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Open Source GIS – Architecture sharing Data and Knowledge in an UNESCO MAB Biosphere Reserve

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Abstract

Biosphere reserves have three main objectives: conserving biological and cultural diversity; providing models of land management and experimental sites for sustainable development, and serving as sites for research, environmental monitoring, education and training. These three biosphere reserve functions can be implemented only through involving and mobilizing all the structures and stakeholders concerned. Therefore, a biosphere reserve must have the necessary tools to help it reach its various objectives. Geographic Information Systems (GIS) are such tools, explicitly expressed to support management, monitoring and communication between the actors of the reserve.

GIS are able to act as platform where relevant knowledge, information (e.g. case studies) and data on different issues can be shared, analysed, searched through databases, and managed, and where synthesized findings, lessons learned and best practices are made available.

But, to become accepted as Biosphere reserve by the different stakeholders there is a long and intensive discussion to follow. Accompanying these processes of discussing the benefits of a new Biosphere reserve in the Bliesgau region (Saarland / Germany), within a students project, we developed a GIS – architecture as information platform using the iterative prototyping approach. This was done in close collaboration with the ministry of environment of the Saarland, which is driving the Bliesgau region towards a biosphere reserve.

Based on a requirements analysis, a client-server architecture using open source components (Postgres/Postgis, GRASS, ZMapServer UMN, Zope CMS) was set up. Most important point in the development was the implementation of an Internet Map Service as a communication and information tool for the stakeholders participating in the discussion. Visualising maps in an interactive manner is a much more direct and powerful communication tool than displaying lists and tables. In addition,

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Web-based maps are able to give the different users the same level of information in a way easy to understand and easy to access.

Keywords: MAB Biosphere Reserves, Geographic Information System (GIS), Open Source Software, Internet Map Services.

1. Introduction

The world network of Biosphere reserves has remarkable high natural values (high ecological integrity, high biodiversity, limited human use, rather unstressed systems, resource management is not extraction-oriented, etc.) and high cultural values. It comprises ecosystems and people, thus reflecting the human dimension in the environment. It is a network founded upon principles of maintaining biological values while sustaining human populations. In addition, Biosphere reserves serve as laboratories for research and demonstration of ways in progressing towards sustainability of human-environment interactions (including wise-use and economic development).

A Geographic Information System (GIS) of such a Biosphere reserve is able to act as a platform where relevant knowledge, information (e.g. case studies) and data on different issues can be shared, analysed, searched through databases, and managed, and where synthesized findings, lessons learned and best practices are made available.

But, to become accepted as Biosphere reserve by the different stakeholders there is a long and intensive discussion to go through. Accompanying these process of discussing the benefits of a new Biosphere reserve in the Bliesgau region (Saarland / Germany), within a students project we developed a GIS – architecture as information platform using the iterative prototyping approach. This was done in close collaboration with the ministry of environment of the Saarland (Germany), which is driving the Bliesgau region towards a biosphere reserve.

2. UNESCO MAB Biosphere Reserves

The Man and Biosphere (MAB) Programme was launched in 1970 by UNESCO with the aim of establishing the scientific basis for improving the relationships between people and the environment, addressing problems such as rational use of natural resources and their conservation, and ecologically sound land use. Since 1976, biosphere reserves have been set up as sites where MAB principles are put into practice. In 2004 there exists a list of 440 UNESCO MAB biosphere reserves in 97 countries, 14 reserves are located in Germany (http://www.unesco.org/mab).

Biosphere reserves have three main objectives:

- Conserving biological and cultural diversity;

- Providing models of land management and experimental sites for sustainable development, and
- Serving as sites for research, environmental monitoring, education and training.

2.1 Reserve Zonation System

In order to integrate the different functions, activities are organized according to a zonation system. In general, there are core areas for nature conservation (min 3 % of the reserve area), a delineated buffer zone (min 10 % of the reserve area) and an outer transition area or zone of cooperation with the local communities (min 50 % of the reserve area). Core- and buffer zone together should cover 20 % of the reserve area for minimum. The minimum extent of the reserve to fulfil the requirements of the UNESCO must be 30.000 ha. (Deutsches Nationalkommitee 1996)

The core areas have long-term legal protection in order to conserve biological diversity, to monitor relatively undisturbed ecosystems and to undertake non-manipulative research and other passive activities such as education.

