OPEN SOURCE SPATIAL DECISION SUPPORT SYSTEM FOR SUSTAINABLE WATER MANAGEMENT

Sibylle Niederer, Karel Kriz, Alexander Pucher
Department for Geography and Regional Research (Cartography and Geoinformation) of the University of Vienna
niederer@atlas.gis.univie.ac.at, kriz@atlas.gis.univie.ac.at, pucher@atlas.gis.univie.ac.at

Water scarcity is a central problem in Mediterranean countries. By the means of GIS answers to this problem can be found through the development of sustainable and local water management solutions. The project “Zero Outflow Municipality” (Zer0-M) within the Euro-Mediterranean Partnership aims in developing concepts and technologies to achieve optimised close-loop usage of all water flows in small municipalities and settlements not connected to a central wastewater treatment. A major task of the Zer0-M project is the development of a geo-visualisation and modelling environment in order to provide local experts and decision makers with a tool for the planning of sustainable water management solutions. Themed “low cost – high tech”, the development of this environment is aiming at sustainability in terms of economic, social and cultural compatibility in order to promote its future usage. The tool represents a “high tech” Spatial Decision Support System (SDSS) based on the functionalities of “low cost” Open Source WebGIS components.

INTRODUCTION

The intention of the Zer0-M project is to develop concepts for a sustainable water and wastewater management in four Mediterranean countries (Egypt, Morocco, Tunisia and Turkey). Each MEDA-partner country should be enabled to implement and disseminate Sustainable Water Management (SWM) solutions and to promote the technologies and the approach among authorities and consumers. One of the main issues is the development of integrated concepts of decentralised waste water treatment and re-use in small settlements in rural areas with agricultural production, isolated tourism facilities or peri-urban areas not connected to a centralised waste water collection and treatment system. Several sustainable water management technologies (new and traditional) are already available for efficient wastewater treatment and re-use without hygienic risks on a low-cost and easy-to-handle level. Thus, they are giving the possibility to see wastewater not only as something that has to be disposed but as a valuable resource when treated accordingly.

OBJECTIVES

A major part of the Zer0-M project is the development of a SDSS named Design Support System (DSS) stressing that it is mainly intended to help design sustainable water supply and disposal systems from a broad technical perspective. This means that the design of SWM solutions is done in a rough way on the basis of SWM technologies making up alternatives. Additionally, the user is supported during the design phase to consider different technologies and combinations of technologies by the possibility to retrieve special information on SWM technologies and on SWM solutions already existing. Main aim of the SDSS is to help the user in developing and planning water management solutions and comparing them on a multicriteria approach. Pros and cons as well as impacts of these roughly planned solutions are thereby assessed according to economic, social and environmental factors.
The Zer0-M DSS is meant to be a form of information technology and software specifically designed to assist local experts in designing SWM solutions especially for small settlements in rural areas, isolated tourism facilities or other areas not connected to a waste water collection and treatment system. Its aim is to improve decision-making by integrating the required information, tools, models and decision-making procedures in a user-friendly system. Based on the integration of thematic and geographical parameters it has to support the decision-making process through creating insight into the pros and cons of various options of SWM solutions. The SDSS has to combine spatial analytical technologies with mathematical models so that the results of various actions can be simulated and compared with the existing situation. This allows users to consider and evaluate a series of “what-if” questions based on the representation of the spatial relations of the real world in a visual and analytical form.

In line with the maxim of the Zer0-M project it is clear that sustainability has also to be seen as a basic condition for the development of the Zer0-M DSS. In order to ensure reasonable and future usage of the tool – and thereby the distribution of the ideas of SWM – potential problems arising in developing countries have to be taken into account during the development of the tool.

Challenges

Technological innovation is not only luxury for developed countries. In fact, technical innovation is a possibility to help developing countries to advance local knowledge and to facilitate the development of independent and adapted solutions. Still, in these countries the usage of high-tech technologies can be disturbed or prevented through various circumstances; e.g. social circumstances affecting the usage of high-tech tools might be a lower level of education or generally less familiarity with computer and information technology. These circumstances are partially the consequence of technological or economical circumstances leading to infrastructural equipments of lower density and quality. Other obstacles can derive from political influences, e.g. scarcity of current and high quality geodata for reasons of military secrecy.

