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LANDSCAPE ASSESSMENT - FROM THEORY TO PRACTICE: APPLICATIONS IN PLANNING AND DESIGN

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Faculty of Forestry, Belgrade, Serbia

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NATURE CONSERVATION IN A FARM MANAGEMENT SYSTEM FOR SUSTAINABLE AGRICULTURE

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Abstract: A new software module that is being developed in a research project at the Institute of Environmental Planning/ Leibniz Universität Hannover is designed to assist farmers who are interested in managing and improving their environmental performances. The project focuses on developing a system which helps farmers to integrate biodiversity and recreation aspects into farm management. This comprises methods to assess farm sites in terms of biotopes and species, landscape aesthetics and recreation, the impact of farming as well as proposals for improvement. The outcomes of the application can be used for documentation and report, management and self control, application for agri-environmental funds, certification of products (commodities), certification of farms, benchmarking or information of the public about environmental farm achievements. For the generation of the required field data, information from existing landscape plans can be used. Alternatively or in addition other data sources are available and more specific information may be provided by farmers or advisors. Assessment algorithms were developed for the appraisal of farm performances in view of different environmental benefits or impacts produced by the farm. A pre-test of the software module on six project-related pilot farms showed that the chosen assessment methods are applicable and comprehensible for the farmers. The farmers' ability to provide detailed information about their acreages and the surrounding landscape elements grew with smaller farm sizes, lower percentages of landscape elements, higher consolidations of acreages and more interest for nature conservation. The farmers regarded the results achieved with the software module as valuable for their management, especially concerning the possible visualisation of their ecological performances. However, they preferred to use the software with the help of an advisor because of their lack of time, limited software experiences or missing knowledge about nature conservation issues.

Key words: nature conservation, farm management, nature conservation advice, sustainable agriculture, species and biotope protection, landscape aesthetics and recreation, Geographical Information Systems, assessment methods

INTRODUCTION

Due to the implementation of European and national agriculture regulations and the growing importance of agri-environment programmes, German farmers have to meet increasing demands concerning their farm management. In recent years, several software-based farm management systems were developed and implemented. These systems are mainly focused on agricultural production and abiotic topics (e.g. soil and water), but aspects of nature conservation have been neglected. This was the starting point for a three year research project, which is conducted by the Institute of Environmental Planning (Leibniz Universität Hannover, Prof. Dr. von Haaren) in collaboration with the Chair for Ecological Cultivation (Technical University of Munich).

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The project aims at the development of a nature conservation software module based on a geographical information system (GIS). By means of the software module, farmers will be enabled to assess their farm in terms of environmental performances and assisted in improving their farm practices. The results may serve as a basis for the following purposes:

- Documentation (environmental services) and report (Good Farming Practice - GFP)
- Management and self control
- Application for agri-environment programmes (farm management plan)
- Certification of products (commodities), certification of farms, benchmarking, comparing of farm performances
- Information of the public about environmental achievements of farms
- Information basis for co-operation of farmers in providing contiguous environmental services.

A desired side effect when farmers use the system is that their knowledge of their premises and their environmental awareness may increase. A central project issue is to work on methods to assess farm sites in terms of biotopes and species as well as landscape aesthetics and recreation. For this purpose existing landscape assessment methods were adopted to special requirements relating to farm scale. Prototypes of the software module are evaluated with the help of the potential software users: farmers and their advisors. Both are asked to review the transparency of the assessment methods as well as the usability of the software. The evaluation results are used to improve existing parts of the nature conservation module and to adjust further developments to the users needs.

USED SOFTWARE AND DATA FOR THE FARM ASSESSMENT

Open source products are used to develop the nature conservation software module to avoid additional royalties for the user. The database management system PostgreSQL (www.postgresql.org) is used for administrating and storing the used datasets (e.g. data about farm operations, land use and soil). In addition, supplementing the database, analyzing the data and visualising the results of the analysis with maps, diagrams or tables can be realised with the help of the desktop GIS OpenJump (www.openjump.org). PostgreSQL as well as OpenJump already offer adequate functions to meet most of the demands resulting from the used assessment methods. In order to support the future user who might not be a GIS expert, appropriate tools for importing, editing and analyzing data and a user-friendly interface are additionally developed.

