Conceptual modeling for geoinformation mapping of landslides

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SUMMARY

The role of conceptual models in geomatics and cartography is determined. The results of landslide formation in the system "Society-Nature" conceptual modelling in the form of a structural-graphic model are presented. The conceptual model of the algorithm of geoinformation modelling of landslides is offered. An example of using data from expeditionary research (geodetic and engineering-geological) on the highway in the Ternopil region to improve the conceptual model of landslides is given.

Introduction

A good conceptual model means correct use of things; bad model means improper use of them. *(Norman, 2013)* Conceptual models follow us all over our lives. These models can be different in shape, however, most of all they are pictures, schemas, images. Traditionally cartographers call them structural-graphic models (structural-logical) because their main goal is to show a structure of any object in graphical format. Other professionals call the models as mind maps, block diagrams, etc. As has been mentioned before the conceptual models show the structure of objects, peculiarities of its functions, objects relations, sequence, and hierarchy. They are a kind of theoretical model that is the base for the creation of less formal models: sketches, graphs, maps.

Peter Chen *had* proposed the kind of conceptual models and call them entity-relation (ER) diagrams *(Chen, 1976)*. Later universal modeling language (UML) was founded and became very popular. These tools nowadays are useful for modeling any matter and are helpful in database creation, projects management, etc. *(Guizzardi et al., 2002)*.

A GIS specialist or a cartographer while making a map, an atlas, or carrying out a GIS project need to arrange spatial data about an object of modeling and its relations. The process can be improved by cooperation with specialists in the subject areas who have experience of treating similar problems.
Making a map is a sequence of clear sequential steps. As a result, researchers get a generalized view on a problem without unnecessary details, with emphasis on important matters: title of a map, map scale, indicators, background and foreground spatial information layers, map key, cartographic signs and graphic primitives used, etc.

Method and Theory

An emergency is a situation that poses an immediate risk to health, life, property, or environment. Most emergencies are characterized by life conditions violations caused by social or natural hazards, epidemics, pandemics, epizootic, accidents, wildfires, or other dangerous events. A natural emergency usually can be caused by anthropogenic activity inside a dramatically changing natural environment. Economic activity often pushes the sequence of events that are responsible for emergencies.

So it is obvious fact that interaction occurs in between the Natural and Social parts of the geosphere (figure 1.) These interactions involve the lithosphere, hydrosphere, atmosphere, biosphere, human society, and its activities.

The economic activities of mankind affect natural components in the process of mining, civil and industrial engineering, road and pipeline construction and operation. Also, many natural bodies are involved in the process of interaction: geological formations, rock, debris, subsoil, soil, ground and atmospheric water, atmosphere (with its rapidly changing characteristics), plants and animals, industrial activities. There are many sources of energy involved in endogenous and exogenous geological processes: geothermal energy, solar energy, gravity (the gravitational potential of the Earth, the Moon), etc.

Economic activity changes the natural way of matter and energy cycles inside geological and geographical environments. For example, roads, mines, open pits, and water reservoirs construction causes weakening of soils strength, excessive moisturization of soils (by groundwater flows changing), shore abrasion with water of artificial water reservoirs. Also, temperature and vibration regimes are changing around cities, enterprises and transport facilities, forests and natural land cover are passing away. In some cases, these processes are a kind of impetus for emergencies.

