From Information to Participation

Interactive Landscape Visualization as a Tool for Collaborative Planning.

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DISS. ETH NO. 17409

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A dissertation submitted to
ETH ZURICH

for the degree of
Doctor of Sciences

presented by
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12.06.1975

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2007

Acknowledgements

I would like to thank the following people for their assistance with my research and in writing this dissertation:

- My supervisor Prof. Dr. Willy A. Schmid, who gave me the possibility to research the interrelations between planning and landscape visualization in the VisuLands project and in more detail, in my dissertation thesis. My co-supervisors Prof. Dr. Eckart Lange, project leader of the Swiss VisuLands team, who had prepared the ground for my research on landscape visualizations; Prof. Dr. Stephen Sheppard, who helped me structure my thoughts and invited me to discuss my thesis with the CALP team; Prof. Dr. Lorenz Hurni, who helped me in reviewing cartography and geovisualization for additional input.

- My colleague Ulrike Wissen, with whom I worked on the VisuLands project, and all colleagues from the IRL, particularly Duncan Cavens, Jolanda Hofschreuder, Dr. Isabella Mambretti, Peter Küpfer, Dr. Peter Staub, Dieter Beyeler, Ruth Förster, Sandra Monsch, Yvonne Largiader, Brigitte Henauer, Andreas Gaehwiler, Beverly Zumbuehl, Sabrina Meier. Special thanks go to Dr. Sigrun Beige (Institut für Verkehrsplanung und Transportsysteme, ETHZ), Dr. Christian Häberling (Institut für Kartografie, ETHZ), Jon Salter (UBC Vancouver), Dr. Mike Meitner (UBC Vancouver), Howie Harshaw (UBC Vancouver), Andrea Boltshauser (Lacope), Sabine Thürig (Lacope), Barty Warren-Kretzschmar (Universität Hannover), Simone Schipper (Universität Hannover), Philip Paar (lenné3D), Dr. Wieland Röhricht (ZALF Müncheberg), Konstantin Baumann (Hasso-Plattner Institut Potsdam), Prof. Dr. Jürgen Döllner (Hasso-Plattner Institut Potsdam), Carsten Colditz (Universität Konstanz), Cordula Püstow (Departement Architektur, ETHZ), Dr. Rolf Bürki (Universität Zürich), Paolo Gremli (photographer), and Robert Zanini, for working together, fruitful discussions, design suggestions and other kinds of support.

- The VisuLands partners, especially Dr. David Miller for project co-ordination, Max Hislop for the important input from his M.Sc. research and survey, Pernette Messager Belveze and Dr. Åsa Ode for their visualizations, and all other participants for the productive international collaboration.

- The UNESCO Biosphere Reserve management and Dr. Engelbert Ruoss, Bruno Schmid, Theo Schnider, Dr. Anette Schmid Hofer, Maurus Stöckli, Metke Lilienthal, Sandra Steffen-Odermatt; Alex Arnet and Agnes Amir (lawa Lucerne); Karl Lustenberger, Susanne Rychener, and Sepp Schumacher and all the local stakeholders and visitors who participated in the workshops and the survey. The geodata was provided by the Canton Lucerne. I want to thank Thomas Hösli and Daniel Peter for inviting our team to present our work to their department.

- I would like to especially thank my partner Dagmar Wandinger and my parents, Helene and Friedhelm Schroth, for always supporting me during the preparation of my dissertation.

Abstract

In spatial planning, landscape visualizations are promising tools for facilitating public participation. Current developments in computer visualization now make it possible to go beyond static images and interact with virtual landscapes. This thesis addresses real-time interaction with landscape visualizations and researches the benefits of interactivity for collaborative approaches in public participation.

Two research questions guide the analysis. The first research question asks: How can different types of interaction with landscape visualizations facilitate the process and improve the outcome of collaborative planning? Hypotheses are formulated on the basis of the qualities of collaborative planning. The hypotheses are tested in a multiple-case study in the Entlebuch UNESCO Biosphere Reserve in central Switzerland. The transdisciplinary research addresses the topics of tourism, agriculture and forestry in three cases. Data on the cases is gathered from different perspectives, e.g., from observation data, from facilitator interviews and from group discussions. Based mainly on qualitative methods from empirical social sciences, the analysis focuses on the key moments in which interactive visualizations have an impact on the process or outcome. The second research question asks: Are there any relationships between user group characteristics and user preferences for different types of interactions? In this question, the users are the focus. Their rankings of importance are queried in a quantitative survey on different visualization features related to interactivity. The analysis of the survey is mainly quantitative.

