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Comprehensive Evaluation of Future Landscape Quality by Joining Indicators and 3D Visualisations

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1 Introduction

Cultural landscape is changing by the influence of economic and political conditions causing environmental pressure on the natural living resources. Therefore, a management of the development is needed balancing the ecological, economic, social and aesthetic requirements. On the one hand, this demands for an active involvement of the public in the management of landscape change to ensure the implementation of measures. On the other hand, the participative planning approach needs instruments facilitating the communication between stakeholders and assisting in the understanding and assessment of the consequences of future changes.

Indicators are a helpful tool to achieve a better understanding of complex issues as they simplify information that can help to reveal extensive phenomena. With regard to environmental issues, a wide field of indicators does exist from global to extremely local scales, mainly gathered from monitoring data. For the evaluation of future scenarios, indicators are needed that provide information on the potential change in landscape qualities associated with land use change.

3D visualisations of the landscape provide means that are better understandable than maps, especially for lay people. With them, visual changes of the landscape can be shown very impressively and they allow for an intuitive assessment of the visual landscape quality. Joining these visualisations with non-visual indicators enables a comprehensive evaluation of future conditions.

The purpose of this paper is to demonstrate a possible design of 3D landscape visualisations combined with indicators and the evaluation they allow for. Therefore, indicators are described required for the assessment of landscape change, potentials seen for their visualisation and the technical visualisation process. These integrated visualisation tools are tested in real planning situations to get feedback from end users with regard to understanding and utility. Problems are mentioned faced producing these tools as well as their advantages and disadvantages for participative planning processes.

2 Combining 3D landscape visualisations with indicators

2.1 Indicators for the assessment of landscape change

Landscape development concepts are set up to assist in the protection, management and planning of the human's natural environment. In general, different steps and phases as preparing, analysing, designing, and application planning have to be passed through. Essential for these steps is an information basis on the conditions of the landscape that is broad but relevant for specific questions. The aim of this information basis is not the presentation of reality in all its facets. This is not possible

due to a lack in knowledge, time and money and even prejudicial to the planning process mismatching the needs of the end users. Therefore, a strong selection of the landscape characteristics to be collected and assessed has to be made enabling for decisions on certain actions. Thus it is aimed at a spatially differentiated illustration of the landscape functions with respect to the planning question (v. Haaren 2004).

The landscape functions comprise the current and potential ability of the landscape to fulfil the human needs regarding the natural resources and the landscape experience. They include both, material needs as productivity of the soil, water supply and retention, climatic regeneration as well as immaterial needs e.g. quality of life, the desire for geological and biological diversity and the conservation of the natural heritage for future generations (Leser et al 1997; v. Haaren 2004). For a comprehensive assessment also social and economic criteria have to be evaluated. This means that the integrated analysis of landscape change requires a spanning examination of the landscape under different aspects (Tress & Tress 2001).

The information needed for the assessment of the landscape functions can be gathered directly in nature or via indicators as an instrument for measuring. In planning practice, they are limited to those that are relevant for the description of the potentials, the current function of, or the pressure on the landscape functions. A precondition is that these indicators match the type, scale and question of the planning and that they are comprehensible for everyone.

The impact on the visual landscape quality as the diversity, character and structure of the landscape, the degree of human impact, and the visibility in the landscape can be measured by visual indicators as relief, vegetation, land use, structural elements or lines of sight (Nohl 2001). But also characteristics as harmony and scenic beauty that depend on the perceptual process the features of the landscape evoke in the human viewer should be assessed (Daniel 2001).

Non-visual processes with respect to the geological or biological impact of a landscape change relevant for nature protection can be derived from visual indicators. The ecological needs of different plant species are used as an indicator value for the sensitivity of and adverse effects on a biotope. Other indicator species as birds, bats or amphibians indicate the ecological functionality of spatial-functional relationships. These indicators can be shown spatially explicit (Hehl-Lange 2001).

