

DIGITAL LANDSCAPE MODEL AND ITS UTILIZATION IN PRIMARY AND APPLIED GEOGRAPHIC RESEARCH

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ABSTRACT. - Digital Landscape Model And Its Utilization In Primary And Applied Geographic Research. A large thematic, geometric and format geodata variability as well as its storage in different distant databases are typical for the situation in Czech Republic. If these data layers are overlaid many false parameter combinations originate. The digital landscape model (DLM) is an example of a new geodata base tool reducing such data errors for efficient application in research and territory management. The DLM structure and utilizing are presented.

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1. Introduction

Geography, similarly to other scientific disciplines, entered the age of information. Creating and sharing information is the main scientific objective in all respective fields. Traditionally, geography has been processing and presenting its finds in the form of models:

- ▶ Numerical (mathematic or statistic) – represented by a number of mathematic formulas (equations, functions, logical formulas and others)
- ▶ Graphic (symbolic) – represented by images, ranging from abstract diagrams, graphs and drawings to maps and cross sections of different kinds
- ▶ Verbal – represented by written or spoken texts or descriptions, interpretations and others.

All these models can be either static or dynamic.

The key to creating models is to approximate reality to the users of the transferred information in such a way which would enable them to fully understand it. Owing to the fact that a model always represents a degree of simplification of reality with certain studied aspects highlighted, it is difficult to create a universally binding concept of geographic models which would employ state-of-the-art geoinformation technologies. One of the possible ways of outlining suitable forms of digital graphic modelling (and ensuring objective processing of geo-spatial data) in geography is the concept, construction and implementation of a digital model of landscape. The object of geographic studies is landscape and the subject matter includes predominantly its specific characteristics, relations and processes taking place within it. Territorial projection of phenomena and processes is the elementary attribute of geographic studies. The spatial aspect of monitored phenomena and processes is documented in thematic maps in an accurate graphic form. However, thematic – for example analytic – maps represent only certain aspects of landscape while the landscape always represents a continuous system from the perspectives of both space and time.

Thematic analytic data for maps have been and will be gathered independently of each other. This is the characteristic feature of thematic mapping carried out by experts from individual fields (Fig. 1) and to a certain extent it guarantees a reliable quality of resulting outcome.

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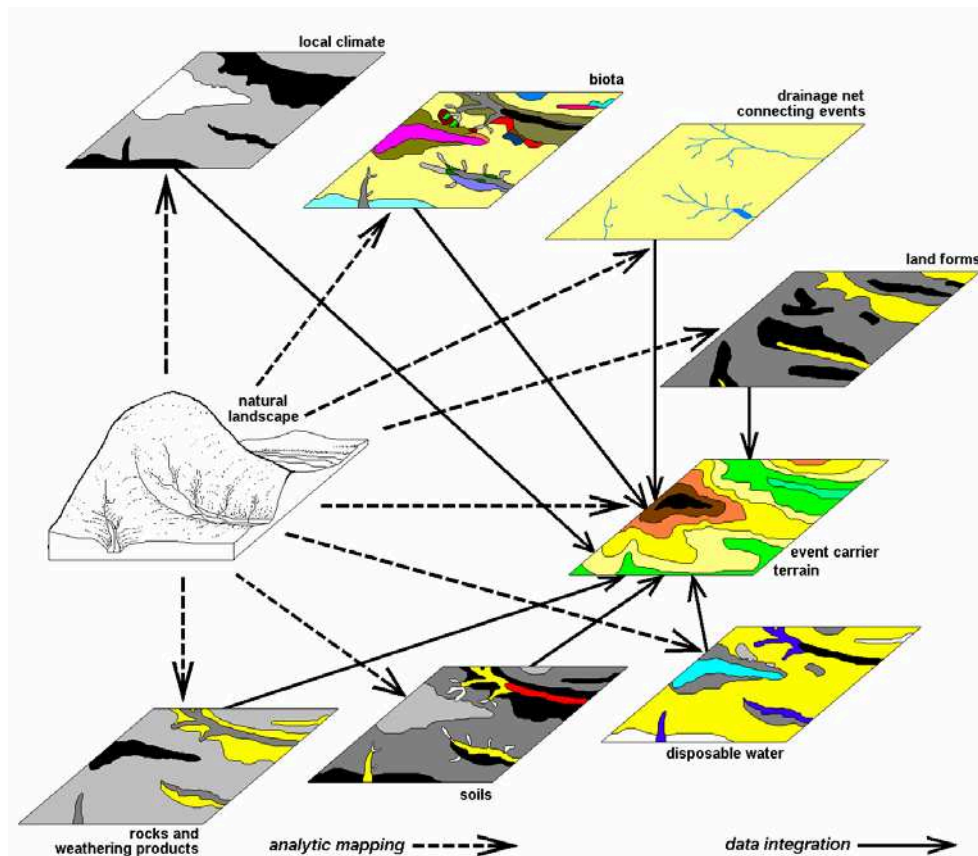