In principle, it is desirable that the farm assessment should be based on existing spatial and preferably digital data. Landscape planning can be used as a crucial information base. In Germany there is blanket coverage of landscape plans on regional or local scale (1: 150.000 or 1: 10.000). However, as information may be outdated, incomplete or not sufficiently detailed, there will be often the need to specify existing or generate new data on farm scale. Other data sets which can replace or complement landscape planning may be already in possession of the software user (like soil data) or are available from authorities. The following datasets are, in principle, suitable for the application in the nature conservation software module:

- land use data: spatial base data (e.g. Digital Orthophotos, Digital Landscape Models), land use plans, CORINE Land Cover,
- data about properties: Automatic real estate map (ALK), data from the Integrated

Administration and Control System (IACS),
- data about vegetation/ biotopes: selective biotope maps, landscape plans, flora, fauna, habitat inventories according to the EU Habitat Directive (FFH inventories),
- soil data: pedological maps, soil evaluation data (German "Reichsbodenschätzung"),
- data about cultural landscape elements: landscape plans, registers of cultural landscape and
- data about floristic and faunistic species: landscape plans, FFH inventories.

In addition, data about farm operations is needed to assess the effects of the cultivation on biotopes, species and landscape aesthetics and recreation. This input data derive from standard farm data bases (field records) or from the database of the farm management system REPRO (Hülsbergen, 2003). For REPRO a data import interface was programmed. The assessment is realised in a mostly automated way with the help of master data that is integrated in the PostgreSQL database.

The output of the assessment is presented in different forms with the help of OpenJump: textual descriptions, geodata, maps, tables and diagrams of the results and accordant suggestions for the management provide detailed information about the ecological performances of the farm (Fig. 1). Scenarios of the ecological effects of management changes considered by the farmer can be produced by comparing the present state with the simulated assessment results under changed management conditions.

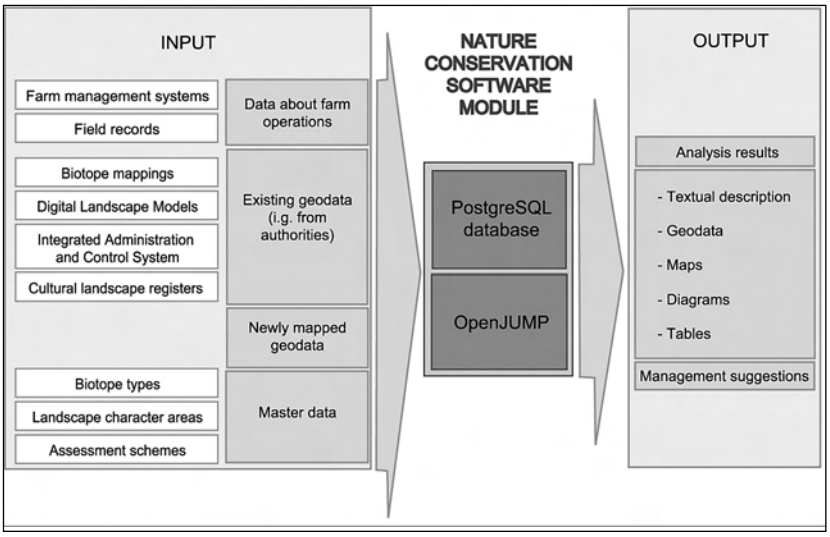

Figure 1: Structure of the nature conservation software module

PRINCIPLES OF DATA COLLECTION AND ASSESSMENT

The methods developed for the assessment of farms are confined to biotopes, species, landscape aesthetics and recreation. Further nature conservation aspects (e.g. ecological soil functions, water resources) are only considered e.g. in conjunction with potentials for habitat development.