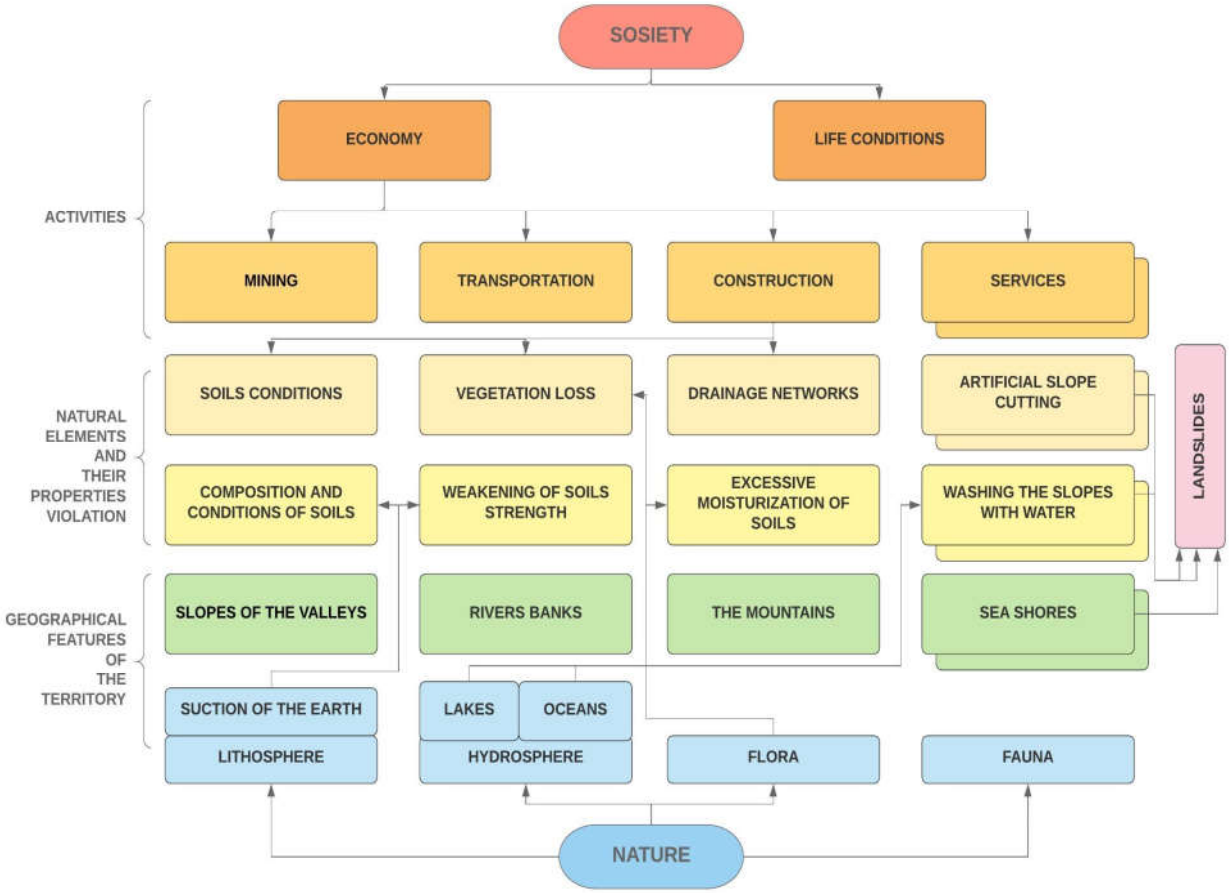

Figure 1 *Modeling the features of landslides in the system "Society-Nature"*

Results

One kind of dangerous exogenous geological processes that can cause emergencies is landslides. In the paper the term 'landslide' is considered as all types of gravity-caused mass movements, ranging from rock falls and topples and a variety of slumps and slides to flows of different materials. *(Mihalić Arbanas and Arbanas, 2015)*

Landslides activation (failure stage) is characterized by the formation of a continuous surface of rupture. It is closely related to the ingress of moisture into the horizons, which under normal circumstances remain dry. Landslides can be pushed by the construction of ponds on watersheds, the leakage of water from damaged water supply and filtration in the middle of the horizon composed of soils prone to landslides, failure or clogging of drainage systems and sewers, and so on.

