AUTOMATED MAPPING AND UPDATING TECHNIQUES IN TRANSBOUNDARY EAST EUROPEAN UNESCO BIOSPHERE RESERVES DEVELOPMENT

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ABSTRACT:

The article contains a brief overview of joint research activities (done using GIS methods) in the East European chain of valuable areas of the world connecting five countries: Belarus, Lithuania, Poland, Russia, Ukraine. Mentioned territories are currently under focus of such international organizations as Man and Biosphere UNESCO, which are performing some initiatives in this region. The first is international project "Establishment of a Transboundary Biosphere Reserve and a Regional Ecological Network in Polesie". Geoinformation technologies are one of most important methods involved in all project objectives and are used for the documentation and analysis purposes. From the GIS point of view the project has a broad extent because of these characteristics: small scale result maps, multisource, multiscale and different quality source data integration, necessity of using the universal documentation and analysis technology, the need for comparability of research results. Object based automatic techniques for feature detection were proposed as a main tool for mapping and monitoring of environment. The article describes main problems and propositions of theirs solutions in main problem fields. Results of research proved the adequacy of proposed methodology, projects regarding other biosphere reserves on the Eastern Border of EU will be analysed in respect to the different specific issues.

1. INTRODUCTION

There is an East European chain of valuable areas connecting five countries: Belarus, Lithuania, Poland, Russia, Ukraine, containing some of most valuable areas of the world (Fig. 1) e.g.: Large forest areas – Biosphere Reserves: Belovezhskaya Pushcha – Bialowieza; Wetlands complex of Polesie – West Polesie – Shatskyi – Pribuzhskoye Polesie; Chain of the Carpathian Mountains – East Carpathians and Carpathians; Natural ecological corridor of the rivers: Bug (Polesie Region) – Muchawetz – Bug-Dnieper Canal – Pina – Pripyat – Dnieper (the coastal zone of Black Sea).

Primary characteristics of this area are: high level of biodiversity, a large meridional extent causing crossing of different climate zones. Because of the location between five countries there is a lack of environmental policy on the transboundary level respecting this region. There is insufficient coverage of protected areas. A large part of this area is under degradation of environment. There are some threats to biodiversity: from drainage as a result of agriculture methods and exploitation of peats; urban pollution; uncontrolled fishing and hunting; unsustainable forestry practices. There are also social problems in these regions caused by large unemployment and migration of young people to large cities. Currently, the region is undergoing great social and economic changes, which could result in successive modifications of the landscape structure and biodiversity.

Mentioned areas on the Eastern border of European Union are currently under focus of such international organizations as Man and Biosphere UNESCO, which are performing some initiatives in this region. It started with the international project "Establishment of a Transboundary Biosphere Reserve and a Regional Ecological Network in Polesie" launched by three countries: Belarus, Poland and Ukraine. The project consists of

Figure 1. The map of Transboundary Chain of East European Biosphere Reserves with Zone of Joint Efforts

six main fields of research and monitoring: wetlands, bird species, landscape structure, ecohydrology and nongovernmental organizations. Each one of these problems is important on international level especially thorough historical conditions of the EU border countries affecting the environment and precluding the perspectives of collaboration on the nature research field. Now there is a necessity for documenting the state of the nature and society of these regions, giving an scientific background for establishing and management of protected areas and international planning of future development of these regions. Main effects of the project are: Elaboration of integrated (common for three neighboring countries) strategy of protection of natural values and sustainable use of Polesie potential. Initiation of several nature conservation and sustainable development projects: Restoration of water and peatland ecosystems. Promotion of agro-tourism in

accordance to nature and landscape. Establishing some new protected areas.

2. AUTOMATED MAPPING TECHNIQUES IN TRANSBOUNDARY RESEARCH

2.1 Needs and specificity of the transboundary research

In described projects objectives are strongly expressed main benefits of using geoinformation methods (Breymeyer, Adamczyk, 2005): having consistent, repeatable, relatively inexpensive data; seeing whole landscapes; making comparisons between different kinds of information, also from different periods of time; improving of actualisation and accuracy of data. The important problem in research activities is optimisation of costs of data collection and processing, what indicates using fully digital remote sensing and GIS instead of laborious analog methods – common for hitherto research in the all involved countries. It provides the most cost effective and timely method of collecting environmental data over large e.g. transboundary areas.