The buffer zone surrounds the core areas and protects them from human impacts. Ecologically viable activities are carried out here, such as research, training and education as well as certain forms of recreation and suitable use of renewable natural resources.

The transition area, also called the area of co-operation, contains various human activities. It is the place for applying various models of sustainable development where local communities, conservation agencies, scientists, civil associations and other stakeholders should work together to manage and to develop the resources of the region. This is the place where the biosphere reserve project is made known through cooperation between the different stakeholders. (Bioret et al. 1998)

As expected it is not the transition area which causes problems in the lobbying work for a biosphere reserve to be defined, but it is the core- and the buffer zone where landowners and –users such as farmers, fishermen, hunters, foresters are expecting limitations in their “traditional” use of this regions. Their willingness to put the biosphere concept into practice varies significantly. Thus, the biosphere actors have a major role to play in informing these actors and stakeholders.

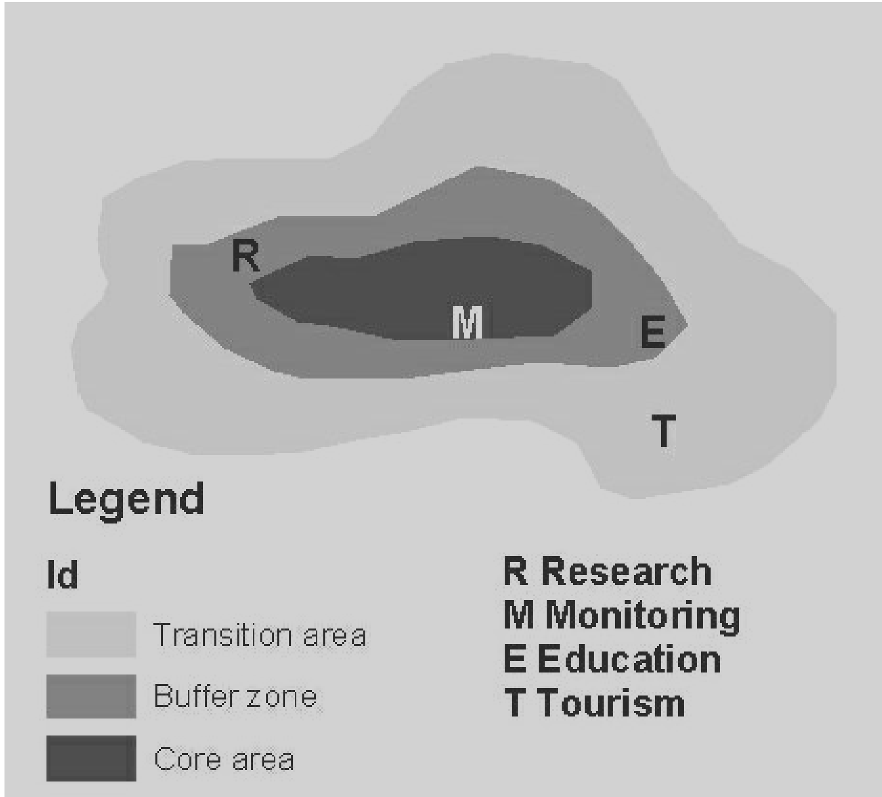

Figure 1: Zonation system in a biosphere reserve

2.1 GIS in MAB Biosphere Reserves

The three biosphere reserve objectives mentioned above can be implemented only through involving and mobilizing all the structures and stakeholders concerned. This causes fears and conflicts. Therefore, a biosphere reserve must have the necessary tools to help it reach its various objectives and to ensure better harmonization and interaction among the biosphere reserve zones.

Beside the guide to biosphere management (overall strategy), appropriate communication and management structures (management board, scientific council, …) there is a need for a GIS-tool explicitly expressed to support management, monitoring and communication between the actors of the reserve (Deutsches Nationalkomitee 1996, UNESCO 2002).