The landslides risk increasing can be put through visually and instrumentally: by processing the results of geodetic monitoring (geometric and trigonometric leveling, comparison of points clouds obtained by lidar survey, stereophotogrammetric method, processing of numerous remote sensing products), by analysis tectonic, geomorphological, hydrometeorological factors. *(Ivanik, 2018)*

While working on a conceptual model of high quality researcher must take into account the whole set of problems of the subject area. For example, to model landslides in a certain part of the territory, it is necessary to take into account the preconditions of landslides, their characteristics (rock composition, volumes and speed of rocks, possible future consequences of landslides and their mitigation measures). The geoinformation mapping algorithm presented in figure 2 provides for the

implementation of the following sequential steps: 1) objects observation; 2) abstraction and obtaining scientific conclusions based on the analysis and synthesis of raw data; 3) verification of conclusions and decision making. At the first stage a researcher selects optimal data sets for modeling, at the second stage – the data is being processed for an adequate model obtaining, at the third step the model is checked for compliance with the tasks.

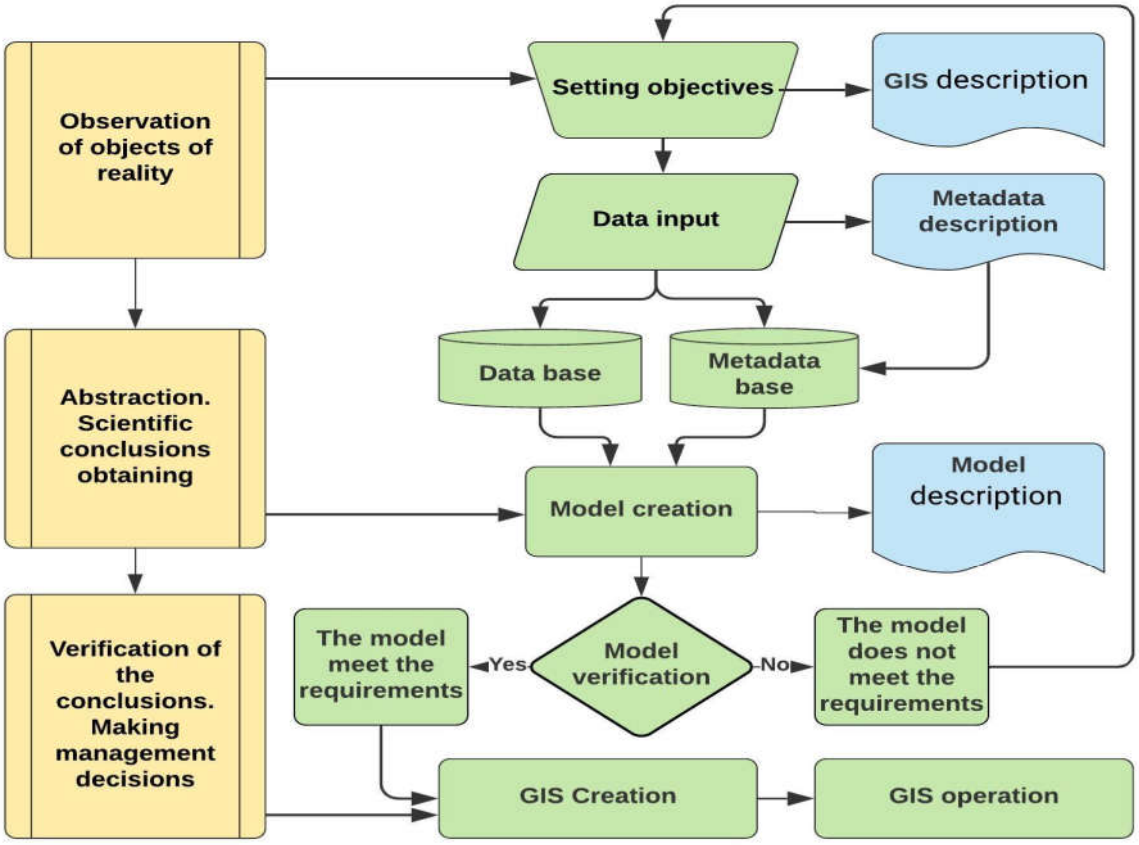

Figure 2 *Conceptual model of geoinformation modeling algorithm*