Geoinformation is most important set of methods involved in all project objectives and are used for the documentation and analysis purposes:

- Retrospective analysis of natural changes of wetland ecosystems using paleolimnological analysis of sediments; correlations with paleo-climate and some predictions of Global Climate Change influence on wetlands – documentation of results using universal method for all fields.
- Census and monitoring of selected species of threatened birds and their habitats – documentation of results, research e.g. detecting of areas with a good natural conditions for birds nesting.
- Landscape structure description and multitemporal change analysis of the proposed ecological corridor Bug-Dnieper – application of remote sensing techniques in landscape structure analysis.
- Implementation and development of ecohydrology concept in West Polesie Transboundary MAB Biosphere Reserve – remote sensing in hydrological applications and documentation.
- Nongovernmental organizations cooperation in Polesie Region: "Bug Connects Us – Nadbuzanskie Trans-Border Days"; "The nature of Polesie invites you!". The rural and urban areas mapping and analysis.

The main concept of the introduction of automated mapping techniques is based on the former research regarding the need of improving adequacy of the environmental object representation in GIS (Adamczyk, 2005). It was established that there is a need to delve into the research concerning the methods of developing GIS systems dedicated to the representation of the structure and relationships among the landscape elements. The Biosphere Reserves special role in development of geographical information systems between the protected areas of the World come from some important reasons: convergence of main objectives and functions of the MaB UNESCO programme (BRIM, 2001) and main needs of the Information Society concerning knowledge about protected areas.

Transboundary research is very specific from the GIS point of view the project:

- The common scale of result maps is 1: 100 000 but the information is integrated from multisource, multiscale and different quality source data. The base data are satellite images from the Image 2000 but there are also a plenty of aerial photos, Russian satellite KVR images and thematic maps.
- There is a necessity of using the universal documentation and analysis technology, because of the need for comparability of research results.
- Used technology must be reliable and cost/time effective.

The starting point for the project was completely different:

- There were available only topographic data for participating countries – and often in very low quality and out of date. The quality of data was verified through integration with satellite images from Landsat ETM+ (obtained from the European database Image 2000). Geometrical consistency of layers was very low. From this point of view there was a need for using different data as a base maps. There was also a lack of digital data for broad parts of countries territories.
- There was a lack of useful spatial digital data from research activities. Hitherto researchers in the all countries have had no possibility and essential preparation to using GIS methods of documentation and analyses of data.
- There were huge databases containing attribute digital data from monitoring. There was a problem of syntactic integration of the databases and the spatial reference of the data.
- Uppermost important problem in databases integration was inconformity of research methods, causing hard to solve semantic incompatibilities.

The most important problems were caused by different history of research activities in three participating countries. Two of them (Belarus, Ukraine) were former Soviet Union Republics and same research methods were developed. Poland was also the socialistic country, but research methods were developed separately. Also, through the period of time in which map reference systems were the same in the Soviet Union and dependent countries a large part of cartographic documentation in Poland was prepared in different reference system and other methods than in the former Soviet Union Republics. There is also another very important source of errors in maps – the Polesie Region was the border zone of SU. Omnipresent secrecy of topographic data, caused intentional introduction of a large uncontrolled distortions to distributed (only for restricted applications) map data.

2.2 Automated mapping techniques method and applications

First stage of the project proceeded through the two iterative processes of discussing the new method of improving the environmental objects representation adequacy and creating the proposition of technical solutions, fulfilling in practical needs of the method. As a result of the research Geographical Information System dedicated to the representation of the environmental objects for the Network of Biosphere Reserves UNESCO and other protected areas was proposed. The system was designed to allow the co-operation with the other information systems on the national and international levels.