The results of the qualitative case study provide evidence for an impact on both the participation process and the outcome. Strong evidence is given in all cases that a shared exploration of the causes of landscape change benefits from interactive navigation and spatial analysis. The spatial analysis supports the facilitator's attempt to open the discussion on the topic of more balanced tourism strategies. There are strong indications that it has an impact on the outcome as well. In two cases, the perception, or as participants said, the imagination of the landscape is facilitated through interactive navigation. There is also evidence that the temporal navigation between different timeframes facilitates the perception of landscape change. Time progression successfully draws attention to long-term landscape processes by collapsing centuries into a few moments.

For collaborative planning, it is very important to ensure an open-ended dialogue. The results show how interactive navigation can provide the flexibility needed to respond to the vivid discussion processes in collaborative planning. It is apparent in all cases that interactivity can be used to highlight points of interest and to provide immediate visual feedback. There are promising indications that interactivity may facilitate the support of minority opinions, increase the transparency of the visualization process, and facilitate collaborative learning. In one case, the overlay of maps of different stakeholder interests becomes a catalyst for conflicting stakeholder parties to come to a consensus. It can be suggested that the interactive tools help to establish a shared mental model that finally leads to a consensus.

However, the landscape visualizations did not have additional benefits in the entire study. The benefits of the tools depend on several context variables and the level of participation, the work of the facilitator, the commitment of the stakeholders and the individual user preferences. Within these limitations, interactive landscape visualizations are powerful tools in these three cases and it is interactivity that seems to make them useful for collaborative planning.

In order to answer the second research question, a survey was conducted. A surprising result of the quantitative survey is the low ranking that the combination of non-visual information and 3D visualizations received, although such a feature is considered promising in the literature and in the qualitative case study. The questionnaire analysis suggests that this type of interaction requires a higher level of map-reading skills than the others. The map-reading skills are also related to the ranking of photo-realism. While inexperienced map users rank photo-realism very high, the experienced map users prefer abstract representations. Temporal navigation and the navigation between different scenarios seem to be considered important among all respondents.

In conclusion, the results indicate that interactivity enhances landscape visualization through contributing to a more inclusive, better informed, dialogue-oriented, more transparent, consensus- and learning-oriented participation process. Therefore, it is suggested that landscape visualizations should at least provide a minimum level of interactivity if applied as tools for participation. The final chapter provides recommendations on how to integrate interactive landscape visualizations in a collaborative workshop. These might help the perception of landscape processes to gain in importance and more stakeholders may acknowledge that landscapes are inherently dynamic. Above all, the participation process may become more process-oriented. Interactive landscape visualization seems more appropriate to support collaborative scenario-building than traditional static computer images. On the basis of these conclusions, it is likely that the interactivity of landscape visualizations will become even more important in future.

Abstract

Über die letzten Jahrzehnte hat sich mit der Landschaftsvisualisierung ein eigenes Forschungsfeld herausgebildet, in dem daran gearbeitet wird, Planungen durch 3D-Computervisualisierungen zu unterstützen. Bisher ließen sich Softwareprogramme zur 3D-Landschaftsvisualisierung im Wesentlichen danach unterscheiden, ob sie auf detailreiche, fotorealistische Standbilder bzw. Animationen oder auf die Erstellung von interaktiven Echtzeit-Umgebungen ausgerichtet sind. Dieses Unterscheidungsmerkmal wird durch aktuelle Entwicklungen in der Landschaftsmodellierung und durch Fortschritte in der Computergrafik und Computerhardware zunehmend hinfällig, so dass Softwarelösungen mit Echtzeit-Unterstützung, GIS-Integration sowie hohem Detailgrad technisch machbar werden. Je breiter aber die verfügbaren technischen Möglichkeiten sind, desto dringender stellt sich für Landschaftsvisualisierer und Planer die Frage nach der Wahl einer zweckentsprechenden Visualisierungsmethode. Die vorliegende Arbeit untersucht dazu den Mehrwert der Interaktion mit Landschaftsvisualisierungen beim Einsatz in kooperativen Beteiligungsverfahren.