Working on farm level and dealing with software, the methods are subject to several restrictions. All developments are based on the assumption that farmers and advisors are no scientists

and need manageable tools. These tools should minimise application efforts, but also produce satisfying outcomes as regards content. For example, the relevant data should be derivable from the operating system or it should cause no (or only low) additional expenses. If data collections on-site are necessary, they should be compatible with the operating schedule. There should be two options in terms of skills required by the applicant: One simple version for the farmer should do without special knowledge or skills. A second more comprehensive version for advisors or skilled farmers will require some expert skills in the field of landscape inventory. In order to be useable for software implementation, assessment methods should be capable of being automated and translated into algorithms to the greatest possible extent. They should be applicable nationwide or be transferable on the level of federal states. The outcomes of assessment should be convincing, easy to understand and to communicate. They should be decision-relevant, quantifiable and rateable. To ensure a high rate of application and implementation, measures should be assigned to the assessment results and they should be manageable for the farmer.

The assessment methods are focused on two main issues:
- the current state of the farm land (indicating momentary conditions and qualities in terms of biotopes, species and landscape aesthetics and recreation) and
- pressures due to the application of cultivation methods (potentially causing adverse effects e.g. on species in relation to their degree of sensitivity).

The following explanations focus on methods of collecting data and assessing the current state of farm sites as these methods were evaluated.

- **Biotopes and Species**

DATA COLLECTION AND ASSESSMENT OF BIOTOPES

In order to assess farm related biotope types such as acreages and adjacent landscape elements, appropriate data is required. Using landscape plans or other geodata (see Chapt. 2) may reduce efforts of field working or data entry to a minimum. In case no data is available or existing data is insufficient, farmers or their advisors are challenged to collect data on biotope types. It is assumed that greater demands can be made on advisors specialised in nature conservation than on farmers. As a consequence, farmers who are not supported by advisors are asked to collect information on a rather general basis by concentrating on main units of biotope types. Advisors may apply the entire official key of biotope mapping relevant for the federal state and may subsequently obtain more detailed results. Both groups of users are expected to do only very restricted field work for the biotope inventory: Presumably farmers know their farm land very well and can therefore classify the biotopes on the basis of aerial photographs whereas advisors can interpret aerial photographs in combination with limited ground-truth information.

To realise an automated analysis, the assessment of biotope types is based on the allocation of basic grades rather than on detailed descriptions. These grades reflect the significance of each biotope type in terms of nature conservation goals. Some of the underlying criteria for classification are naturalness, endangerment or rarity (Bierhals et al., 2004). The spectrum of basic grades for the federal state of Lower Saxony, for instance, ranges from 1 (e.g. sealed surfaces) to 5 (e.g. wet grasslands), with 5 as the category of highest significance for nature conservation (ibid.).

In order to allow more specified assessments, users are asked to have a closer look at individual features of acreages or landscape elements. Relevant parameters for data collection must be compatible with software requirements. In addition, the collection of more detailed data is focused on parameters

- which are easy to map (e.g. width of field margins),
- which cannot be ascertained alternatively by means of existing geo data (e.g. age of hedgerows), and
- for which quality standards are available in literature.

As a prerequisite for reassessment, quality standards for parameters like width, length and area were compiled for most of the common farm related biotope types. Provided that relevant parameters are mapped and quality standards are fulfilled, the basic grades of biotopes will be upgraded (Tab. 1, Fig. 3). The prospect of a possible upgrading is meant as a secondary effect to serve as an incentive for biotope mapping. There is no degrading in case biotopes are not optimally shaped.