Conceptual models can be improved by expeditionary data. Figure 3. presents some results obtained by National Transport University Laboratory of Road Modelling. Detailed instrumental surveys of the road part and the adjacent territory (geodetic survey of the landslide area, stamp tests of pavement layers to determine the modulus of elasticity, drilling) revealed some design and construction failures. They are: pavement layers low bearing capacity, drainage structures insufficient capacity, the presence of a waterproof horizon and filtration of water from the artificial reservoir located above the slope led to the intensification of landslides and partial degradation and destruction of the road structure. The use of field research data allows to supplement and improve the conceptual model, to identify features of geological processes in a particular area.

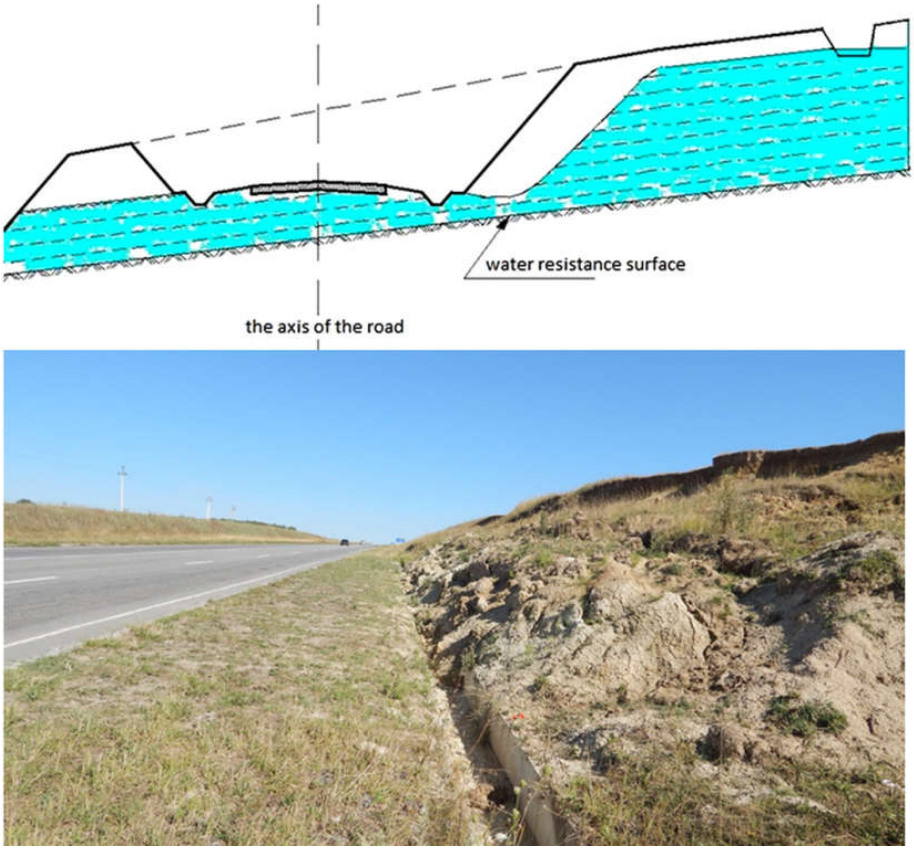

Figure 3 *Activation of landslide processes on the highway in Ternopil region.* Sketch *of the highway and photo of landslide by D. Pavlyuk*

Conclusions

Conceptual modeling is an important tool for geoinformation modeling and mapping. It helps to organize a knowledge about the subject area. As the object of conceptual modeling, landslides are kind of processes that can lead to emergencies. Landslides can be caused by a number of natural and anthropogenic factors, as well as their combination, including earthquakes, extraction of natural resources, construction of artificial reservoirs, etc. GIS modeling is a powerful tool for assessing and reducing the danger and risks of landslides. Conceptual modeling creates an image of the problem under study and promotes the optimal use of geoinformation modeling tools and decision support.

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