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GEOGRAPHIC COMMUNICATION FOR SUSTAINABLE DECISIONS

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Abstract. Information communication technologies are widely used to support sustainable development. As both nature and society exist and develop in the geographic space, a good decision making can hardly be imagined without a prior thorough analysis of spatio-temporal distribution and spatial correlation of diverse ecological, economical and social parameters. Wherever such geospatial relationships are concerned, the methods of geography as of a geographic information science are commonly applied, among which cartography is the most efficient information communication method. Different levels of representation of geographic information, such as databases, geographic information systems (GIS), maps, atlases and Spatial Data Infrastructures can be easily and conveniently used for different steps of planning. More than that, maps have a hidden potential to reveal unknown spatial patterns and trends and the process does not require any specific technological skills from the user. Therefore it is very important to include geographic/cartographic dimension into regional and national sustainable development strategies, so that spatial structures, diversities, similarities and geographic determination are always taken into account. To facilitate the process of geographic decision making, we develop a uniform model of description of geographic methods that could be used online and provide suggestions on which of the known methods could be efficiently applied.

Keywords: cartography, geography, maps, geographic methods, GIS, sustainable development, decision making.

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1. Introduction

Our society, as well as nature, exists and develops in space and time. Location of territories and different spatial relationships are among the most important factors that influence the ecological, economical and social parameters. Development plans should in some way take

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into account the spatio-temporal distribution and spatial correlation of these parameters. Thus geospatial analysis plays a very important role in the decision making. Applications of the methods of geography and geographic information science for planning and long-term decision making at all levels have been exhaustively discussed in numerous scientific publications.

The goals of the papers are: firstly, to demonstrate the role and possibilities of cartography in sustainable development and secondly, to name the problems of geographic/cartographic thinking that create barriers for using this possibilities to full extent. We also introduce a prototype model of description of geographic methods developed in Vilnius University, Lithuania. The model is uniform and location independent. It could be used for international collaboration online and provide suggestions on which of the known methods could be efficiently applied.

2. Geographic dimension of sustainable development

2.1. Spatial data: need and resources

Spatial data, that most often means data related to the surface of the Earth, are generally very expensive to collect and maintain. It is due to their complexity and vast amounts of classes and objects that belong to this group. There are two major types of geographic data: the relatively stationary information, such as topography, and thematic geographic information that describes the objects of different complexity and changeability. Both types are important for planning. Topographic information is usually referred to as georeference base data and is necessary for general evaluation of situation and as the base data for environmental modelling. The need of it is relatively well understood and satisfied by the national topographic databases and maps. On the other hand, thematic data are mostly used in the specific field of investigation and rarely combined together with a purpose of re-using them in cross-field analyses. For this reason, investments into collection of geographic data on changeable environment, society and economy are not efficient, on the other hand, many planning decisions prove to have been wrong due to ignorance or misuse of geographic data that have been collected and available for re-use. The charts of Figure 1 show the misbalance of the structure and amounts of recently available geographic data and the three key aspects of sustainable development.

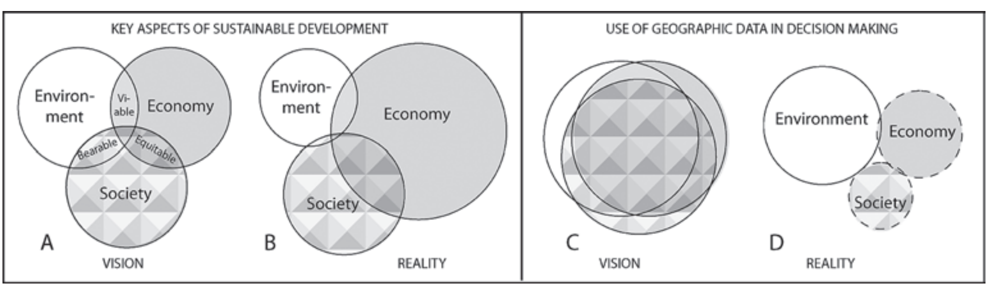

Fig. 1. Data for sustainable development: A – vision in proportion with the expectations, B – actually available, C, D – data used for planning