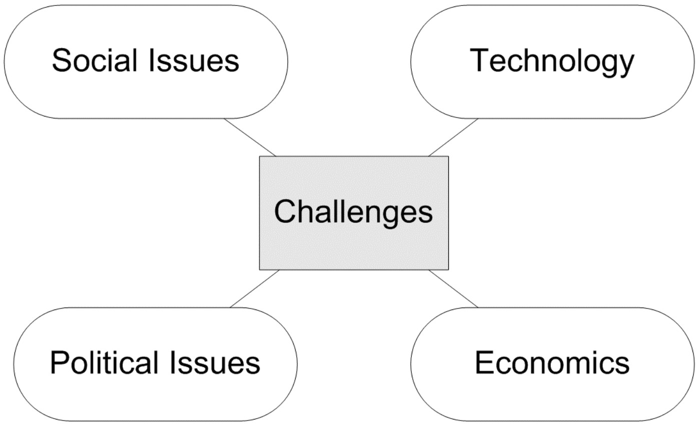

Figure 1: Possible obstacles for the usage of a SDSS in developing countries

In order to develop a “sustainable” tool ensuring reasonable and ongoing usage for its purposes the challenges posed have to be met. The approach chosen for the Zer0-M DSS is therefore mainly aiming at the following aspects:

- **Adapted Functionality:** The aim is to provide the user with a system that is powerful and easy to handle. Thus, the functionality of the system has to be adapted to the actual needs of the user during the decision making process (e.g. not fully-featured GIS has to be included but specified GIS functions only).
- **Openness:** The development of a cohesive framework with independent modules and flexible interfaces between all parts of the system makes an easy extension and adaption possible
- **Flexibility:** The system has to be able to work with a wide range of input data (data from best quality and quantity to low quality and quantity)
- **Affordability:** Standard equipment together with the usage of affordable software in order to remove economic obstacles.

Particularly suitable for this kind of approach is the usage of Open Source software. Through its characteristics and potential Open Source software gives the possibility to develope adapted and flexible application. Another great advantage is the minimisation of costs in comparison with commercial or proprietary software.

DECISION MAKING

Planning and management are based on a problem solving process which begins with problem definition and description, involves various forms of analysis, and then leads to design usually followed by the evaluation of alternative solutions. The Zer0-M DSS will guide the user through the process of decision making helping him to consider different SWM solutions and comparing them. According to the process of decision making the user is guided by the system through three major phases (Simon 1960):

(a) Intelligence:

The intelligence phase is used for the identification and specification of existing problems. Therefore, thematic and geographic information has to be acquired in order to be evaluated by the user. Visual and exploratory data analysis is used to process this information. The availability of an Experience Database gives the user the ability to search for similar cases and provides him with information about possible solutions to his problem. Further information on specific technologies is provided as well.

(b) Design:

The design phase involves the development of spatially defined alternatives for decision problems that have been identified in the intelligence phase. Formal models in interaction with adapted GIS functionalities are guiding the user through the process of developing alternatives. By the means of an interactive map the user is able to explore and edit the thematic and geometric data available. By choosing suitable technical options the user is able to sketch rough plans of water management solutions (so-called alternatives).

(c) Choice:

The choice phase comprises the evaluation of the alternatives designed as well as the selection of one of these alternatives. Evaluating spatial and non-spatial attributes of the alternatives and its objects necessary input parameters for the models are computed using GIS functionality. The alternatives are then assessed on the basis of economic, social and environmental models producing indicators that are available for comparing on a multicriteria approach.

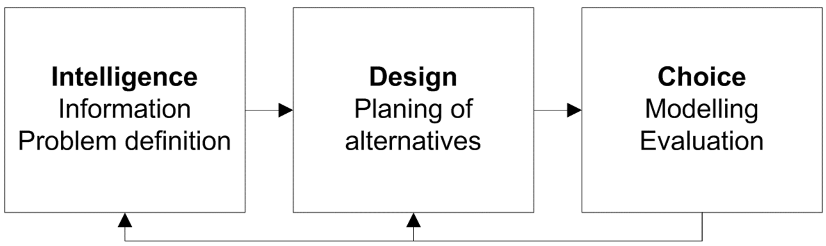

Figure 2: Three major phases of the decision process

SYSTEM ARCHITECTURE

Resulting from the definition of the steps that have to be gone through during the decision making process functionalities needed can be defined. Along the lines of classic SDSS four major categories of functionalities can be determined for the Zer0-M DSS. These comprise functionalities for data input (digitising, import), data manipulation (editing of geometric and thematic attributes), data analysis (data query) and data display (visualisiation).

Starting from this information a general framework of the SDSS can be made. This framework consists of several architecture components, each of them responsible for a specific task within the architectural workflow.