Origin of the key method, determining the structure of the discussed system, is identification of spatio-temporal and functional characteristics of landscape. Comparing this with method of describing and representing the reality in computer memory, the author developed rules fulfilling mentioned above objectives of the system and complied it during systems building process (choice from the whole text):

1. Adopting of three dimensions of data completeness: thematical – exhausting the main range of functional components existing in landscape; scale – ensuring the full range of representation scales, to view the landscape on different levels of environment organization; spatial – the spatial range of information, necessary for the full analysis of relationships occurring between ecosystems.
2. Distinguishing between environmental space data (describing processes occurring among ecosystems) and topographical data.
3. Introducing the new concept of environmental reference data – a minimal range of data that could be used to make full characterization of landscape and its components.
4. The object oriented approach to elements of the environmental space – related to the integral parts of landscape analyses in different dimensions and hierarchical levels.
5. The necessity of delivering data on the particular scale level also for objects too small for cartographic representation.
6. Standardization of nomenclature describing environmental space.
7. Visualization under requisition of different methods, adequate to character of represented objects and processes, especially using a wide range of image data and 3D effect – for giving more possibly real insight into topographical situation.
8. Using time series data as a standard – data gathering process planned with comply with comparability of methods.
9. Demand for high level of quality of GIS data.
10. Making possible to use a wide range of GIS analyses, which are accessible with the Internet interface.
11. The modular structure of the system – referring the functional heterogeneity and different ways of data handling and distribution.
12. The necessity of protecting some kinds of data about the nature objects and phenomenon's.

The above mentioned propositions caused decision to use object based automatic techniques for feature detection as a tool for mapping and monitoring of environment. Main problems and propositions of theirs solutions in following fields:

- Data integration for mapping purposes;
- Feature extraction – especially for purposes exceeding the simple land use / land cover recognition;
- Updating information from different sources for monitoring and maps actualization;
- Multitemporal data comparison – for mapping history of environment;
- Object based valorization of the landscape for all projects aims.
- Representation of result data for applications related to protected and urban areas management and education.

Method of omitting incompatibility of data provided by participating countries was creation of GIS database based on remote sensing data as a critical component of the landscape analyse process. Other important data, being at most results of research activities were integrated by adapting to the predefined database model. It was in detail described as guidelines for the further method of data collecting and distributed through participating institutions.

Integration of existing data was priority before creation of new layers. In effect there was a necessity of doing some fittings and corrections by using automated and semi-automated methods. A part of data stayed in the input form because of possibility of errors caused by inadequate integration.

In result all used maps are based on remote sensing data, used to complete contents of maps with a background data into a kind of image maps[*]. Using image data instead of other (e.g. topographical) layers gave following possibilities:

- Delivering quite full information about the environment and topographical objects in spite of lack of data in thematic aspect or spatial coverage.
- Obtaining several kinds of information about the character of objects not covered by environmental classifications stored by vector data – by using different kinds of color compositions.
- Free interpretation of environmental space not determined by the subjective approach of specialist preparing the data.
- Allowing transboundary analyses of environment because of their continuous character, also image data can be used as a reference for data integration.
- Cost of delivering image data is relatively low in comparison with process of creating vector data. That advantage plays a special role in aspect of making time series of data.
- More automatic process of integration can ensure a higher level of data quality (e.g. in geometrical aspect).

Using remote sensing data as a base for database model had also advantages directly connected with further analyses possible to perform on so defined data model. Method used for documentation purposes was feature extraction - performed in context of landscape ecology methods. Base environmental unit for feature extraction and developing environmental hierarchy is geocomplex[**]. Using this feature there is possibility of analysing landscape in two dimensions:

1. Documentation of different types of features in landscape in base units. The method, dependent on the predefined parameters, is used for mapping and monitoring of: land cover/use types and changes, watersheds, ecohydrological processes, urbanized areas development, mapping of environmental phenomenons.
2. Spatial dependencies in landscape, between geocomplexes and geocomponents, monitoring and mapping by using the concept of hierarchy of environmental objects.

[*] The term "image map" is used in the meaning of satellite or airborne image with additional vector layers and standard map information added as topographical contents, completed by additional elements as: grid, sale bar, legend. All these elements together give map-like visualization.

