LAND USE AND GROUNDWATER MANAGEMENT CONFLICTS

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ABSTRACTS

Integrated water ressource management has to balance groundwater protection requirements with a variety of demands for land-use activities in the sence of sustainability. This is difficult to achieve in practice. This complex issue can be supported by Spatial Decision Support Systems (SDSS), in which legal frameworks and socio-economic aspects with emphasis on land-use activities will also be implemented. A decision-support system (DSS) is comprised of specialised databases (including GIS), knowledge base and interactive modelling. Basic work for such a SDSS has been done within the transnational and interdisciplinary project KATERII (Karst waTER research project), supported by the EU INTERREGIIIB CADSES programme, involving co-operation between institutions from Austria, Croatia, Italy and Slovenia. The major studied land-uses in four pilot areas were summer and winter tourism, settlements, transport, forestry, agriculture and pasture management. In the paper methodological aspects for SDSS will be presented, mainly focused on knowledge base development.

Key words: knowledge base, decision support system, karst aquifers, land use, water management.

INTRODUCTION

Karstic areas are essential for public water supply, since currently karstic aquifers contribute 25% of world-wide water supply. This proportion is supposed to rise to almost 50% in the near future (Kollarits et al., 2003). These areas are at the same time highly sensitive and valuable natural environments. Conversely, development of such areas is increasing. Sustainable development of karstic areas means a maximum use of the environment with simultaneous conservation of natural resources. This is difficult to achieve in practice. It requires an exceptional knowledge of natural resources and skill and knowledge of physical planners who have to optimize effects of human activities. Governmental authorities are forced by law to take decisions within the framework of European, national and regional directives in the fields of spatial planning and groundwater and environmental protection. These tasks can be supported by a decision-support system (DSS), which integrates data from various sources and helps to make decision processes more effective and transparent. Such a decision support system has been developed in a transnational and interdisciplinary Interreg IIIb project KATERII (www.kater.at) in order to quantify and assess the impact of different land-use activities on environment and water

resources in karstic areas. Land-uses considered include summer and winter tourism, settlements, transport, forestry, agriculture and pasture management, studied at pilot areas in Austria, Croatia, Italy and Slovenia. Legal frameworks and socio-economic aspects with emphasis on land-use activities were also implemented in the DSS.

The Slovenian KATER II study focuses on tourism development in the karstic mountain area of Krvavec. The mountains of Krvavec and Zvoh are situated within the Slovenian Kamnik Alps, approximately 30km north of Ljubljana. This area is traditionally an area of pasture and mountaineering but good geographical position and vicinity of the capital city have also enabled fast tourism growth and other forms or recreation in the recent decades. Intensive tourism development has developed over altitudes from 1400 to 2000m, where the skiing place is located.

Table 1.: An example of an impact-effect matrix for winter tourism (PRO = provokes: it is a general activitiy provoking activities which are linked to the processe; COF = consist of an activity).

Winter tourism	PRO	Traffic facilities: Roads & car parks
	PRO	Traffic facilities: Railway lines
	PRO	Traffic facilities - Trails and footpaths
	PRO	Traffic facilities: Accidents
	PRO	Construction in general
	PRO	Technical Infrastructure (111)
	PRO	Settlements (114) - housing & hotels
	PRO	Domestic water supply
	COF	Spring capture
	COF	Ground water abstraction
	COF	Surface water abstraction
	COF	Water transfer / import
	COF	Water treatment
	PRO	Domestic wastewater production
	COF	Septic tanks - construction, maintenance & leakage
	COF	Wastewater drainage systems - construction, maintenance & leakage
	COF	Wastewater treatment plants - construction & maintenance
	COF	Wastewater treatment plants - sludge disposal
	PRO	Domestic solid waste production
	COF	Recyclable wastes
	COF	Non-recyclable wastes
	COF	Hazardous wastes
	COF	Transport of solid wastes
	COF	Solid waste storage & disposal
	COF	Flytipping / illegal dumping
	PRO	Emission of air-pollutants (traffic, heating)
	PRO	Storage, application & disposal of chemicals
	COF	Storage: household chemicals (paints, solvents, detergents, antifreeze, batteries etc.)
	COF	Storage: agrochemicals (pesticides, herbicides etc.)
	COF	Application of agrochemicals (gardens, roads etc.)
	COF	Storage: fuels for vehicles and machinery

Covering the infiltration areas of springs supplying densely populated flatlands below, much of the upland area has been defined as a water protection area. This conflict between land-uses demands careful study, planning and management in order to protect the vulnerable natural system whilst allowing sustainable local socio-economic development. Decision-making processes need to balance the local land-use demands with the requirements to protect the vulnerable natural system.