Basic grades	Compliance with quality standards (parameter: width)	Reassessment	Final grade
Field margin: 3 (out of 5)	either		
	Optimal width of field margin (Albrecht et al. 2004: 95): 5 – 6 m (→ field margin wider than 5 m)	Double upgrading: (3) + 0,2	3,2
	or		
	Minimum width of field margin (Albrecht et al. 2004: 95): 2 – < 5 m (→ field margin wider than 2 m but smaller than 5 m)	Simple upgrading: (3) + 0,1	3,1
	or		
	Below minimum standard (→ field margin smaller than 2 m)	No upgrading: (3) ± 0	3,0

Table 1: Principles of reassessing basic grades for biotopes depending on the compliance with quality standards, shown exemplarily for the main biotope unit "field margin"

A more differentiated assessment method was developed exemplarily for hedgerows. It takes into account additional parameters like age, number of tree and scrub species or percentage of native species. For these parameters additional quality standards were compiled based on literature inquiries (Albrecht et al., 2004, Auweck, 1978 and 1979, Broggi & Schlegel, 1989, Kaule, 1991, Schulze et al., 1984, Söhngen, 1975, Zwölfer et al., 1984). A special user interface for the collection of parameters relating to hedgerows was developed (Fig. 2) and tested in the course of evaluation.

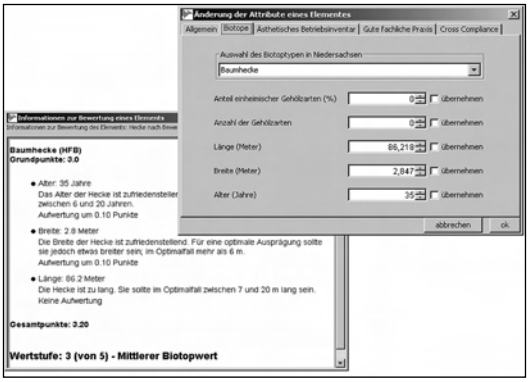

Figure 2: Screenshot of the user interface developed for the collection of parameters on hedgerows and subsequent results of assessment

DATA COLLECTION ON RED LIST PLANT SPECIES AND ALLOCATION OF BONUS POINTS

Species and their habitat requirements are covered to a great deal already by the biotope assessment, as this is based also on information about species (especially vege-

tation) which characterises the biotope type and its features. It is stated in literature, however, that aspects of species protection and biodiversity cannot be covered fully by dealing with biotopes alone (Plachter et al., 2003). Therefore, farmers or their advisors are challenged to collect data on red list species. To minimise efforts, they are asked to focus on vascular plant species found in grasslands or agricultural fields, but they may extend their inventories to animal species or other elements of the agricultural landscape if desired. In order to facilitate mapping and software inputs, red list plant species which are typical for agricultural fields and grasslands were compiled on the basis of the National Red List and specifically for those federal states which are covered in the project (based on the official red lists for vascular plants). For each single red list species found and entered into the software, farmers will be rewarded with bonus points (Tab. 2).

Red list categories (categories may vary slightly depending on the federal state)	Allocation of bonus points (per single species found)
Extinct in the wild or missing (RL 0)	5
Threatened with extinction (RL 1)	4
Critically endangered (RL 2)	3
Endangered (RL 3)	2
Vulnerable (V) *or* Considered to be threatened (G)	1

Table 2: Principles of bonus point allocations for different categories of red list vascular plants

The number of assigned bonus points depends on the number of species found and their red list status (Frieben, 1998). All bonus points can be summarised for individual acreages and for the farm as a whole (Fig. 3). That way, farmers will get information about the quality and significance of their farm land in terms of endangered species. Farmers might use the information for presentation purposes or for participating in specific agri-environment programmes.