[**] Geocomplex is a relatively closed sector of nature which constitutes a whole due to processes occurring within it and interdependences of geocomponents of which it is composed (Richling, 1983)

The object based technique (eCognition) of data integration and classification is used. In described projects applications it has some advantages among other methods (based on description done by Blaschke et al., 2005):

- Possibility of integration of different kinds of data, including thematic layers containing important information about geocomponents.
- Broad range of the object's features taken into consideration in classification process.
- Way of distinguishing of objects allows to consider environment in context of it's spatial structure.
- The segmentation method allows standardizing landscape analyses into method based on the landscape patches theory. There is also possibility to define particular patches as a base objects for data integration for updating purposes.
- The possibility of considering landscape in the hierarchical aspect. It is allowed in the thematic dimension by using class definitions and in hierarchical dependencies – considering the landscape on the different levels of spatial organization. Limitation of method is difficulty of creating land use classes which could be defined as "interpretative" – not directly based on spectral response of environmental objects.
- Possibility of choosing between a wide range of features for classification, allowing opitimization of objects characters description.
- Fuzzy approach to classification – strongly connected with main character of the environment. On the basis of existence of fuzzy objects further research in field of improving recognition of ecotones was developed.

The landscape segmentation approach is used for further analyses of integrated data (with limitation on success in data integration) in fields related to main goals of the project:

- Multitemporal analyses were essential for mapping of state of the nature in previous periods of time and for further development of prediction models. Main applications are monitoring of changes in: wetlands and open waters, land use, urbanization, deforestration and aforestration processes caused by changes in the state of environment and strong social processes in this region.
- Description of the landscape structure with using the spatial pattern analysis in the patch-corridor-matrix model, was one of the most important task documenting of the ecological corridors network in this region. There are important European range corridors connected with the Bug River. There was also need of defining the ecological network on local scale, but in transboundary aspect.
- Quantification of the landscape and its composition with using metrics giving some information about the biodiverstity, proximity, eveness, composition, edges description and analyses – primary applications of this method are connected with documenting of the state of environment for protection and management purposes: nomination some new protected zones and identifying problem areas. There were also some tasks related to research activities archived with this method – on the base of spatial pattern objects evaluation of places occupied by bird species was done.
- Watershed analyses by integration the segmented data with Digital Terrain Model, for ecohydrological modelling purposes.

Output data are usable in both forms – vector and raster, what gives a lot of further analyses opportunities including advanced methods of geostatistics. Based on image objects, standardization of data gives possibility of creation easy attainable visualization of research results.

2.3 Integration of mapping methods in the GIS system

All data were introduced into the GIS system, developed in accordance with above described guidelines. The main functionality of the system (Fig. 2) is a result of two conditions: specific structure of environmental data and system users needs. The whole structure of the system is divided into two parts: integration; processing and distribution modules.

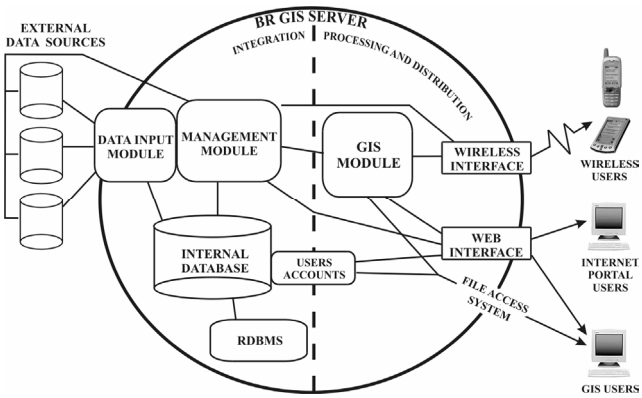

Figure 2 The overview of the Biosphere Reserves GIS structure

Respecting the main topic of this article there is especially interesting method of integration and handling of environmental data. The system integrates data provided by a external databases, they, in the future, will serve as clearinghouse systems. Method of storing and handling information can be summarized as adopting source data structure to special data handling in the system. Information stored in the system is divided into reference- and other data. The reference data is basis of structure of the system and their integration into main schemas of: scale levels and information content structure. scale levels of visualization were divided respecting rules of landscape ecology for representation of sequential approximations of ecosystems organization into 5 levels: international, national, local, particular and non cartographic (the objects too small for cartographic representation). The Entity Relationship Diagram was designed based on following groups of the integrated reference data: landscape components; nature protection; tourism and recreation; typological classifications; scientific research; thematic maps; image data (satellite and airborne images, 3D visualizations); topographical maps; databases.