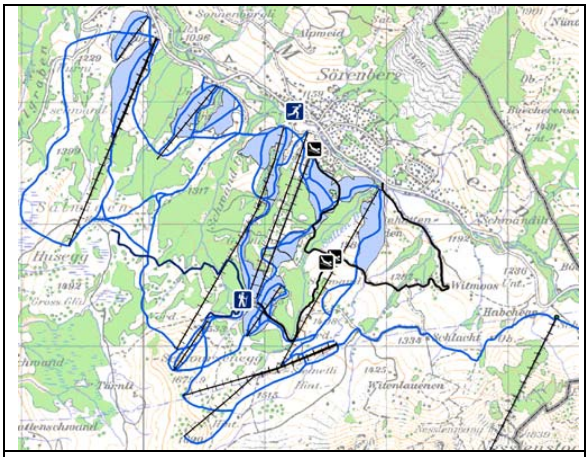
Most of the economic and social indicators are rather hard to express as they are non-visual and not spatially explicit. Their assessment is not formalised yet with regard to landscape assessment and the relationships are rather complex (v. Haaren 2004). Nevertheless, some basic indices of productivity e.g. of agricultural land and forest can be derived even from land cover/use map data (Quine et al. 2004).

3D visualisations offer the opportunity to link all dimensions, the visual and non-visual parts of the landscape, and may provide for a new planning tool. In the EU project VisuLands 3D landscape visualisations are developed that are coupled with indicators for the assistance of lay people in the assessment of landscape change. In the following the technical possibilities of the integration of indicators in the 3D visualisations is described.

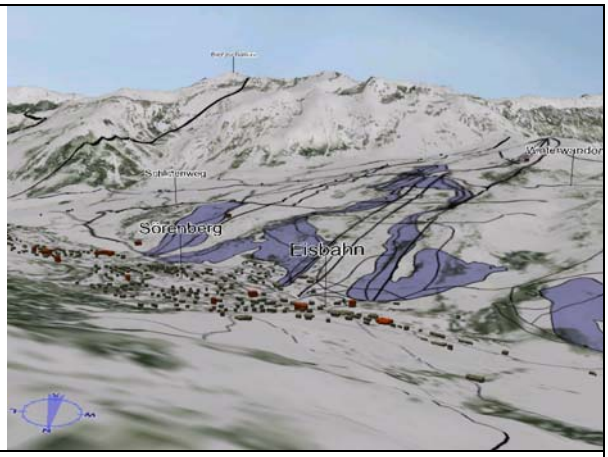
2.2 Development of integrated visualisation tools

For the visualization of spatial indicators of landscape change various forms of infographics are suitable, coming from fields like cartography, scientific visualization or multimedia design. A basic method of visualising spatially related information is the use of thematic maps. Furthermore, diagrams or other schematic images can be linked to an image and new multimedia techniques allow the interactive combination of various media on demand. The visualization of indicators changing over time may be realised by animations and non-temporal animations which are an important technique for the iterative development of complex indicator relations (Oberholzer / Hurni 2000). In the following, examples for thematic maps, diagrams in combination with 3D models and various combinations of these techniques are given.

Thematic Maps
A thematic map shows objects or topics that are not part of the topography, e.g. data on the natural environment, economy or society (Hake et al. 2002). The topographic basis provides the spatial context and orientation. Traditionally, these maps have been limited to two dimensions, although new computer graphics allow to project themes into three-dimensional (3D) models as well. The use of 3D maps, i.e. interactive 3D map related design (Döllner 2001) may provide specific benefits, if the illustrated topic is closely related to the topography, e.g. in visual landscape assessment.



2D map of ski areas with snow cannons near Sörenberg (VisuLands 2004 © geo data: GIS-Coordination Office, Canton Lucerne)



3D photo map of ski areas with snow cannons near Sörenberg (VisuLands 2004 © geo data: GIS-Coordination Office, Canton Lucerne)

Fig. 1: Examples of thematic maps with ski facilities as an indicator for human impact on the landscape

Linking, 3D Maps, Diagrams and Photorealistic Renderings
Today, the term diagram is used as generic term for any graphic presentation of quantitative data referring to some kind of scale, ranging from bar charts to illustrations. Some diagrams may be used as map symbol, either referring to an area (diagram map) or to a specific location (signature). Alternatively, it may be helpful to add a diagram at the map border in addition to a thematic map (Bollmann et al. 2002).