Fig. 1. Origin of thematic geodata and its integrated utilizing

This type of maps forms the basis of map archives and digital databases. Regardless the fact that geo-spatial data can be in analogue or in digital form, when overlaying them we obtain an enormous number of illogical parameter (attribute) combinations which do not exist in the real area (Fig. 2). A significant part of such faults can be removed through a precise geometric relayering of data based on an identical scale, projection and definition and in case of digital data also realigning the data format. However, a number of such faults remains untouched and thus downgrades the reliability of results produced through a routine way of solving given spatial tasks. If the outcome of data processing is a model of an event, such as an estimation of fire range, the extent of pest infestation, inundation area during floods, erosion or landslide areas, then its reliability is still not satisfactory. The reason being the processing procedure which works with several data layers and does not check whether those layers (usually analytic ones) mutually correspond as they do in real areas. Producers of both commercial and non-commercial software packages usually do not deal with this problem and rely on the quality of input data instead. When viewed from an isolated thematic perspective, these data can rarely be reprehended. Yet, when combining differing themes, their mutual logical incompatibility becomes apparent.

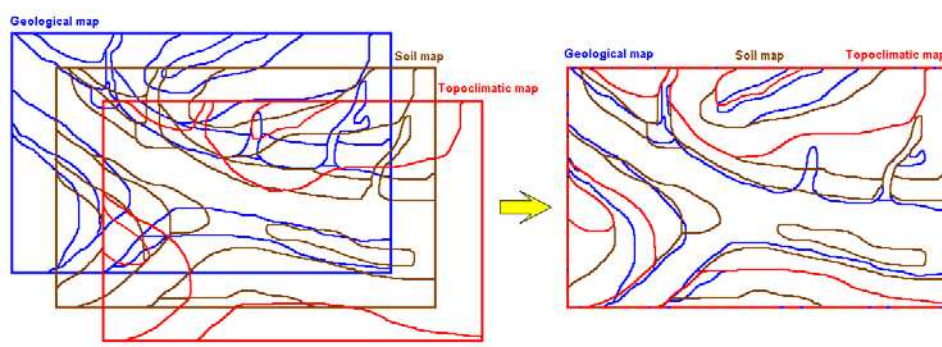


Fig. 2. Disproportion in thematic geodata overlay

2. The need of integrated geo-data

At present the GIS software package market offers a number of analytic tools for processing spatial data. The offer of synthetic tools remains rather limited in the range of standard tools of commercial GIS. However, through the so-called external models (modules) different purpose superstructures can be created in order to solve individual thematic problems.

Data security of operations in different GIS varies in terms of meeting the needs of thematic models (modules). An exception of a kind is the integrated database of the German digital landscape model (Digitales Landschaftsmodell) (Zöllitz-Möller, 2002) where a number of thematic data layers of identical projection, definition, format and other are concentrated. From geographic point of view, however, we cannot consider it a landscape model in a real sense of the word (after all, on a general level every map could be a kind of "landscape model", including the digital ones).

3. Logical integration of geo-data in a digital landscape model

Should the highest possible reliability of assessment, search, warning or other model procedures be reached, it is vital to consider the question of input data quality again.

The reasons are the following:

1. The need to create a logically integrated database which would overcome the format, geometric (scale, definition, projection) and logical incompatibility of the available data on landscape.
2. The need to create thematic models which better fit the problem of real landscape and the available data sources and also the need to possibly bring the well-tried foreign models and local data sources closer together.
3. The necessity to carry out an experimental check of possible ways of creating an integrated database, its use within our own and imported external models and graphic visualization in 2D, 3D and 4D presentations.

Under these circumstances it is vital to start developing such procedures which would put digital analytical (thematic) data in context, as is the case in nature, cultural landscape and socio-economic sphere. For this purpose a digital landscape model was developed as a procedure of universal geo-data integration and as an optimum data model for operating GIS technologies and possibly other related software packages, such as expert systems or thematic models (modules).