Especially within the Biosphere Reserve Integrated Monitoring programme (BRIM) which should act as a platform where relevant knowledge, information (e.g. case studies) and data on different issues can be shared, analysed, searched through databases, and managed, and where synthesized findings, lessons learned and best practices are made available, Geographic Information Systems (GIS) activities have to be established.

Based on visualisations of different "layers" of spatially defined data (e.g. abiotic, biodiversity data, socio-economic variables) at a chosen scale, GIS functionality is used to display spatial relationships, to build and analyse new variables by combination of the linked information, to recognize patterns or to draw conclusions about interacting variables to name but a few.

In general, two analytical tools are essential: proximity and spatial analysis. The former relies on an algorithm called "buffering" to determine distance between objects. A buffer is a zone of a specified distance around features in a coverage. Buffers can be set at a constant or variable distance based on feature attributes. The spatial analysis can highlight previously undetected spatial relations by integrating data from different layers e.g. soil, vegetation, ownership, etc. Integration in the biosphere context implies the linking of abiotic, biotic and socio-economic components finally resulting in a better understanding of cause and effect.

In addition, the publication of maps and associated information with functions such as zooming, choice of information layers and tabular information requests - standard functionality known from Internet map services- is getting more and more important especially in the framework of tourism, but also in the field of communication.

3. System Requirements and Architecture

The development of the system dedicated to the Bliesgau biosphere reserve is ongoing based on the iterative prototyping approach.

3.1 Requirements Analysis

To be able to serve the needs of all the stakeholders sharing the discussion such as inhabitants, politicians and planners, scientists, target groups for education, regional users (e.g. NGOs), in a first step we have to analyse the potential users and the different user requirements of all these groups.

This was done by a screening of relevant literature, an internet-based analysis of existing Biosphere-GIS and, by interviews with stakeholders involved such as the ministry of environment, research groups, farmers, the friends of the biosphere Bliesgau and others. Visualized in fig. 2, beside the system administrator there are two main user groups identified:

- Internal users who are involved in management and monitoring activities;
- External users who are dealing with all the marketing and communication aspects