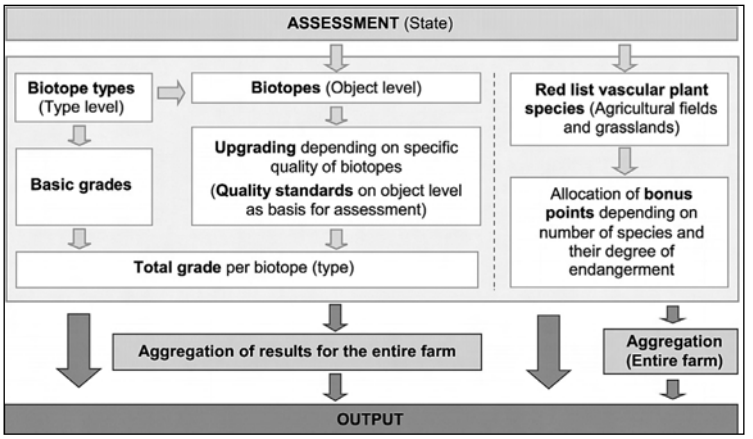

Figure 3: Principles of assessment relating to the current state of the farm in terms of biotopes and red list plant species

LANDSCAPE POTENTIAL FOR THE DEVELOPMENT OF NEW HABITATS

In addition soil data is used to determine the landscape potential for the development of new habitats and restoration of former ones ("Habitat Development Potential"). An already existing methodology for assessing the potential of soils to support the development of (rare) target vegetation (Brahms et al., 1989) was modified and adopted to the soil data provided in REPRO and OpenJump. The methodology results in an evaluation of the abiotic environmental site conditions that are relevant for habitat development and recommendations concerning different development options.

• Landscape Aesthetics and Recreation

For the assessment of landscape aesthetics the methodological background is connected with several uncertainties (Roth, 2006). In practice of landscape planning, methods are often developed for single cases of use. In German literature alone more than 100 different methods are known (ibid.).

For assessing agricultural enterprises with respect to landscape aesthetics using software, only formalised methods are generally suitable. A precondition is that the method takes into account the physical equipment of the landscape, which can be saved and treated in the software following clearly definable rules. But these kinds of methods show some disadvantages especially for multi criteria decision processes and trade-off-analyses like they are aspired in this research project. Mostly they lack in precision and in conjunction with that they show deficiencies in sensitivity with respect to different options of land use (Daniel, 2001). Furthermore, formalised methods often do not consider the character of landscapes appropriately (Eisel, 2006, Körner, 2006), which is a problem particularly for the intended use of the software throughout Germany. Within the formal basic approach of the "farm inventory of aesthetic and recreation properties" ideas for reducing the described disadvantages were developed. Main components are the use of

- landscape character areas in combination with
- differentiated assessments of land uses taking seasonal developments into account.

It is not claimed in this project to solve the fundamental and system-dependent problems and limits of formal and quantitative methods (Eisel, 2006, Güsewell & Falter, 1997, Hahn-Herse, 2005, Hoisl et al., 1991, Körner, 2006, Wöbse, 2005). But the applied approach may reduce well-known weaknesses of these methods needed for the software-based approach.

THE FARM INVENTORY OF AESTHETIC AND RECREATION PROPERTIES

The basic idea of the developed software module is to assess the landscape components of a farm for their aesthetic qualities. A list of landscape components which have to be assessed (Lobsiger & Ewald, 2002, Nohl, 2001, Stöckmann, 2006) represents the data basis required on each farm. This list of landscape components with their qualities is not claimed to be final, considering the variety of landscapes in Germany. Further qualitative assessments of the landscape components assigned to the farm are set up on the farm inventory (Fig. 4).