All these representation types have in common that the reality is abstracted in order to simplify and to focus the content. In contrast, more realistic landscape visualizations that are of high complexity provide the possibility to assess visual characteristics like beauty or character of a landscape intuitively.

A design concept how all dimensions for a comprehensive landscape assessment could be linked is shown in figure 2. The photo-realistic 3D visualisation of the area of investigation shows the current situation and topics can be chosen from the list on the left providing for further information on a specific planning question e.g. tourist development. Data from the GIS database can be superimposed as thematic maps on the image allowing for the assessment of the spatial conditions like the location and actual state of nature protected areas. In addition, diagrams can be linked giving the development of the overnight stays of tourists in the past.

A slider bar at the bottom gives the opportunity to look at the variability of the landscape development over time due to defined driving forces. Pre-prepared visualisations of different points in time can be shown with the related thematic maps and diagrams.

Aggregated indicators presented in bars signalise the direction of the development for different categories i. e. with regard to economic, ecological and social aspects.

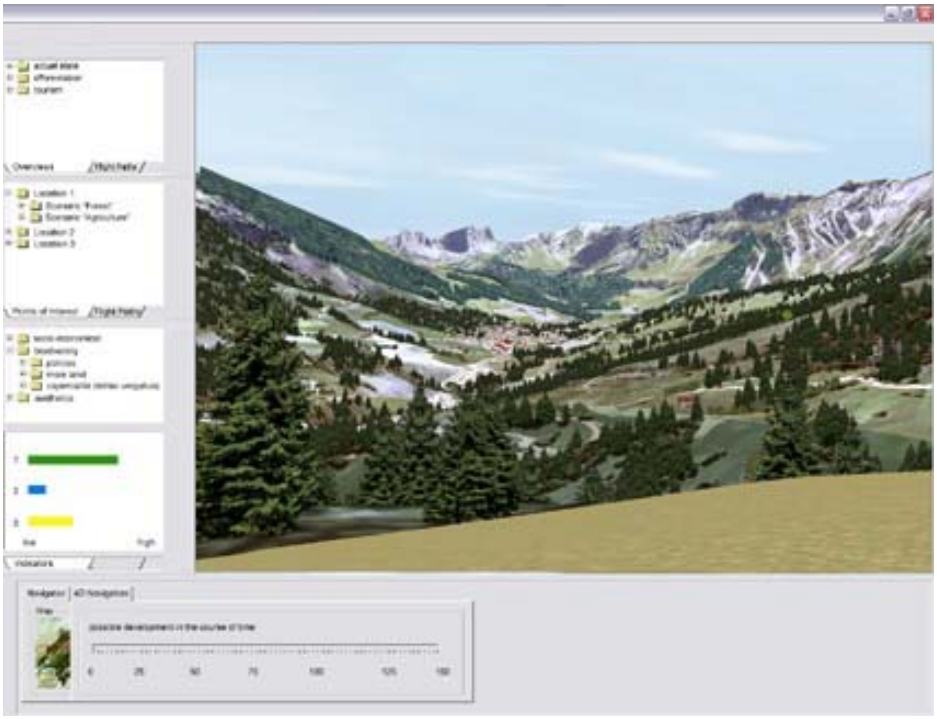


Fig. 2: Design concept of the integrated visualisation tool

The VisuLands project analyses the potential benefits of the interactive link between different types of landscape visualizations with diagrams and thematic maps. To ensure that the visualization tools fulfil the needs of end-users they are iteratively tested in real planning workshops. With this approach the tools can be gradually adjusted to the requirements.

3 Applying the integrated visualisation tools in real planning situations

The tools are tested in co-operation with local stakeholders of the Entlebuch UNESCO Biosphere Reserve (www.biosphaere.ch). Until now, seven workshops on settlement patterns, tourism, forest management plan, and the future of local agriculture have already taken place. They were facilitated by moderators from the Biosphere management and took place locally. The 3D visualizations were integrated into the moderation and the VisuLands team presented them on demand.

