Landslide GIS-modelling with QGIS software

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SUMMARY

The article is devoted to modern methods of detecting and mapping landslides. It is indicated that the cause of landslides can be a number of natural and anthropogenic factors, including earthquakes, degradation of permafrost, seizure of natural resources, construction of artificial reservoirs, urbanization, etc. soundings allow the detection, investigation and mapping of landslides. Landslide modelling can be performed using digital elevation models constructed by both ground and aerospace methods. QGIS is a powerful tool for landslides data modelling and visualisation.

Introduction

The term 'landslide' is considered as all types of gravity-caused mass movements, ranging from rockfalls and topples and a variety of slumps and slides to flows of different materials *(Mihalić Arbanas and Arbanas, 2015).*

The issue of landslide detection and modelling is relevant to the most territory of Ukraine except Rivne and Volyn oblasts. This fact can be explained for the reason that the most part of the territory of these regions is comprised of loam and other vulnerable bottoms. High landslides activity (state, distribution and style of landslide movements) also can be caused by extractive and construction industry activities: the creation of escarps, waste piles, open pits etc. and can occupy wide areas inside cities and industrial territories. The main sources of landslides in urban landscapes are improper drainage systems engineering and construction.

One of the most relevant techniques of landslides activity investigation is landslide monitoring. It defined as a system of measurements and observations using installed monitoring sensors and other equipment with the aim to observe changing conditions that may lead to total failure of the slope where slope movement is occurring *(Mihalić Arbanas and Arbanas, 2015).*

Because of a big amount of landslide parameters (composition, cushion course, humidity, weight, value, velocity etc.) that have spatial coordinates, geographic information systems (GIS) are the best tool of landslides data management, mapping and monitoring. GIS can combine different spatial data captured from ground geodetical, airborne and space-borne sources and use it for remedial measures and landslide hazards minimizing *(Popescu, 2001).*

A map is the most significant part of the GIS user interface. It gives possibilities to get access to spatial data. In GIS environment one can create, compare and overlay maps. Every parameter of the geological environment can be modelled and modified with a big amount of spatial analysis tools that help to evaluate, compare, and estimate every landslide case. Also, it is possible to visualize a spatial image of landslide and simulate its future development.

That is why landslide mapping helps to identify landslide features on the ground surface and make a cartographic representation of slope movement. It is a significant part of landslide monitoring (system of measurements and observations using installed monitoring sensors and other equipment with the aim to observe changing conditions that may lead to total failure of the slope where slope movement is occurring and safety factors against sliding are low, or where the high risk is present by a possible slope failure *(Mihalić Arbanas and Arbanas, 2015).*

Landslide monitoring gives an opportunity of landslide peculiarities its factors and consequences.
Due to the fact that landslides differ greatly from each other in their types, sizes, mechanisms and speeds, methods of its monitoring can also differ significantly.

Modern research advantages of remote sensing data use in complex with the ground-based measurement electronic devices. These tools are able to detect the moisture of the soil, calculate the surrounding's temperature and humidity. Also, the rainfall data has been taken for supporting the water index information. The results of the three specified parameters; soil moisture, temperature and water index; SMI, LST and NDWI shown the more moisture of the soil, the more the tendency of the landslides to occur *(Yaa'cob et al., 2020).*

It is reported that GIS can be used for landslide detection or investigation, landslide monitoring and landslide susceptibility modelling *(Zhao and Lu, 2018).* The authors give a vide literature review on

landslides researches. The analysis of publications shows the following levels of landslides research: local, regional, national. Every level uses its own list of modelling methods and data sources.

Method

In order to perform landslide monitoring at the regional and local levels, remote sensing data must meet the following basic requirements - to cover the territory and to have sufficient spatial resolution.

Nowadays there are a number of landslide detection remote sensing techniques that are technically feasible and have the potential to raise significant revenues. These methods are carried out with both airborne laser scanning for the largest and undercovered area and terrestrial laser scanning modelling with very high resolution (<cm) for the landslide toe *(Lissak et al., 2020)*.

Among the remote methods of monitoring a larger number of shifts, spread over large areas, a special place is occupied by the method of satellite radar interferometry, which allows to detect shifts and displacements and monitor their changes over This is the so-called Interferometric Synthetic Aperture Radar (IFSAR) program that represents an effort to ingest and process high-resolution elevation data produced through a technique called radar interferometry. The main source of these data will be the Shuttle Radar Topography Mission (SRTM), which is an IFSAR mission to be flown aboard the Space Shuttle in January 2000.

The data can be used for surface relief modelling (the surface height information, inclination or steepness of a surface, aspect etc.). These characteristics can help to predict landslides activity of territory.

Example

We had an experience of Quantum GIS use for surface modelling and possible landslides detection on industrial territory such as Gorishne-Plavninskoe/Lavrikovskoe (GPL) open pit. It is the iron ore mine that currently mines approximately 27 million tonnes per annum (Mtpa) to a depth of approximately 300 m below the surface. It is reported that Poltava Mining has been operating GPL for nearly 40 years. *(Czajewski, 2020)*

QGIS (or Quantum GIS) is an open-source geographic information system. Nowadays it is rapidly developing by a team of dedicated volunteers and organisations. It is a cross-platform software that runs on Windows, Mac OS X, and Linux. There are also numerous plug-ins that extend QGIS functionality.

The data for open pit modelling was downloaded from opentopography.org. It contains SRTM elevation data on a near-global scale captured within an international project spearheaded by the National Geospatial-Intelligence Agency (NGA) and the National Aeronautics and Space Administration (NASA). It is possible to obtain raster data of 30-meter resolution. It is reported that SRTM consisted of a specially modified radar system that flew onboard the Space Shuttle Endeavour during an 11-day mission in February of 2000.