In applied geography worldwide there has been an ongoing effort to connect analytical data layers into a logical complex. We call them either REA – relative elementary area (according to Sivapalan and Kalma, 1995) or HRU – hydrological response unit (according to Flügel, 1995). In a similar manner a so-called ecological balance model (Haber, Schaller, 1988) has been developed. It strives to represent relations among the components and elements of landscape in a chosen 3D extract from the interest area landscape from space and time perspective with the help of formalized relations between downloaded informational layers.

A model which among other things provides this aspect of the data on the surrounding environment, is the digital landscape model (thereby DLM). A digital landscape model (DLM) is defined as a minimum 3D or 4D computer generated scheme of a chosen segment of Earth's landscape sphere which represents a simplified, yet integrated image of its elementary structural features, optimally also its dynamic features. The model's first three dimensions (spatial coordinates) describe the model's structural aspect, while the fourth dimension registers the time aspect. In other words, the DLM simulates a complex 3D or 4D map of present landscape as a universally integrated geo-database. DLM is thus a product of complete data integration into a limited file of multi-attribute information layers (1-3) which facilitates various static and dynamic modelling procedures and presentations representing real relations between the variables in the area (Fig. 3).

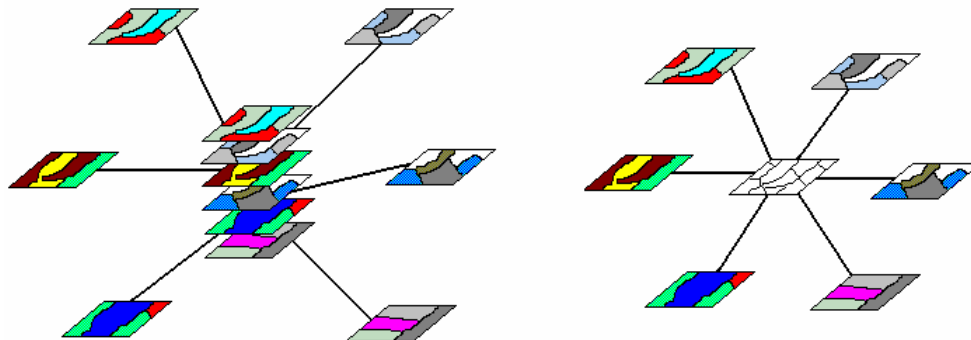


Fig. 3. Analytic multilayer composition of classical GIS geodatabase (left), synthetic multiparameter layer in DLM geodatabase

4. DLM structure

From a formal point of view, the digital landscape model is made up of logically (not only through scale, format, projection or definition) integrated data layers simulating the newly composed GIS database where instead of a big number of overlaid monothematic (analytical) data layers a small number (1-3) of multi-attribute (polythematic) layers and a digital terrain model are placed (Fig. 4).

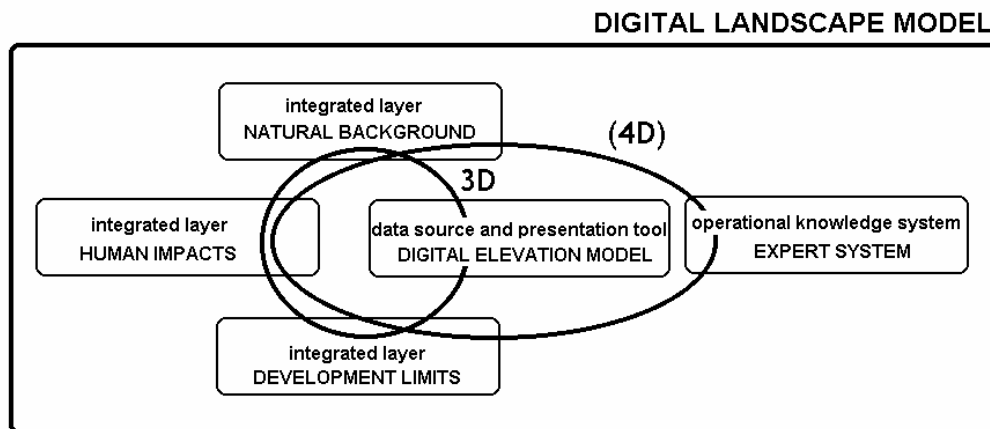


Fig. 4. Operational blocks of digital landscape model

In order to fulfill the principal DLM function, which is data support for a number of spatial analyses and syntheses required by the GIS procedures, the following multi-attribute layers and the digital terrain model are sufficient:

1. An integrated layer of “natural background” (so-called primary area structure) simulating the role of a multi-layered database describing the area’s natural subsystem. The reference unit is a homogenous natural landscape unit (e.g. geotop, geochora and others).