Zwei Forschungsfragen leiten die Analyse. Im Mittelpunkt der ersten Frage steht der Planungsprozess. Es wird gefragt, welchen Mehrwert verschiedene Typen von Interaktionen mit Landschaftsvisualisierungen für die Prozesse und Ergebnisse kooperativer Beteiligungsverfahren bieten. Dazu werden Hypothesen auf Basis der Qualitäten kooperativer Verfahren als besonderer Form der Partizipation formuliert. Überprüft werden die Hypothesen anhand einer in der UNESCO Biosphäre Entlebuch im Schweizer Kanton Luzern angesiedelten Fallstudie mit drei Fällen zu den Themen Tourismus, Landwirtschaft und Forstwirtschaft. In dem transdisziplinären Forschungsansatz werden Daten aus verschiedenen Perspektiven, d.h. aus teilnehmenden Beobachtungen, Experteninterviews und Gruppendiskussionen, erhoben. In der hauptsächlich auf qualitativen Methoden aus den empirischen Sozialwissenschaften beruhenden Analyse werden die durch die Visualisierung bestimmten Schlüsselmomente näher auf die Rolle, die die Interaktion spielt, untersucht. In der zweiten Forschungsfrage stehen die Nutzer im Mittelpunkt: Besteht ein Zusammenhang zwischen den Nutzermerkmalen Geschlecht, Alter, Kartenkompetenz und den Nutzerpräferenzen bezüglich interaktiver Visualisierungen? In einer quantitativen Umfrage haben Einwohner der UNESCO Biosphäre Entlebuch verschiedene interaktive Visualisierungen nach der von ihnen geschätzten Bedeutung im Planungsprozess in einer Rangliste geordnet. Die Analyse der Befragung bedient sich im Gegensatz zur Fallstudie hauptsächlich quantitativer Methoden der empirischen Sozialforschung.

Die Resultate der qualitativen Fallstudie belegen einen Einfluss der interaktiven Landschaftsvisualisierungen sowohl auf den Prozess als auch auf die Ergebnisse der Partizipationsverfahren. Es ist belegbar, dass die gemeinsame Bewertung der, den Landschaftswandel bestimmenden, Einflussfaktoren von interaktiver Echtzeitnavigation und räumlicher Analyse profitiert. In den Fallbeispielen hat der Moderator die Möglichkeiten der räumlichen Analyse erfolgreich dazu genutzt, die Diskussion über Zukunftsstrategien im Tourismus in eine nachhaltigere Richtung zu lenken, was sich auch in den späteren Ergebnissen des Beteiligungsprozesses belegen lässt. In zwei Fallbei-

spielen waren sich die Beteiligten einig, dass die Echtzeitnavigation ihnen dabei hilft, sich zukünftige Landschaften vorzustellen. Weiterhin liefert die Studie Hinweise, dass die Navigation zwischen verschiedenen Zeitpunkten die Wahrnehmung des Landschaftswandels unterstützt. Dieser Zeitraffer lenkte die Aufmerksamkeit erfolgreich auf langfristige Veränderungen, die sich über Jahrzehnte hinziehen und daher nur selten von der Öffentlichkeit wahrgenommen werden. In kooperativen Beteiligungsmethoden ist besonders der offene Dialog wichtig. Die Studie zeigt, wie Interaktionen die Flexibilität bieten, die notwendig ist um auf eine lebhafte Diskussion zu reagieren. Ebenso gibt es viel versprechende Anzeichen, dass interaktive Landschaftsvisualisierungen dazu eingesetzt werden können, Minderheitenmeinungen zu stärken, die Transparenz des Visualisierungsprozesses zu erhöhen, und gemeinsames Lernen zu unterstützen. In einem der Fallbeispiele trägt die interaktive Überlagerung der Karten zweier Interessengruppen wesentlich zur gemeinsamen Bildgestaltung und zur Konsensfindung bei.

Die Landschaftsvisualisierungen konnten aber nicht immer erfolgreich eingesetzt werden. Ihr Mehrwert hängt wesentlich vom Grad der Beteiligung und von externen Kontextfaktoren ab. Dazu gehören vor allem die Moderation, das Engagement und die Interessen der teilnehmenden Akteure sowie individuelle Präferenzen. Innerhalb dieser Grenzen sind interaktive Landschaftsvisualisierungen ein mächtiges Werkzeug, dass durch hohe Interaktivität auch für kooperative Workshops nutzbar wird.