In the future, after finishing the project and obtaining necessary permissions the data distribution service will be provided by three ways: Internet access; wireless access – to PocketPC-s, telephones and other handhelds, using the standard Web interface and LBS (Location Based Services); directly by file access system – obtaining data as all kinds of files.

Now the test version portal is introduced into project and accessible only for the participants of the project. One of the most important features of the portal GIS Analysis Tool – nowadays there is the possibility to make some operations using vector and attribute data; raster data analyses seems to make too big load for the servers and takes too much bandwidth. But

progress in this field is very fast and there are preparation to introduce some other analyses tools into the portal.

3. TESTING THE SYSTEM

Testing realization of main tasks related to improving adequacy of environmental objects representation, was performed using following applications of the system:

1. Practical applications –need of obtaining data indoor and outdoor for different kinds of users needs.
2. Considering the environmental space from point of view of landscape components and relationships among them.
3. Possibility of following phenomenon's in a hierarchical schema (of visualization scales) complying different levels of ecosystems organization.
4. Analyzing the data in a spatio-temporal aspect.
5. Visualizations in a 3D model – for obtaining a closest possible insight into a topographical situation.
6. Providing analyses of different kinds of data: statistical and about structure of the landscape.
7. Obtaining visualization of objects and phenomenon's on a very particular, non cartographic scale level.

Results of testing process are positive. It affirmed high level of realization above mentioned needs. Thematic schema of the system was evaluated by users: as proper, giving a large number of possibilities and easy to use. The main thematic information come from vector data, but it is necessary to complete contents of maps with a kind of background data: a layers of topographical maps – often insufficient spatial range and simplification of information about real appearance of the terrain; image data – some image maps were created. Users affirmed that practical applications of image maps are giving a much richer information than topographical maps. The reason is possibility of obtaining additional information about characteristics of objects, only symbolically represented on traditional maps.

Despite of described above (chapter 2.2) advantages of using image data, there are some conditions and problems to solve during process of building of such system:

1. Image data are more difficult in interpretation and is recommended for advanced users. In case of further distribution of data to ordinary users, the system should contain a broad range of thematic layers giving interpretation of objects and phenomenon's. But also in this case image data should be used as a background, supplementing the map information.
2. Parallel using of vector and raster data cause necessity of developing the system of generating custom map symbols for vector data (changing symbols, colors and making transparent polygons).
3. Comparability of contents of images collected in different terms is determined by techniques of registration and radiometric characteristics. Vector data created by stable technique are dependent on subjectivity of interpretation done by the specialist.
4. Proper visualization of data, from cartography point of view, is easier to attain using vector model. For creating image map, more advanced cartographic skills are needed.
5. Nowadays main weakness of the image method is caused by a big processing power involved in operations with raster data, being reason of limitations of possibility to offer more advanced raster data analyses through the Internet. This factor will be less essential in the future.

4. CONCLUSIONS

Results of research testing of functionality and capabilities of the system proved possibility of improving environmental objects representation adequacy, using the remote sensing data and its derivatives in a model of Geographical Information System for Biosphere Reserves. Also adequacy of proposed method was successfully verified. Information schema and method of data organization allow to satisfy most users and give possibility of developing transboundary cooperation. Special role in fulfilling this task plays image data. In the past this kind of data was often underestimated, but described above tests proved the usefulness of image map method. Main advantage of image maps is making visualization much more complete.

Being conscious of impossibility of giving ideal projection of environment using geographical information systems, author believes, that further research and progress in technical possibilities, will allow continuation of improving the adequacy of the representation of environmental objects.

The system is currently in the stage of implementing in research institutes in participating countries. Now it should be verified by users and improved in necessary points. The research on methodology should be continued and, in the future, be able to introduce to other transborder biosphere reserves on the Easter Border of EU.

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