2. An integrated layer of “human impacts” (so-called secondary area structure) represents the spatial layout of human activities in the area and their products.

3. An integrated layer of “development limits” (so-called tertiary area structure) represents the sum of known spatial interests, wishes and limitations inherent to the area, whether they should be protected nature and landscape areas.

4. The framework of the digital landscape model is created by the digital terrain model (DTM) as a “lifting surface” on which (or over/under which) the statistic assessment of situations takes place, together with the simulation of dynamic phenomena (e.g. on the one hand there is an assessment of convenience, risks or capacity, on the other hand there is the extent of drainage, pollution, atmospheric currents, morphogenetic processes and others) and 3D or 4D presentations of data, results or project products. DTM is the universal reference area.

5. A convenient, yet optional complement of the DLM is an up-to-date colour or black and white ortophotomap of a given area.

The multi-attribute layers in DLM include mutually and logically (thematically) integrated multi-parameter information (on all the components of nature, the aspects of human impact and development interests or limitations). If necessary, each of the multi-attribute layers can be unfolded into individual analytical layers. However, in such a case the layers not mutually aligned and in details differ from the original, non-aligned, layers of geodata.

5. The construction of DLM

The process of integrated data layers and digital landscape model was tested via three elementary methodological procedures:

- a) manual integration of analytical layers over input data in analogue form and the analogue integrated output with posterior digitalization,
- b) on-line semi-automatic integration of digital analytical data following a formally implemented format, projection and scale integration of data.
- c) automatic integration of digital analytical data in pre-done and unprocessed form via methods of higher statistics, e.g. classification of automatically created poly-component areas (polygons) with the help of a statistic method, such as cluster analysis with ensuing automatic corrections of attributes in “faulty” combinations of an area’s parameters (Fig. 5).

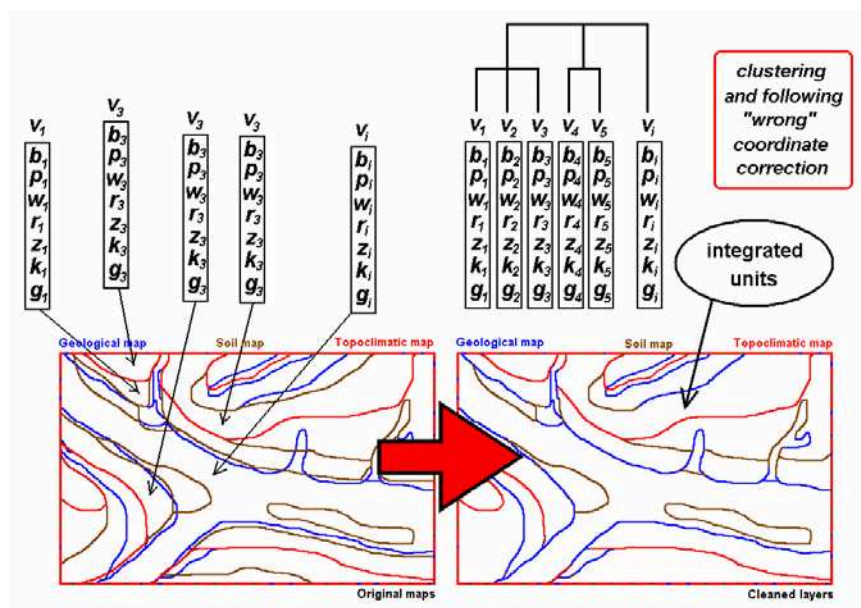


Fig. 5: Automatic geodata integration using cluster analysis

6. The implementation of completed DLM in solving geographic problems in an area

In the past, DLM of smaller scale (of up to approximately 150 km², always based on data corresponding to the map scale of 1:10 000) were drawn with the objective to solve concrete projects, usually when solving problems of landscape planning and risk assessment.

Digital landscape model of the surroundings of the town of Telč (150 sq km) in the colder plateau part of the Czech Moravian Highlands was used for area use optimization and for selecting optimum sites for the town's landfill (Kolejka, Pokorný, Skrott, 2002). The same model was also used in the field of practical landscape management (Kolejka, et al., 2003), focusing on agriculture and forestry (e.g. optimization of land use according to its potential for housing, orchards, production forests, etc. - Fig. 6). This DLM is also interpreted for determining adequate use in terms of the crisis management project.