Communicating visual indicators
Local farmers as well as nature protection, wild life and forest officers came together to develop in a participative workshop a concept for agricultural management in the area of Sörenberg. According to the overall trend, the future development of this area depends on political and economic driving forces, and the liberalisation of the agricultural market will increase the pressure on existing practices (Bundesamt für Statistik 2004).

The 3D visualisations of the change of land cover in five, fifteen and thirty years (Fig. 3) due to the abandonment of pastures in the case of lower grazing intensity were shown to assess the impact on the visual landscape quality. The visualisations enabled for an intuitive assessment of the visual indicators as the land use mosaic on a regional level.

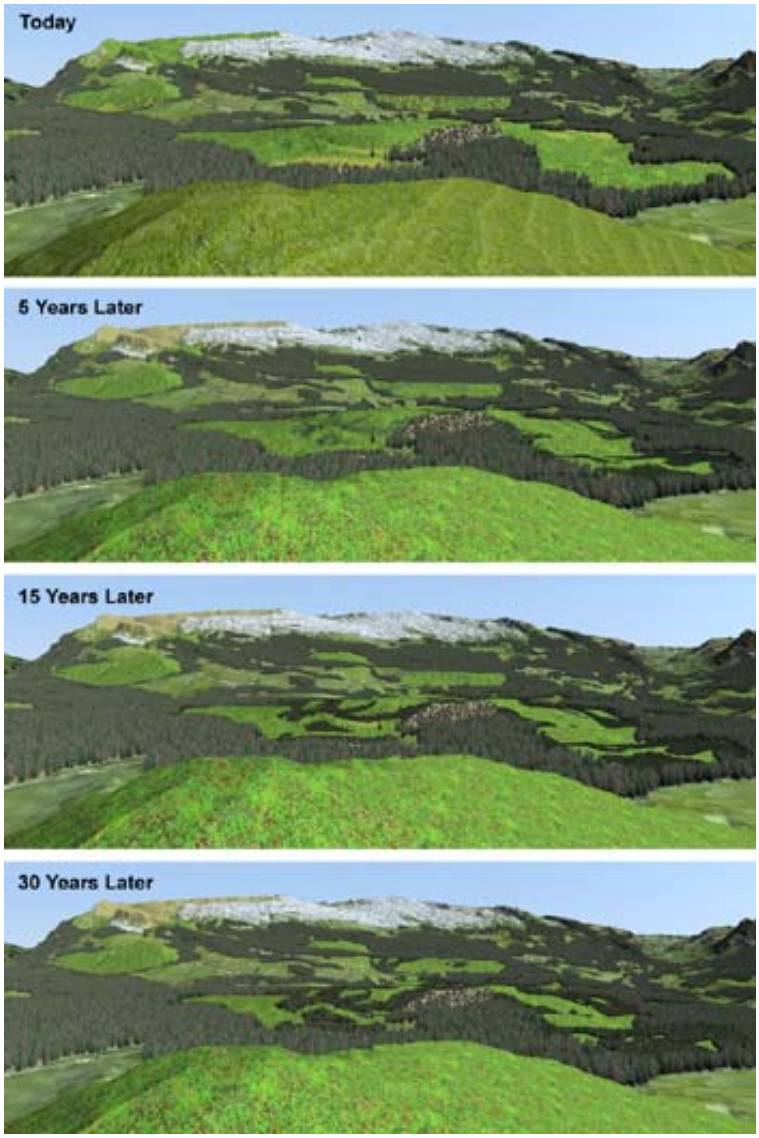


Fig. 3: Development of the view of the landscape due to agricultural management changes (VisuLands 2004 © Geo data: GIS-Coordination Office, Canton Lucerne)

Correlations between the management system and the changes on vegetation level were shown with high realistic 3D visualisations (Fig. 4). Here the focus is laid on the development of the visual landscape quality and on the shift in the presence of species at vegetation level presented by indicator species e.g. rush species. These visualisations were seen as very valuable to communicate a certain fact to stakeholders not familiar with the area.