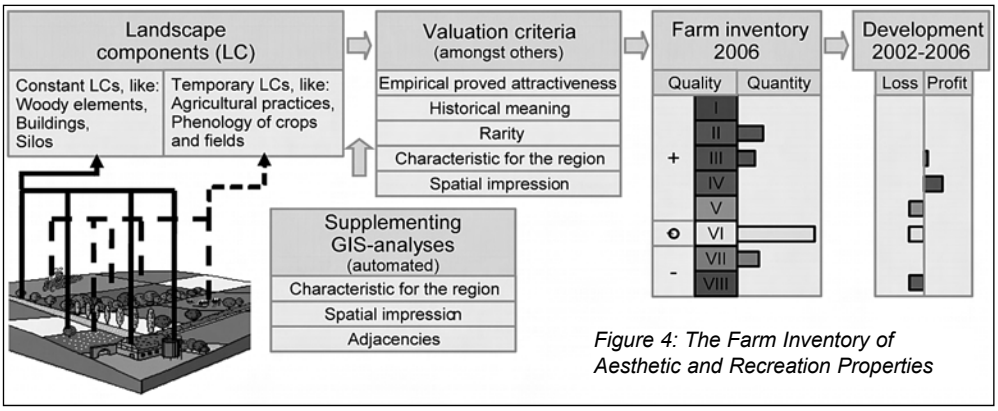

Figure 4: The Farm Inventory of Aesthetic and Recreation Properties

The rules for rating are built on landscape preference studies - especially carried out in the agricultural landscape (Hoisl et al., 1987, Lindenau, 2002, Strumse, 1994) - as well as on formal assessment criteria derived from a comparison of several element based approaches (Amann & Taxis, 1987, Leitl, 1997, Stöckmann, 2006).

In addition to the qualitative assessment, the occurrence of landscape components on a farm is analysed quantitatively based on a method by Hoisl et al. (1989 and 1991). They devised gestalt-psychological founded rules on quantifying landscape components for measuring a value of diversity. Background of these "rules of quantification" is that people perceive landscape by reorganising observed single features to higher figures in their minds. Regarding landscape aesthetics, this gestalt-psychological approach most likely allows a suitable relation of objects that are saved as points, lines or polygons due to technical demands of a GIS.

LANDSCAPE CHARACTER IN A FORMAL ASSESSMENT METHOD

A crucial GIS-application is the analysis of how typical the components mapped on a farm are for the region they are found in. For this purpose, landscape character areas (Köhler & Preiß, 2000, Leitl, 1997) with the characteristical kind of landscape components assigned to them can be saved in the master data of the programme. Such landscape character areas could also be administrative units. On the basis of landscape character areas, the mapped components can be assigned using a spatial query if they shape the character of an area in a positive way. These landscape character areas enable to consider local goals of landscape development (like they could be specified e.g. in landscape plans). Moreover, they provide a basis for the integration of demands and wishes of inhabitants or stakeholders. Thus, the quantitative-formal basic approach with a standardised and German-wide uniform assessment process is extended by an assessment based on a landscape vision or by a user-based approach (Augenstein, 2002, Güsewell & Falter, 1997, Umbricht, 2003).

DIFFERENTIATED ASSESSMENT OF SEASONAL ASPECTS OF CROP COVER

Existing methods for assessing landscape aesthetics usually distinguish agricultural land by its "perceived naturalness" (Augenstein, 2002, Hoisl et al., 1991) and diversity. Arable farm land - highly influenced by man - gets the lowest value, while (intensive) grassland as moderate natural, and extensive grassland or fallow land as natural get a medium to high value. This generalised way of assessment seems to be inadequate, bearing studies of Lindenau (2002) in mind, in which people criticised the extension of fallow land. Furthermore this kind of assessment is only sensitive against major changes of land use like ploughing grassland or giving up cultivation.

In environmental psychological studies of Coeterier (1996) seasonal development was identified as one assessment criterion for the quality of the landscape. Seasonal development can be perceived well on agricultural land. In German literature the importance of seasonal development is recognised (Nohl, 2006), but such temporary phenomena are taken into account only in a few methods. Stobbelaar et al. (2004) showed that seasonal development on farms is a useful criterion for assessment with respect to landscape aesthetics.