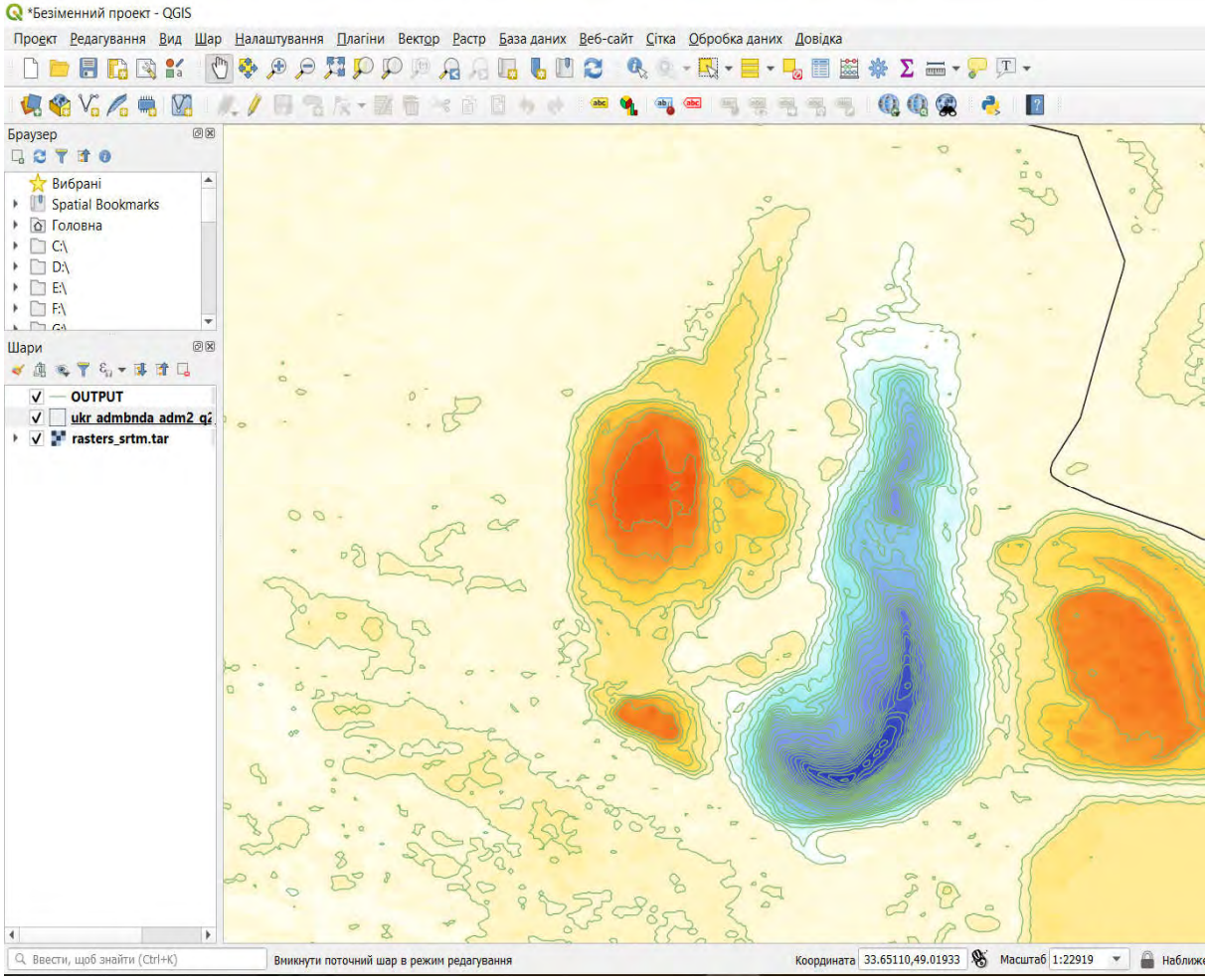

Figure 1 *Gorishne-Plavninskoe/Lavrikovskoe open pit modelling on Quantum GIS platform using Shuttle Radar Topography Mission data*

QGIS functionality allows making different operations with raster layers. QGIS functionality can be widened with modules of GRASS GIS (Geographic Resources Analysis Support System) that is licensed and released as free and open-source software under the GNU General Public License (GPL).

For the landslide susceptibility evaluation, it is possible to use an approach that was proposed by authors. *(Formetta et al., 2014)* The method suggests the evaluation of three main components: a hydrological model for soil suction and soil water content estimates, a component for computing the factor of safety based on the infinite slope hypothesis, and a GIS for visualization and calculation of the outputs. *(An et al., 2018)*

The easy way of landslides probability modelling is the creation of a model of predicted rainfall, based on the interpolation of rainfall values at meteorological stations. The probability of a landslide will be very roughly related to both rainfall and slope (of course a real model will use more layers and appropriate parameters).

Conclusions

Landslides can be caused by a number of natural and human factors, including earthquakes, permafrost degradation, natural resources capture, artificial water reservoirs construction, urbanization etc. GIS is a powerful tool for the assessment and reduction of landslide hazards and risks. Multiple remote sensing techniques, including SAR, optical, LiDAR, ortho-photo, and DEM obtained from satellites, airborne, and ground-based platforms can be utilized to monitor landslide processes. Landslide modelling can use different data and simulation models. GIS and RS now are playing a significant role in landslide monitoring and decision making.

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