Fortunately, awareness is growing at national and at EU level about the need for quality geo-referenced information to support understanding of the complexity and interactions between human activities and environmental pressures and impacts (INSPIRE site 2009). The INSPIRE Directive that has entered into force on the 15th May 2007 obliges the member countries to electronically provide particular geographic data compliant to the standard quality requirements. The directive refers to mainly environmental and some economic (resources, production and industrial facilities) data themes <http://eur-lex.europa.eu/JOHtml.do?uri=OJ:L:2007:108:SOM:EN:HTML>, Annexes I, II, III). There is no clear regional policy on collection and dissemination of socio-cultural data. However, recent socio-economic and political environment is very dynamic in Lithuania and the society is developing a permanent need for the newest geographic information covering these aspects (Beconytė *et al.* 2007).

2.2. Spatial analysis and collaboration: possibilities

Good development and planning decisions based on thorough analysis of surrounding environment are crucial for sustainable development. Naturally, such decisions must take into account the spatio-temporal nature of the natural and socio-cultural phenomena. The spatial dimension adds significant complexity to planning, which is difficult enough due to large number of alternatives, conflicting interests, heterogeneous data and permanent changes in the environment. The spatial methods can and must be used at all stages of decision making (the gray arrow in the Figure 2).

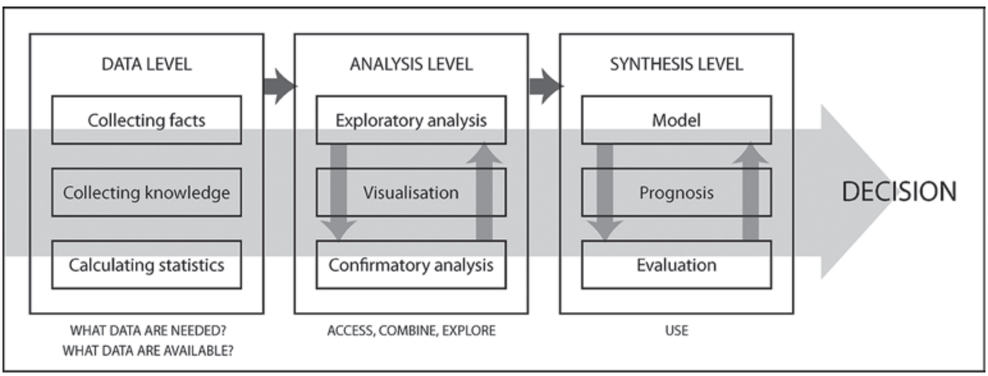

Fig. 2. Spatial methods in decision making

Various geographic information technologies and methodologies can be applied for different activities related with sustainable development that is demonstrated by the studies performed in Lithuania (Baltrėnas *et al.* 2007; Ginevičius *et al.* 2008; Melnikas 2005; Sakalauskas and Zavadskas 2009; Stankevičius *et al.* 2010; Vaišis and Januševičius 2008; Veteikis and Jankauskaitė 2009; Zakarevičius *et al.* 2009; Zavadskas *et al.* 2003):

a) building sustainable development strategies at any territorial level (scientific Geographic Information Systems (GIS)-based evaluation of geographic diversity, determination and disparities);
b) discovering spatial structures, diversities and similarities, trends and patterns that facilitate building more adequate development models;
c) analyzing feasibility, mechanisms and processes of sustainable development (both confirmatory and exploratory geographic analysis, synthesis, modelling);
d) development, measuring, monitoring and evaluation of sustainability indicators (GIS analysis and information systems);
e) communication of information (geographic integration of information on spatial data infrastructures and cartographic products);
f) collaboration, participatory learning and actions (geographic data portals and maps as tools for sharing spatial insights and ideas).