IMPACT EFFECT MATRIX

The formal methods applied for the decision making process include multi-criteria decision-making and techniques of fuzzy evaluation. They are used to define a system of rules describing the concrete forms of impact of land-use activities (derived from an activity impact model) on the natural environment, as described in vulnerability models. This system of rules – the formalised knowledge base - is the core of the decision support system, which will help to make decisions and their potential impacts transparent as well

integrative – bridging the gap between different institutions and experts involved in groundwater protection.

In more detail the effects of a certain land-use category can be demonstrated. Slovene partner is dealing with tourism effect on karst water resources, therefore this topic will be presented. The matrix form of presentation provides a valuable starting point for evaluation and analysis. With the introduction of new land-use activities and infrastructure, tourism may present many potential threats to karst aquifers. Land-use intensifies with growing visitor numbers and major infrastructure construction for residential tourism, transport, communications, ski facilities etc., physically altering the natural environment and introducing many potential pollution sources. At the same time land value and the demand for high quality water supplies are increased. The impact-effect matrix for tourism was divided into several categories, such as winter tourism (Table 1) and summer tourism. The first is divided to skiing tourism, whereas subcategories of summer tourism are mountain tourism, camping, outdoor sports and activities (hiking, biking, mountaineering, caving …), sightseeing and cultural tourism (tourist caves, eco-tourism). Table 1 presents an example for impact-effect matrix for winter tourism - skiing.

DECISION SUPPORT SYSTEM

Decision making requires a lot of different types of knowledge from different fields. To help making decisions different decision support systems have been developed. Decision support systems don't only help making decisions but they also help predict potential effects. Methods used in the decision process include multi criteria decision making and other types of evaluation deriving from research work. Decision support system is a computer system, which helps the decision makers make decisions for uncertain parameters. Decision support system consists of multiple parts:

- Special database (e.g. GIS of the pilot area),
- Knowledge base and analytical and numerical models for data analysis and
- Interactive modelling process.

Decision making is transparent and this is the reason why it is documented. Result of the decision making is a decision supported by text, tables and graphical figures. In the process of decision making are also included remarks and opinions of the decision maker.

The decision support system (DSS) developing was divided into several phases. First part included gathering the information of tourism impact on ground water, with all additional impact like building infrastructure, pipelines, etc. At the same time impacts have been established a detailed geological and geomorphic mapping was carried out. All this information was used to make an impact effect matrix (Čenčur Curk, et all., 2005). Impact effect matrix represents a review of all potential negative effects and their consequences on groundwater.

In the second part a knowledge base using a computer programme *Protégé 3.2 beta* was set up. The knowledge base comprises of information and relations of all potential impacts on

ground water and environment. This system of rules is a formalised knowledge base and is a core of DSS. Knowledge base is organised in an ontology. Sowa (1999) claims that the subject of ontology is the study of the categories of things that exist or may exist in some domain. The product of such a study, called an ontology, is a catalogue of the types of things that are assumed to exist in a certain domain of interest. An ontology is a formal explicit description of concepts in a domain of discourse (classes), properties of each concept describing various features and attributes of the concept (properties), and restrictions on properties (facets) (Noy & McGuinness 2001). An ontology together with a set of individual instances of classes constitutes a knowledge base.

For a successful development of an ontology with the computer program *Protégé 3.2 beta* modelling patterns (Figure 1) were developed, which were, after a critical overview, inserted into the program. The fore mentioned catalogue was, with all additional research, used for a development of a DSS. *Protégé 3.2 beta* is an integrated software tool used by system developers and domain experts to develop knowledge-based systems. Applications developed with Protégé-2000 are used in problem-solving and decision-making in a particular domain *(*What is Protégé – 2000?).
Working in *Protégé 3.2 beta* is done based upon a specific course of events.