(a) User Interface:

The user interface is what the user perceives as the SDSS. The main purpose of the user interface is to assist the user in accomplishing tasks. Therefore, it has to be easily understandable and powerful so that the user can access all functionalities instantly.

(b) Visualisation Environment:

The visualisation environment is a central part of the SDSS as it is providing the cartographic visualisations enabling the user to perceive spatial information immediately, easily and user-defined. By the means of an interactive map the visualisation environment is also making an important contribution to the user interface and the user-system interaction.

(c) System Interpreter:

Standardised interfaces are needed in order to ensure a frictionless interaction between all system components. With the system interpreter as central system component the input and output of the individual components is handled.

(d) Database System:

The database is an important element of the system as it is holding all thematic as well as geographic data along with their metadata and cartographic specifications. The DBMS is used to store and maintain all the data of the system and enables the application to perform direct data queries on demand.

(e) Toolbox:

The toolbox can be considered as a container for those parts of the system that enable the user to perform specialised tasks (e.g. GIS functions, Models). Due to the standardised interfaces between the elements of the system functionalities can be included into the system easily (depending on the needs of the user).

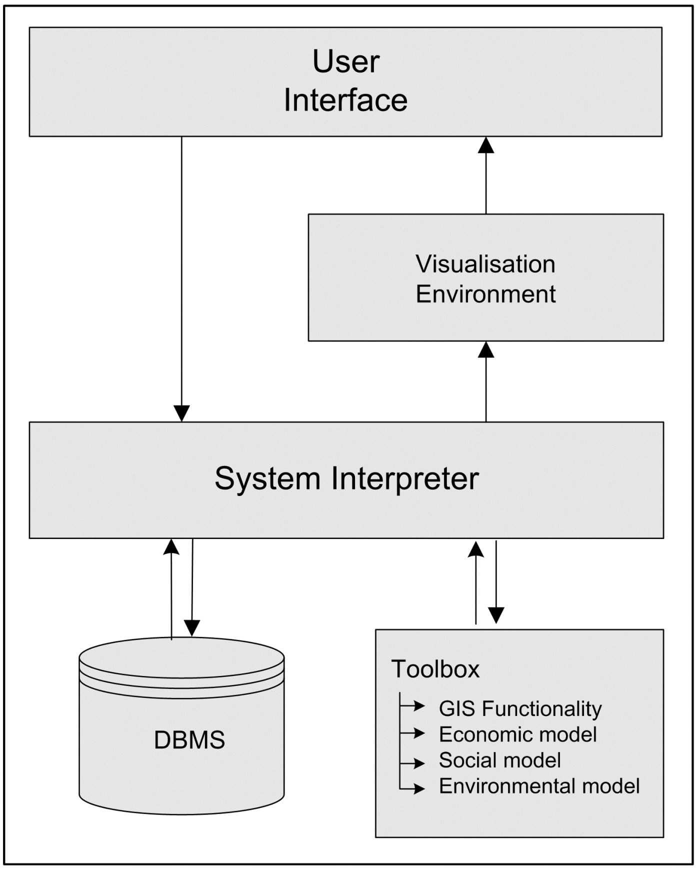

Figure 3: Architecture of the SDSS

CONCLUSION

SDSS represents a powerful tool for the solution of spatial decision problems. With the development of the Design Support System by the Zer0-M project a SDSS will be available especially for SWM. By using Open Source Software this SDSS is developed specifically adapted to the task in an extendable and flexible way. Thus, it is giving the user the possibility to design and evaluate SWM alternatives in a powerful but easy way and helps to propagate the ideas and implementation of SWM.

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LINKS

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http://mapserver.gis.umn.edu/	UMN Mapserver
http://grass.itc.it/	Geographic Resources Analysis Support System (GRASS)
http://postgis.refractions/net	PostGIS
http://postgresql.org	PostgreSQL
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http://opensourcegis.org	Index of Open Source / Free GIS related software projects

Biography

Mag. Sibylle NIEDERER, born 1979, studied geography and cartography at the University of Vienna and graduated with a thesis titled: "Kartographische und konzeptionelle Gestaltung für WebGIS. Am Beispiel eines GIS-Portals für den Katastrophenschutz". Since 2002 she is project assistant at the Department of Geography and Regional Science at the University of Vienna. She is momentarily working on various projects dealing with web-based cartographic applications. Within the project Zer0-M of the MEDA programme she is responsible for the architectural design and implementation of the decision support software. Her major areas of interest lie in web-based cartography, GIS and multimedia cartography.