As about 80% of public sector information can be linked geographically, cartography as visual representation of geographic data is a very efficient method of information communication.

3. The cartographic method

3.1. Cartographic communication of information

Exploration and analysis of spatial information can be performed through:

– Interactive visual interfaces (typical confirmatory analysis);
– Map image for exploratory analysis.

Even though GIS systems and tools of spatial analysis can provide mathematically justified answers to many particular questions, the task of formulating such questions is rather challenging. Maps have a hidden potential to reveal unknown spatial patterns and trends and the process does not require any specific technological skills from the user. Due to this unique quality maps are none the less important than geographic datasets used for precise measurements and analysis (Armstrong and Densham 1995; Brewer *et al.* 2000; MacEachren 2000). They allow for integration of expert and common knowledge discovering cross-thematic spatial patterns. Figure 3 shows the process of information transfer using maps (Beconytė and Govorov 2005). The task of cartographers is to minimize the loss of information in every step of this communication.

A new discipline of *Geovisualization* emerged in around 1995. It investigates into the use of multiple interactively linked views providing different perspectives into the spatio-temporal data, user interfaces and usability of geovisualization tools that provide spatial decision support, including knowledge based systems connected with database and a monitoring system (Fischer 2006; Yandong *et al.* 2007; Sikder 2008). Commission on Geovisualization <http://geoanalytics.net/ica>) of the International Cartographic Association focuses on the use of interactive maps and cartographic techniques to support visual analysis of complex, voluminous and heterogeneous information involving measurements made in space and time.

