calculation of hazardous exogenous geological processes are described and geoinformation models of their calculation are given.

All the above studies indicate that the basis for the calculation of life risks within the area of hazardous exogenous geological processes are mapping data and materials of monitoring studies for the assessment areas (administrative area, district, industrial and urban agglomeration, river basin, etc.). It is advisable to use GIS in a simulation and thematic mapping environment.

It is advisable to perform geoinformation tools on the basis of modern instrumental GIS with support of object-oriented programming language. This solution is QGIS GIS, which supports the use of Python programming language. QGIS is a free cross-platform geoinformation system with advanced API and extensions (modules). It is one of the most functional and convenient desktop geoinformation systems and is dynamically developing. There is a special PyQGIS library for creation a new applications (modules) in the QGIS environment, which combines Python programming language and a set of Python PyQt links.

The stages of creating a geoinformation application are:

- preparation of input data;
- creation of mapping layers and attributive tables with the population density within individual administrative areas, territories of village councils, points of karst processes manifestation;
- development of functional part of the application on Python programming language;
- creation a user interface (GUI) and ensuring the functioning of the application.

Examples (Optional)

The geoinformation toolkit was implemented as an example, to assess the damage of the territory by karst processes and to assess the karst risks of the territory of Vinnytsia region. The karst-bearing deposits are spread over an area of 10.88 thousand km² (41.6% of the territory), 244 karst manifestations are recorded, 200 of them are karst funnels. 27 underground karst events (caves) are also developing within the region (Information Yearbook, 2019).

Figure 1 shows the cartographic distribution of karst processes in the Vinnitsa region.

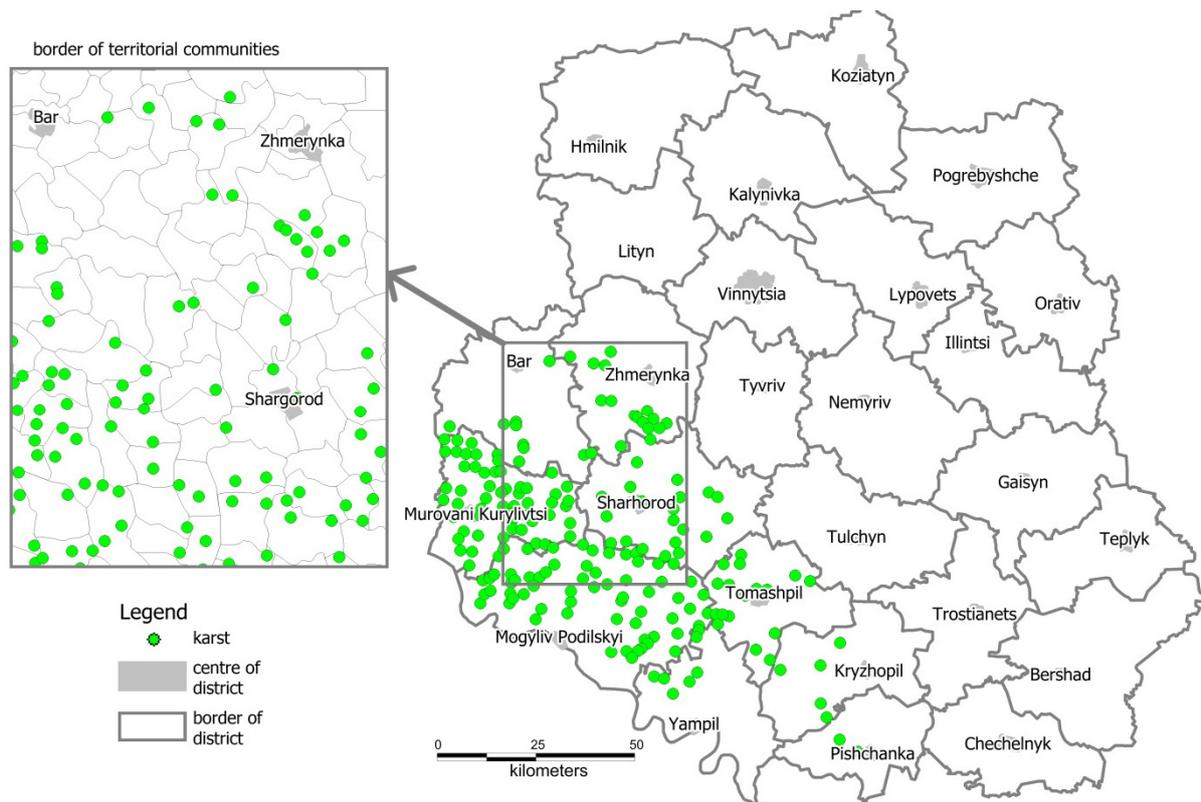


Figure 1 Map of karst processes distribution in Vinnytsia region

Data on the development of karst processes were obtained from the catalogs of the State Research Institute "Geoinform of Ukraine". The assessment of the damage of the territory with karst processes and the assessment of the karst risk within the territory of Vinnytsia region will be carried out for two territorial levels - the level of administrative districts (referred as Regional level) and the level of territorial communities (village, settlement, city councils) (referred as Local level).