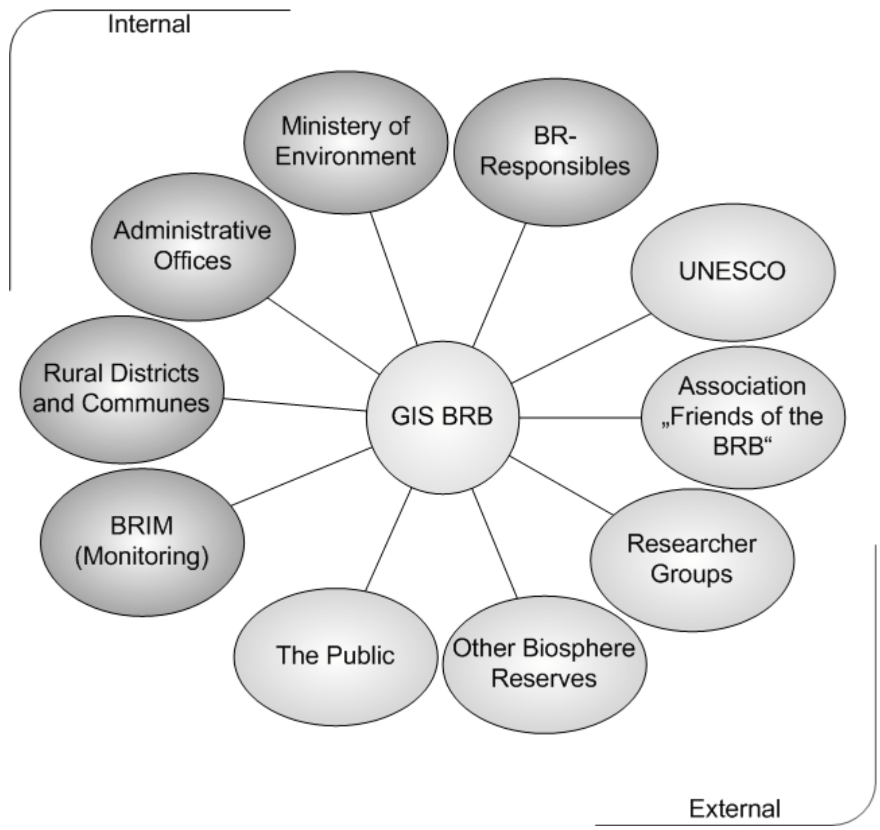

Figure 2: User groups identified

Based on this requirements it was possible to define first some key data variables of an overall interest e.g. climate (abiotic variables), presence of endangered species (biodiversity variables), demography parameters (socio-economic variables), protected areas (administrative variables).

In a second step the systems functionality was designed. There are mainly five groups of functions separated:

- Simple User-Interface (e.g. standard web mapping functions, interactive mapping, high usability)

- Information functions (e.g. semantic object search and mapping)
- Visualisation (e.g. creation of 3D images, predefined thematic maps, free layer combination, TopoMaps, aerial/satellite photos as background information)
- Analysis functionality (e.g. change detection analysis, proximity and spatial analysis, pattern recognition)
- Open environment (e.g. compatibility with other Biosphere-GIS systems, On-the-fly Integration of data from/to external information systems, Integration of real-time data) and non-redundant data management

3.2 System Architecture

The system is designed as a Client-Server architecture and developed within an open source environment (fig.3). Field data ingestion server and GIS toolbox is powered by the GRASS – software, the geospatial database and the thematic inventory server is realized using Postgres/PostGIS tools, the map server is based on the toolbox from the University of Minnesota (UMN-Mapserver) linked via the Zmap WMS-Connector with the Zope content management system. The system is accessible with the expert user client (WMS/WFS) or the standard user browser.

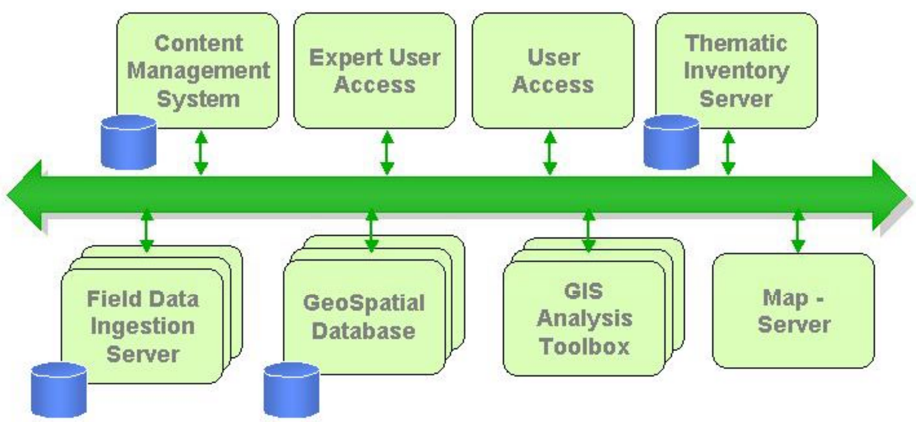

Figure 3: System architecture

Within the system, it makes sense to distinguish between three levels:

- **Data-Level:** Spatial data to be ingested into the system from external data sources or collected by field clients have to be transferred into the Spatial Database. GIS – toolbox and Mapserver are accessing the data from this database. The Map server (UMN-Mapserver) is able to present spatial data from different sources especially via the OGC Interfaces (Web Feature Service WFS and Web Mapping Service WMS).
- **Administration-Level:** The user with administration privileges is able to create Mapfiles, which are containing the information how the spatial data has to be visualized with the ZmapServer. Additionally the administration user is able to create content for the Content-Management-System (CMS) with the Content-Management-System Plone. Zope DTML-Scripts that allow a dynamic interaction from the standard plone-sites with the mapserver do the integration of the non-spatial content and the spatial content.
- **User-Level:** Users must authenticate on the CMS. If not they can only request the data that is visible by anonymous users (e.g. interest places for sightseeing, events, standard thematic maps). The Expert-User is able to access more detailed data for monitoring and research (e.g. habitat-map, environmental information gathered by sensors in real-time, endangered species). Data can be requested by other GIS-systems via the standard WMS – interface and additionally via WFS.