- Definition of classes and their subclasses;
- Definition on instances;
- Definition of properties and relations between them.

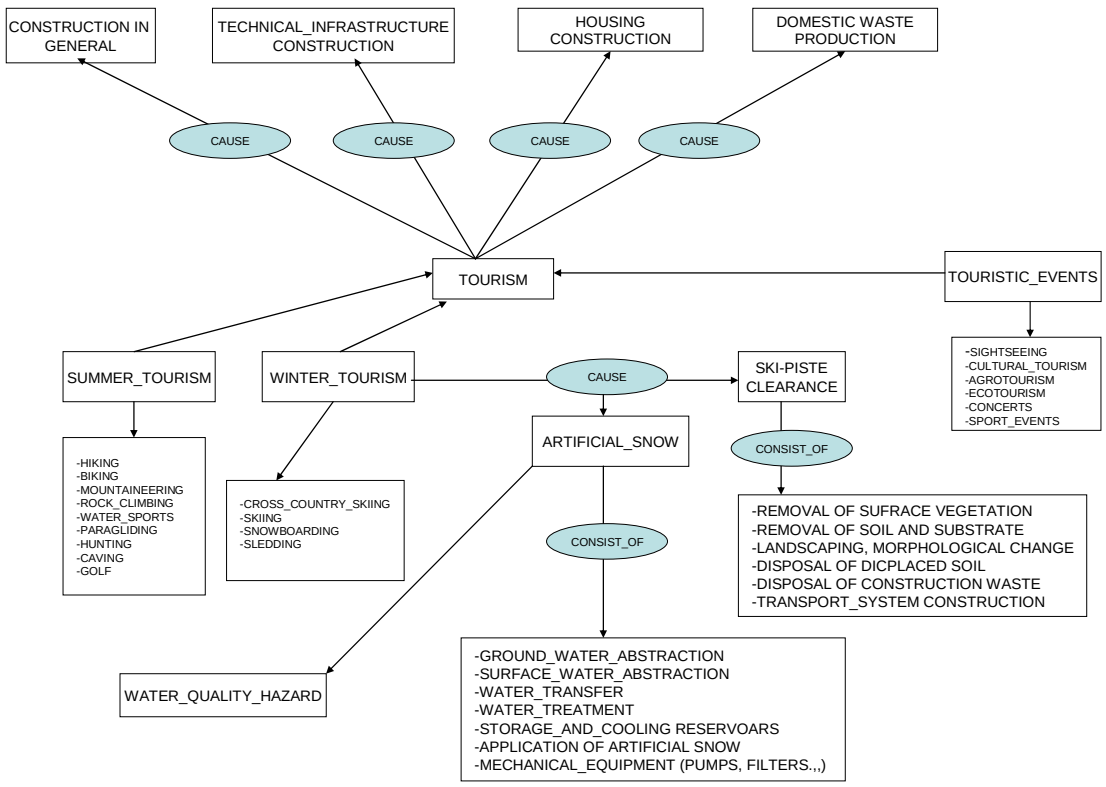

Figure 1.: Modelling pattern of tourism activity.

The mentioned program also enables us to write comments, definitions and express all newly defined expressions in several languages, thus enabling ontolgy to be used world wide.

When developing the ontology a world known ontology DOLCE (a Descriptive Ontology for Linguistic and Cognitive) was used, where a lot of expressions has already been explained and qualified. DOLCE is not an ideal ontology for the needs inside the KATER II project, but it is a very good approximate. In KATER II we used DOLCE as a basic ontology and for the needs of DSS we implemented new expressions and terms. All expressions and terms together in an ontology represent a knowledge base which can be used for different needs.

DISCUSSION

The central goal of the KATER II project was development and evaluation of a GIS based DSS in order to quantify and assess the impact to land-use activities on environment and water resources in karstic areas. Purpose of the DSS is to help legal entities with spatial planning and decision making for this and other similar areas. An important part of the DSS is its integrity since it is necessary to have a lot of different information for a good DSS. Based on data relations and overlaying thematic maps areas are divided into different zones: hydrotope, vulnerability, water protection zones, etc. Then rules need to be established for forbidden, limited and sustainable human activities on individual zones.

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