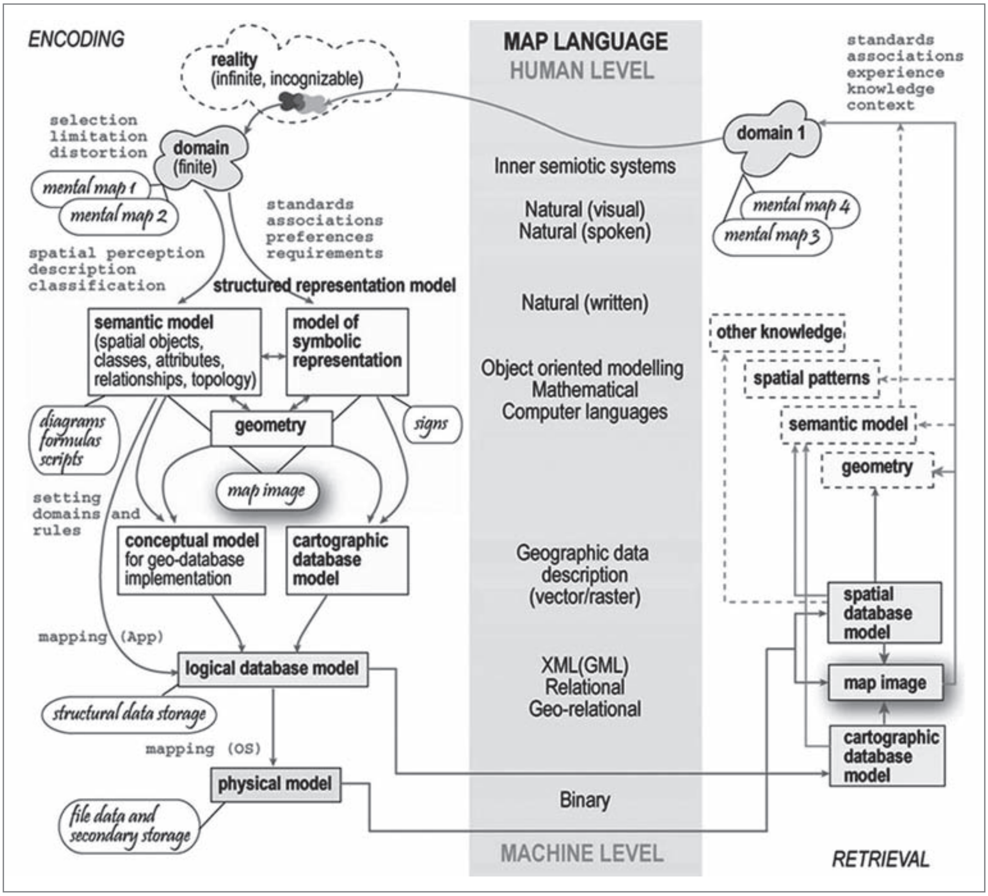

Fig. 3. Scheme of cartographic communication

3.2. Integrated approach

Different levels of representation of geographic information, such as databases, GIS systems, maps, atlases and spatial data infrastructures (SDI) can be easily and conveniently used for different steps of planning (Fig. 4).

GIS data and maps have to be at the core of sustainable development efforts. It is understandable that easy access to precise and comprehensive data from online GIS systems and maps has become a priority. Nevertheless, analysis and surveys performed in 1995–2000 showed a need for **thematic atlases** atlas as sets of complex, mostly synthetic small scale maps due to these major factors:

a) need for synthetic geographic information for decision making purpose;
b) need for a single comprehensive source of diverse and complex information visualising large volumes of data in an understandable way.

A modern atlas is based on and similar to an information system in which different information has to be integrated and successfully visually rendered.

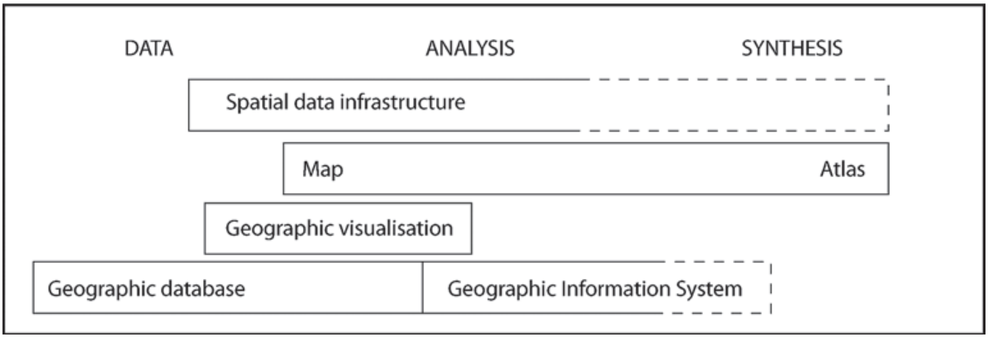

Fig. 4. Levels of integration of geographic information

Spatial data infrastructure is potentially the highest level of integration of geographic and cartographic information. Possible services of an SDI geoportal are the visualisation of information layers, overlay of information from different sources and online tools for spatial and temporal analysis.

4. Uniform model of description of geographic methods

During the last five years fast development of global search systems and Internet cartography technologies made available modern geographic methods and products to wide public with different competences (Goodchild 2009). Geographic products as maps are combined with online geographic applications (services) making so called map "mashups". There is no more need for final users to have complex GIS desktop systems – the same result can be now acquired using Internet browsers with designed user interface for parameter input.

Fast and easy access to geographic services stimulates collaboration between geographic information creators and users of different fields where spatial data are used. The society is approaching the stage when uniform interpretation results, parameters and indicators is necessary for efficient geographic solutions results, parameters and indicators. Besides that, it is important to effectively share the knowledge about geographic methodology already applied as well as to find alternative new methods for problem solving.

One aspect of integral use of available geographic resources is web service standards (OGC WMS, WFS, KML) – they allow interoperable data interchange. The other aspect is to interchange knowledge about data meaning and quality, reality description level, analysis methods and algorithms used – this is the only way for us to know, that identically named geographic datasets that come from different sources match each other semantically and can be combined together. In attempt to develop such geographic knowledge sharing system we started building a model for uniform description of geographic problems and solutions. The research was performed in Vilnius University during the period of 2006–2010. Generally the model is based on a set of descriptive parameters collected from different geographic problem classifications (Demers 2008) and adopted to implemented solutions. Technologically, it is supported by a relational database and user interface (Fig. 5).