After the input preparation phase, application development goes into the coding phase. A number of features have been created to make the application work. These functions are duplicated for two territorial levels. If a function calls a dialog box, then two functions have been developed for it: one calls the window and the other (when you click "OK") invokes calculation function or map creation. These kinds of events are called alerts and bind certain features to specific objects.

When accessing the menu of any function, the user must select the study area and / or map type and confirm their action. User functionality is implemented as a corresponding menu item and is shown in Figure 2.

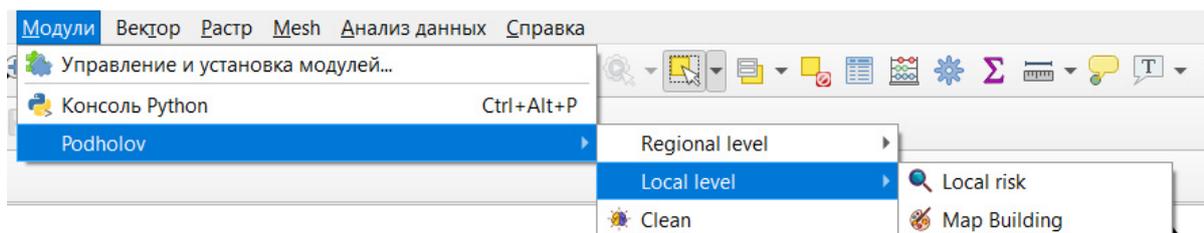


Figure 2 Geoinformation application command menu in QGIS

The user selects the name of the required administrative area from the pop-up list and receives the corresponding risk value. The possibility of building maps of population density, damage of the territory by karst processes, risks of karst hazard for the territories of certain administrative regions

was also realized. At the local level, the user selects the required territorial unit and receives the value of risk, and it is possible to obtain relevant thematic maps. Figure 3 shows an example of the construction of thematic maps for the territory of the Zhmerynka district of Vinnytsia region. The maps obtained immediately show the tendency of the territory to be damaged, as well as the risk of karst hazard. Figure 3 allows us to conclude: 3a - population map - the most populous is the central part of the Zhmerynka region; Fig. 3b - map of the affected area - the most territorially affected are the south-western part of Zhmerynka district; Fig. 3c - karst risk map - the highest risk is traced in the western part and partly in the southern part of the Zhmerynka district.

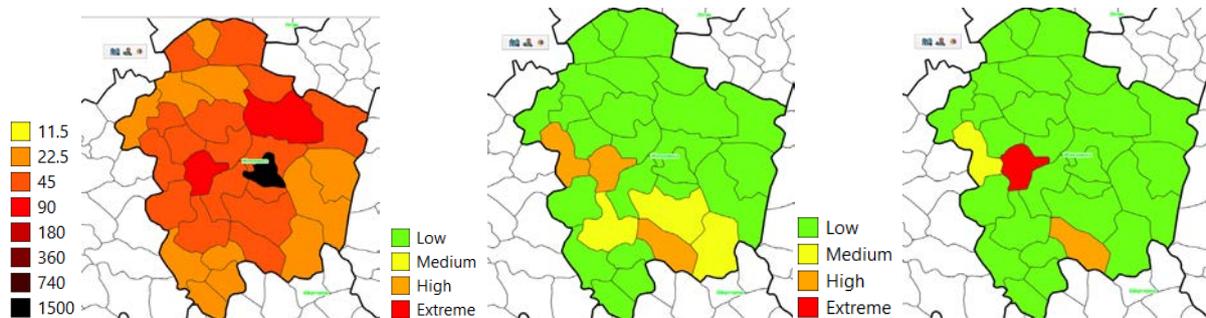


Figure 3 An example of geoinformation tools work: a - map of population density, b - map of affected areas by karst processes, c - karst risk map

A further improvement of the proposed toolkit is its addition to modules of temporal and spatial prediction of karst processes development. The proposed module can be adapted for the whole territory of Ukraine or for the territories of other administrative regions, used to evaluate the development of other hazardous exogenous geological processes and implemented in the form of a multiplication - geoportal.

Conclusions

1. Geoinformation systems are an indispensable tool for assessing and forecasting the risks of hazardous geological processes and provide the basis for management decisions to prevent and mitigate the effects of these processes.
2. Application programming capability allows to adapt desktop GIS tools to needs of users and incorporate problem solving of varying complexity into application functionality.
3. A further improvement of the proposed toolkit is to supplement it with modules of temporal and spatial prediction of the development of karst processes.

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