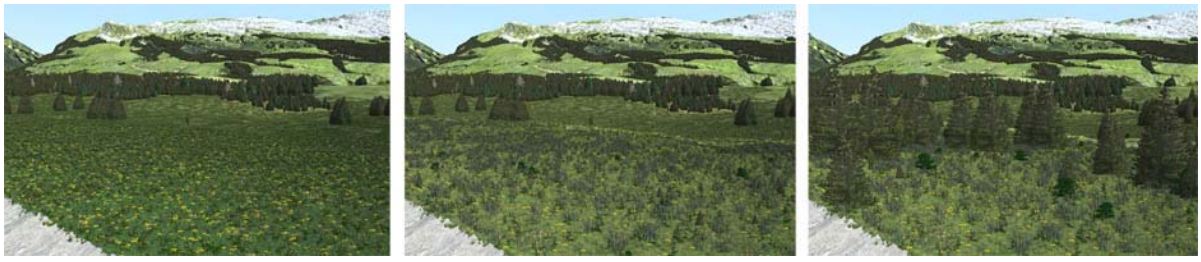


Fig. 4: Changes on vegetation level due to agricultural management changes (VisuLands 2004 © Geo data: GIS-Coordination Office, Canton Lucerne)

Visualising non-visual indicators

Stakeholders from local tourism, i.e. owners of cable cars, skiing facilities and hoteliers, were invited to participate in a workshop, where strategies for the future direction of touristic development were discussed. One of the key indicators for tourism is the number of overnight stays, here shown in relation to the hotels and chalets in the area. Additionally, the panel asked for traffic numbers, because the tourist travel behaviour causes significant fluctuations in the number of cars. These numbers were visualized by a column on the main street, animated in correlation to changes over the year (Fig. 6). The visualizations in figure 5 and 6 highlight the uneven impact of winter tourism in numbers of overnight stays and individual traffic, showing the unsustainable use of resources.

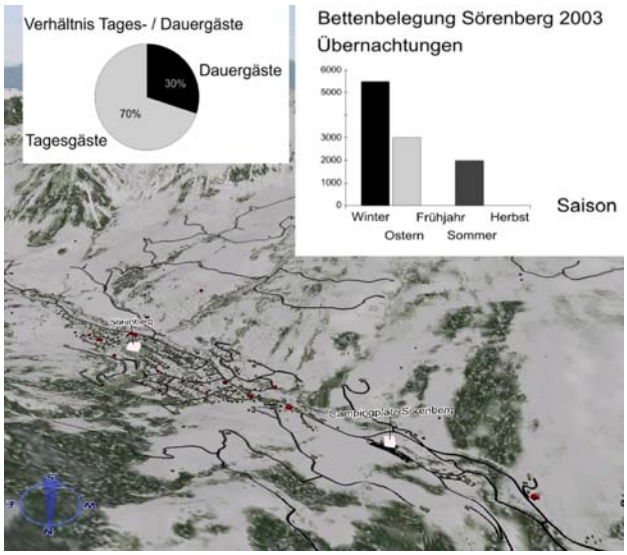


Fig. 5: Overnight stays in Sörenberg in 2003; the 3D model shows the location of chalets (grey) and bed and breakfasts, hostels, and hotels (red) (VisuLands 2004 © Geo data: GIS-Coordination Office, Canton Lucerne)