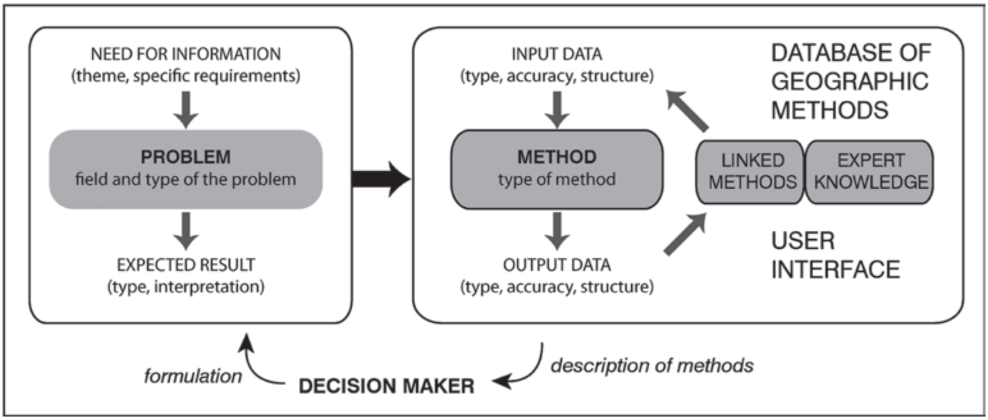

Fig. 5. A model of description of geographic methods

The main idea of the model is similar to the concept of *metadata* used for geographical data description – we have defined a set of characteristics that describe a geographic problem: input and final data structures, input parameters, space and time characteristics, algorithms used, technological platforms where the problem can be solved, references to relevant works etc. It is also very important to derive the relationships between different problems and their solution methods. Descriptions of such relationships serve two main purposes:

a) finding semantically and (or) structurally, judging by output data, similar geographic problems;

b) intuitive construction of geographic analysis sequences based on input-output data.

It is not easy to implement such universal model in practice. Difficulties are due to competing interests of the final users and to different competences. A number of experts usually participate in any type of location related process of planning – implementation – representation – decision making. They may be responsible for different steps: building the geographic model of reality, synthesis of methods, data collection and extraction, construction of algorithms, technological solving (programming), cartographic representation, decision making. It adds complexity to description of geographic problems: such descriptions are needed at different levels of detail. The model of description of geographic methods thus includes an additional relationship that characterizes abstraction level of particular description and links it to the related more detailed descriptions.

As soon as the prototype model is available for the end users, similar geographic experiences can be searched and suggestions found what geographic methods and in what order should be applied for the optimal result.

Development of such system is based on proper methodology, technological platform and cooperation of the users. The first two elements ensuring environment for data collection can be implemented once and the system will not require big further investments. At the implementation stage investments are required for one web server machine with database and web publication software. The work of three developers, one coordinator and two methodological experts for about a half a year must be considered. After technical implementation the most important issue is timely update of information about the new methods. There are two information collection scenarios: institutional – single organization is responsible for all data collection, and cooperational – authors themselves register their methods using an online system. The former is more expensive and requires additional resources (personell, financing, work organizing, legislation). The second approach is based on assumption that there will be active parties having interest to publish their work. There is a risk that the authors of new methods will not sufficiently participate in process, because of additional work besides description of the method in a scientific publication. To ensure effective functioning of such system, support of regulating intergovernmental or standard organizations would be necessary. If international collaboration is achieved, the system would become beneficial for research, geographic education and business worldwide.

Additional important benefits of the model, related with system design, can be expected. For example, at the requirement specification phase of GIS projects development, the requirements could be checked against the methods database and the proper tools could be identified and ranked. Thus the system would support decision making at design stage, for example, facilitate choosing the most efficient geographical information software.