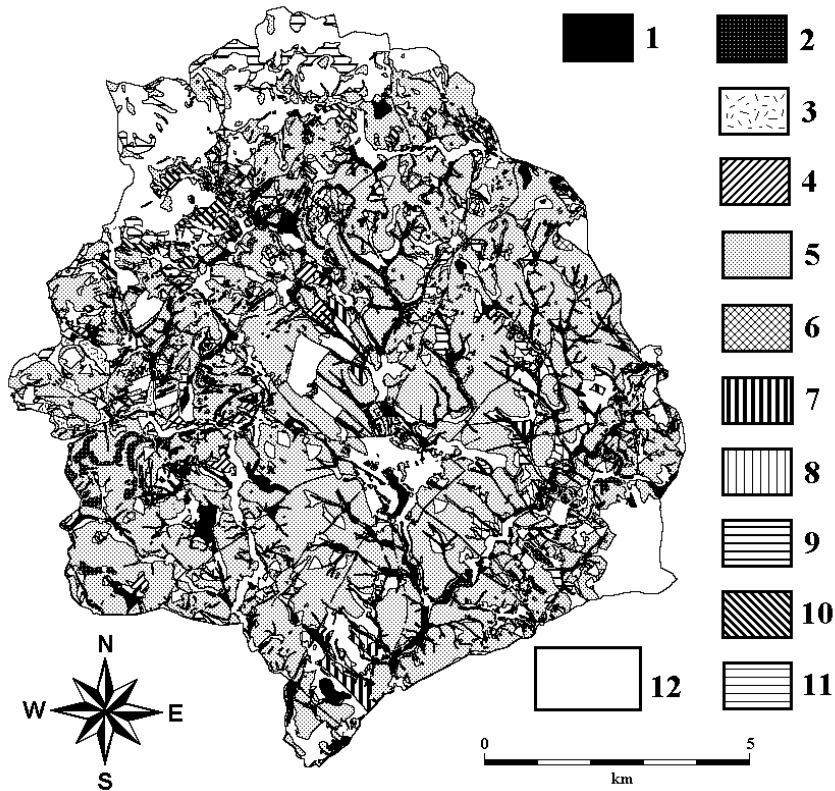


Fig. 6. Optimal land use pattern according to the best natural potential

7. Perspectives of DLM

DLM creates a versatile integrated database suitable for basically any type of implementation in GIS. This database guarantees significantly better results of data processing than the processing of merely overlaid individual analytical layers in GIS.

When visualizing the results of purpose processing of such a database, either in the more visual form of an ortophotomap (Fig. 7) or simply in 3D display, we receive much better results in the course of informing and persuading the general public about the benefits of the proposed measures. The results are better than in case of 2D or 3D demonstrations of the traditional processing of non-integrated data. The better quality of DLM output data owes to the fact that at any time we can retrieve any parameter combination of the area in a given place and this combination will always be correct and logical.

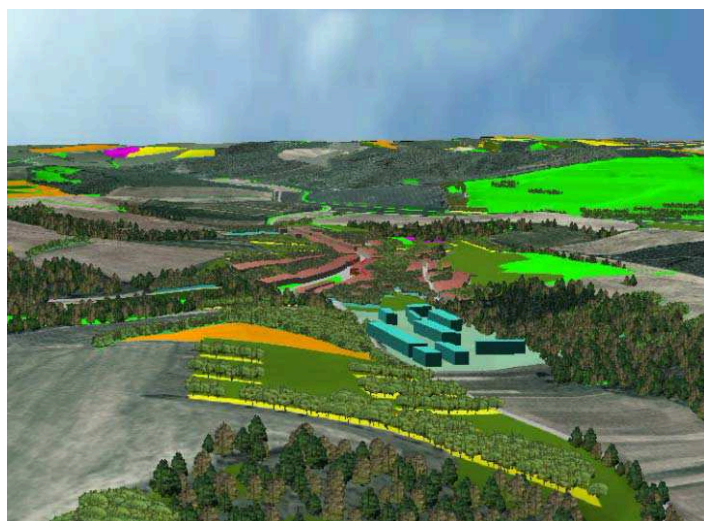


Fig. 7. Photorealistic 3D model presenting original geodata and processing results together

The utilization of DLM in crisis management proves crucial both in the stage of assessing the area's risks and preparing necessary measures, but also when coping with deleterious phenomena and taking ensuing mitigation measures. This aspect of DLM utilization is studied at the Masaryk University in Brno in the current project "Dynamic Geo-Visualization in Crisis Management".

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