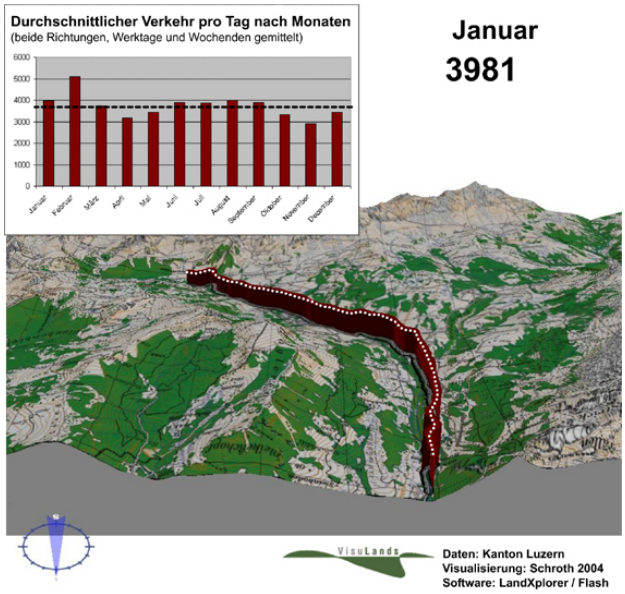


Fig. 6: Visualisation of the change of traffic numbers over the year (source traffic numbers: Cantone Lucerne; 3D visualisation: VisuLands 2004 © Geo data: GIS-Coordination Office, Canton Lucerne)

The joint visualization of realistic 3D models and indicator diagrams was assessed as helpful by participants from various workshops. Nevertheless, the benefit of such visualizations highly depends on the careful design of these information with regard to colors, scales and interactivity.

4 Discussion

Especially in participative workshops the use of integrated visualisation tools is of high potential to facilitate the planning process in the comprehensive evaluation of future landscape quality. First of all, the 3D visualisations have a motivating function. Applying this new technique in the workshops evoked the interest of people and thus helped to draw them into the planning topic. Further, the visualisations enabled for the demonstration of visual qualities and non-visual indicators for a specific area more vivid than with 2D maps. Comments from workshop participants were that they feel the discussion gets much more concrete.

The indicators used so far can be characterised as ‘telling –‘ or ‘warning indicators’. Their purpose was to reveal points at a glance that are of importance for decisions on the management of landscape development processes. They also give hints what should be further assessed in depth. Most of the standard indicators in landscape assessment are monitoring indicators. Most of them are designed to show that there has been a change in ‘state’ of a particular environment, allowing an assessment of ‘impact’ and thus triggering a ‘response’ in terms of policy and management. Indicators that provide information on the potential change in landscape values associated with land use change have to focus on descriptions of state and impact, but must be calculable from scenario data rather than monitored data (Quine et al. 2004). With regard to economic indicators the variety of existing indicators to be gathered from land cover data is rather limited.

This prospective approach demands for the demonstration of the degree of fuzziness that is inherent to the indicators. In the assessment of landscape change we have to deal with insufficient knowledge on landscape processes as basis for decisions. The spatially explicit presentation of indicators in the visualisations might pretend an accuracy that is not true. Particularly the realistic 3D visualisations should communicate the impreciseness e.g. of vegetation development and thus the quality of a biotope. The assumptions behind the visualisations have to be clear in any case. This should counteract the misuse of 3D visualisations many end users worry about.

Up to now, the visualisation process is rather time consuming and therefore cost intensive. Data compilation is necessary and the production of rather realistic images requires not only software skills but lasts rather long compared to the production of 2D maps. Another disadvantage of this visualisation type is that the images have to be prepared in advance. This means that it is rather inflexible in showing new change options requested in a workshop.

Map related 3D visualisations are more flexible in analysing the GIS data base and indicating certain aspects on demand. The used formulas for the calculation of the indicators should also be communicated comprehensively to clarify the application limits and not to provide for a so called ‘black box’.

As remarked in the second chapter, the possible design of these indicators is manifold. The challenge is to find out the appropriate complexity in the presentation of the indicators for a comprehensive assessment.

5 Conclusion and outlook

The better understanding of the information needed for the assessment of planning alternatives enhances the possibility of an active involvement. For the assessment of landscape change options in participative workshops with various types of stakeholders a simplified model is required rather than high detailed scientific models. Visualising smaller entities of the whole landscape system indicating

the extent of specific functional relations or their spatial dimensions for a particular issue are challenging but doable. Further research is required to find an optimum design to show different indicators of landscape change. Especially the link of diagrams with photo-realistic images, the spatial location of visual indicators and the use of graphic variables like color and size need further consideration.

An open question to be solved is which indicators are really useful from the perspective of the end users?

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