Within the research project the opportunity is given to use data from field records for

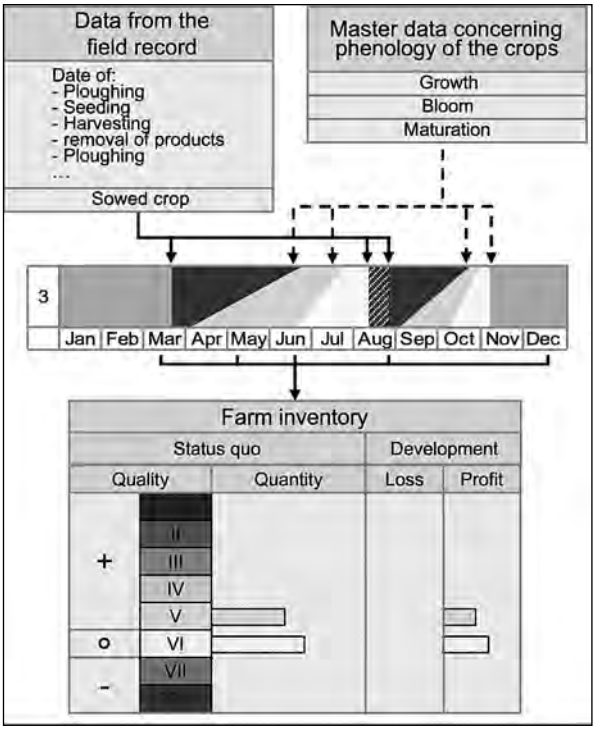

Figure 5: Deriving the seasonal development on fields from a field record

assessing seasonal development on the fields caused by land use (Fig. 5). It is planned to complement seasonal aspects of cropping by assessing the bloom of wild growing flowers. All temporary phenomena should be added to the farm inventory. For this the underlying "rules of quantification" (Hoisl et al., 1991) have to be adapted insofar as the duration of seasonal effects has to be taken into account.

MONITORING LANDSCAPE QUALITY ON FARMS

On the basis of the farm inventory described above, monitoring of landscape quality as postulated e.g. by Nohl (2006) can be applied on the farm (Fig. 4). The possibility of monitoring can be seen as strength of the software-based approach, using it as a 4D-GIS (Weidenbach, 1999). This offers the opportunity to identify and - if necessary - act on landscape changes in a better and even faster way. Such a landscape aesthetic monitoring additionally makes the quantitative measures of the software more intelligible, showing the influence the farmer takes over time. Another advantage is that the monitoring can be useful in an environmental management system like DIN EN ISO 14001.

EVALUATION RESULTS

The evaluation of the software module including the underlying assessment methods was carried out using a prototype along with guideline based interviews for the six pilot farms.

GENERAL USAGE OF THE SOFTWARE MODULE

Regarding the favoured features of the software module, the interviewees responded rather heterogeneously in their demands. General results are that at present the assessment of farms in terms of additional nature conservation benefits is regarded less important compared to challenges in farm management like Cross Compliance (Fig. 6).

Farmers are generally interested in using GIS and its opportunities, like comparing spatial information, visualising information with maps or using the mapped data (e.g. landscape elements) for several purposes. The assessment of their environmental performances with the help of a GIS is ranked by the farmers as valuable for their management. But they also stated that they would not have used it on their own initiative. The main reason is that under current EU and state funding conditions the cost-value ratio is estimated as unfavourable.