5. Conclusions

A variety of data on physical and natural resources, human resources, social practices and economic aspects are required for effective planning and development. The appropriate use of this geographic information can significantly improve planning decisions that may be crucial for sustainable development. There are several levels of use of geographic/cartographic information that must be applied at particular stages of planning: individual data theme, combined data themes, synthetic datasets/models.

There are two types of use of geographic information for decision making: *analysis* (confirmatory approach), mainly performed on geographic datasets, and *visualization* (exploratory approach) that is not possible without maps. Visual analysis has a specific power of revealing hidden patterns that cannot be done automatically.

The decision makers often lack not only ability to formulate spatial problems, but even common geographic literacy. It may result in failure of large scale sustainable development projects. For this reason it is very important to include geographic/cartographic dimension into regional and national sustainable development strategies, so that maximum of important spatio-temporal structures and relationships are recognized and taken into account. Only then the state can fully benefit from the evident potential of the technology to improve the relevancy, accuracy, impact and public control of territorial policies and related decisions.

A model of uniform description of geographic problems and methods, developed by the authors, is a step towards facilitation of use of geographic methods for decision making in different spheres of life. As implemented, such model can be used by everyone moderately familiar with main principles of geography, and, on the other hand, integrate expert knowledge on various methods and their applications, thus providing a roadmap for geographically literate decision making. Due to simplicity of interface and flexibility the model could be used and also developed by planners, researchers, analysts, computer scientists and programmers.

Cooperation of the users is very important for successful implementation. In the nearest future we expect online launch of the expert system based on this model.

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GEOGRAFINĖS INFORMACIJOS KOMUNIKAVIMO PRIEMONĖS IR TVARIOJI PLĖTRA

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Santrauka. Tvarioji plėtra nebūtų įmanoma be informacijos komunikavimo priemonių ir technologijų. Ir gamta, ir visuomenė egzistuoja ir vystosi geografinėje erdvėje, tad neįmanoma įsivaizduoti tinkamų planavimo sprendimų, kurie nebūtų pagrįsti išankstine išsamia dalykinės srities erdvės ir laiko ryšių analize, neįvertintų erdvinių sąsajų tarp ekologinių, ekonominių ir socialinių parametrų. Visur, kur svarbus objektų išsidėstymas ir jų tarpusavio ryšiai geografinėje erdvėje ir laike, yra taikomi geografinės informacijos mokslo (šiuolaikinės geografijos) metodai. Vienas efektyviausių yra kartografinis metodas, leidžiantis intuityviai pastebėti erdvinius ryšius. Galima nagrinėti skirtingus geografinės informacijos organizavimo lygmenis, tokius kaip duomenų bazės, geografinės informacijos (GIS) sistemos, žemėlapiai, atlasai bei erdvinių duomenų infrastruktūros. Visas šias sistemas galima patogiai ir nesunkiai naudoti įvairiuose planavimo etapuose. Be to, žemėlapiai turi paslėptą potencialą atskleisti iš anksto nežinomus erdvinius ryšius bei tendencijas. Šis procesas yra intuityvus ir nereikalauja iš naudotojo jokių specialių technologijų žinių ar įgūdžių. Todėl labai svarbu į nacionalines ir regionines plėtros strategijas įtraukti ir geografinį/kartografinį matmenį, atsižvelgti į erdvinio išsidėstymo struktūras, skirtumus, panašumus ir galimus geografinius apribojimus. Straipsnio autoriai pasiūlė ir šiuo metu Vilniaus universitete plėtoja universalų geografinių uždavinių aprašymų modelį, kuris padėtų geografinės informacijos naudotojams be specialių žinių pasirinkti tinkamą sprendimų seką ir metodus.

Reikšminiai žodžiai: kartografija, geografija, žemėlapiai, geografiniai uždaviniai, GIS, darni plėtra, sprendimų priėmimas.

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