3.3 Why Open Source Software

The system described is developed around open source software components. Open source software promises an attractive range of benefits: it is free, vendor independent, and open to continual evolution and improvement by a global development community. Trakas/Christel (2004) are stating that there are a lot of arguments beyond saving money showing technical advantages of open source concepts:

- Life cycles and development cycles: Open source software tend to have very short development cycles and a higher transparency in the development
- Reliability: Open Source may be more reliable than proprietary products
- Transparency: any programmer can see what happens and why. In general, there are no special codes to express the problem
- Open formats and standards: integration of different systems and data is much easier; especially in the context of GIS software, for example the OGC WMS specification and ISO norms are helping in systems integration
- High creativity: the opportunity to access the source code opens the possibility of greater creativity resulting in huge libraries with solutions

dedicated to special problems which would be not realized under commercial aspect

It is the opinion of the authors that it is not mainly the licensing aspect that makes sense to choose open source products. Main advantage of an open source GIS-environment in the biosphere reserve application domain is based on the creativity of the open source community. Especially with view to the lots of specialized applications needed within the biosphere integrated monitoring, proprietary solutions are not able to compete with the open source community. Contrary to the standard GIS- and Web Mapping functionality, the development of such specialized tools dedicated to biosphere research and education often is not commercially exploitable.

4. Exploitation and Outlook

After the first presentation of the "Mock up" the stepwise refinement of the systems functionality is still ongoing within an iterative and interactive (with the different user groups) process. Up to now, most important point in the development was the implementation of an Internet Map Service as a communication and information tool for the stakeholders participating in the discussion. Especially the production of maps in an interactive manner is a powerful communication tool, much more direct than the display of lists and tables. Providing now lots of relevant data and information via the developed demonstrator system to the stakeholders, the discussion about the development of the reserve is much more objective and constructive.

Within the next steps, the functionality of adding Points of Interest to a map for discussion base is intend to be realised with scripts connecting the spatial database PostGIS and adding the points over spatial SQL-statements. The Points will be displayed on the map as normal Point-Layer on the Mapserver.
Additionally, we intend to establish the same architecture with commercial products to be able to compare the systems functionality and performance based on an identical data and requirements.

The system is accessible using the following URL: http://iss.umwelt-campus.de/aktuelles.html

Bibliography

Bioret, F.; Cibien, C.; Génot, J.-C. ; Lecomte, J. (1998): A Guide to Biosphere Reserve Management : a Methodology Applied to French Biosphere Reserves. MAB Digest 19, UNESCO, Paris

Deutsches Nationalkomitee für das UNESCO-Programm MAB (1996): Kriterien für Anerkennung und Überprüfung von Biosphärenreservaten der UNESCO in Deutschland. Hrsg.: Deutsches Nationalkomitee für das UNESCO-Programm

„Der Mensch und die Biosphäre“ MAB, Bundesamt für Naturschutz. Red.: Stefan Weidenhammer). ISBN 3-927907-57-X

Trakas, A.; A. Christel (2004): Open Source and Free Software: More than Saving Money!.- Schrenk M. (Ed.), CORP 2004 & Geomultimedia04, ISBN: 3-901673-11-2, www.corp.at

UNESCO (1996a): World Network of Biosphere Reserves. Map. UNESCO, Paris

UNESCO (1996b): Biosphere reserves – the Seville Strategy and the Statutory Framework of the World Network. UNESCO, Paris

UNESCO (2002): Recent Developments on BRIM; report of the seventeenth session of the International Coordinating Council of the Man and the Biosphere (MAB) Programme, UNESCO Headquarters, Paris, 18 - 22 March 2002