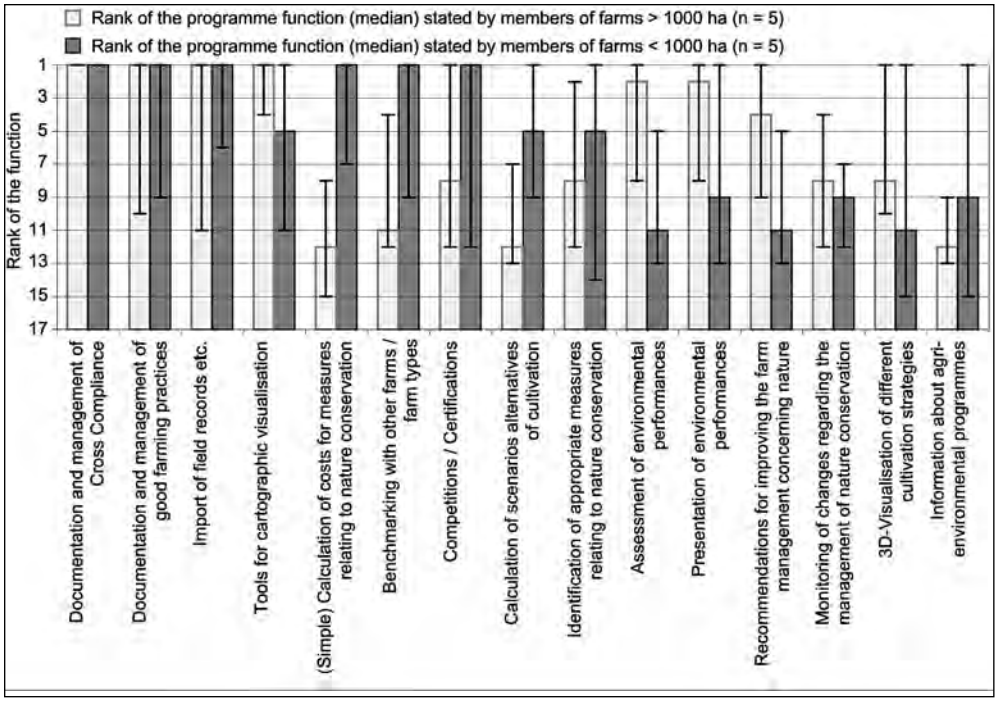

Figure 6: Importance of functions of a nature conservation software module ranked by the interviewees of the pilot farms

MANAGEABILITY OF THE BASED METHODS

Most farmers use spatial base data when they work with GIS. The land surveying offices and chambers of agriculture are important contact points to access these datasets. Spatial thematic data is better known among farmers who cooperate with nature conservation authorities or institutions. In general, farmers considered the thematic datasets as not sufficient in up-to-dateness and accuracy for their usage in farm management. Additional information should be supplemented to represent the situation of the individual farms. However, farmers are willing to secure and finance spatial datasets if an advantage for the farm management is seen. Generally, establishing a data pool and becoming familiar with the software module was regarded as complex and time-consuming.

The intended principles for the collection of data and for software internal assessments concerning biotopes and landscape aesthetics were illustrated taking hedgerows and solitary trees as examples. The majority of farmers were able to determine the relevant features of these elements by heart. However, the difficulties in understanding the terms used in the software and especially their mutual understanding by farmers is a shortcoming of the prototype which has to be considered in the forthcoming work.

As to dealing with species, farmers showed some reservations. They worried about insufficient species knowledge, lack of time and manpower and unfavourable cost-value ratios. While common plant species could have been identified with their German notation, most farmers eliminated any possibility of mapping red list species as they feared unwanted legal binding effects, restrictions in cultivation (e.g. pesticide controls) and sanctions by authorities

in case of nonconforming cultivation activities. The only incentive for red list species mappings would be the prospect of financial rewards.

The evaluation on the pilot farms showed that seasonal development plays an important role in the awareness of farmers when talking about assessing the potential for experiencing landscape on their fields. All farmers regarded their acreages as being of high value for landscape aesthetics.

In summary it can be stated that farmers seem to be prepared to deal with nature conservation issues. They are interested in the use of certain components of the software module provided they can benefit from the applications. Even greater prospects are seen in case they are supported by advisors in terms of establishing a data pool, utilising the software and analysing the subsequent results.

PROSPECTS

Within the remaining project duration the project team will continue with conceptual works and software developments. Existing modules will be adjusted to the users needs on the basis of the farm evaluations. Additional modules will be technically implemented. The overall software outcomes and underlying principles will be presented to advisors specialised in nature conservation within the scope of a workshop. Furthermore, students of agricultural sciences will be interviewed and asked to carry out usability tests. The feedback given by both groups of interviewees will be used for final adjustments of the software.

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