Zur Beantwortung der zweiten Frage sind die Rangordnungen aus der Umfrage ausgewertet worden. Das überraschendste Ergebnis ist dabei das schlechte Abschneiden der interaktiven Verknüpfung von 3D Landschaftsvisualisierungen und Indikatordiagrammen, obwohl diese Kombination in der qualitativen Studie viel versprechend abschneidet. Der Vergleich von Nutzern mit hoher Kartenkompetenz zu Nutzern mit niedriger Kartenkompetenz zeigt, dass die Einbindung von Indikatoren relativ hohe Anforderungen an die Kartenkompetenz stellt. Die anderen Hypothesen zeigen mehr Übereinstimmung mit den Ergebnissen aus der qualitativen Fallstudie. Navigation über verschiedene Zeitpunkte und zwischen alternativen Szenarien werden von allen als wichtig bewertet.

Zusammengefasst weisen die Ergebnisse darauf hin, dass Interaktivität zu offenen, besser informierten, transparenten, Konsens- und Lern-orientierten Dialogen in der Planung beiträgt. Deshalb sollten Landschaftsvisualisierungen, wenn sie mit kooperativen Methoden zusammen eingesetzt werden, ein Mindestmass an Interaktivität besitzen. Das abschliessende Kapitel enthält dazu nähere Empfehlungen, wie sich interaktive Landschaftsvisualisierungen in kooperative Workshops integrieren lassen. Langfristig ist damit zu rechnen, dass dann die Wahrnehmung der Landschaft in ihrer dynamischen Dimension stärker zur Geltung kommt. Vor allem aber erscheinen interaktive Landschaftsvisualisierungen wesentlich geeigneter kooperative Szenariomethoden zu unterstützen als statische Visualisierungen. Auf Grund dieser Ergebnisse ist anzunehmen, dass die Interaktivität als wesentliches Kriterium von Landschaftsvisualisierungen in der Zukunft weiter an Bedeutung gewinnen wird.

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The notation of figure sources in this thesis

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Appendix

1. Introduction and research questions: The role of interactivity in landscape visualization

1.1 The problem of communication biases in participation

Landscapes are constantly being changed by both natural and anthropogenic forces. In Switzerland, public discussion is concerned about increasing urbanisation and the loss of biodiversity, the future of agriculture, and the impact of climate change on the landscape. In its current report on spatial development in Switzerland, the Federal Office for Spatial Development (Quincerot et al. 2005) warns that traditional planning procedures increasingly fail to ensure a sustainable landscape development.

Current policies across Europe and Switzerland acknowledge that the landscape is a rare resource and has to be managed in a sustainable way with public participation playing an important role. Participation is thought to increase the legislative foundation of planning decisions and to establish a broader basis for planning decisions. Furthermore, participation should improve the quality of planning outcomes through the early involvement of key stakeholders and their knowledge. For the members of the European Union, the Aarhus-Convention specifies the new qualities of participation in environmental and landscape planning, including better information, broader and more transparent decision-making processes and wider legal rights for the public (UNECE 1998). For Switzerland, similar guidelines are in place, although the more innovative approaches are usually applied as informal supplements to the obligatory public involvement (Schmid 1999).

Despite the broad acceptance of participation, many participation processes fail to fulfil the expectations and in practice, debates often lead to a dead end (Selle 2005). In landscape planning, the key problem is the lack of communication among stakeholders as Kaule (1994) and Luz (1996) have shown. According to their arguments, the landscape and its values are perceived in different ways by different stakeholders. If the communication between the different stakeholders could be facilitated, the participation process will gain in quality and produce more effective outcomes. Luz (1996) further criticises that experts in landscape planning often withhold their knowledge from the public, establishing "power through knowledge". Even if the experts are willing to share their knowledge, they are often not able to communicate in the language of the public. Additional tools are needed to communicate the necessary information in order to bridge the knowledge gap between experts and lay people. Effective "participation has to counter the different levels of knowledge and skills of participants in order to allow a fair process," (Bischoff et al. 2006: 14).

1.2 Interactive landscape visualization as a tool for collaborative planning

How could the dialogue in participation be facilitated? First of all, it is necessary to further promote more communicative and cooperative approaches to participation and to develop appropriate tools to support these approaches.

1.2.1 Interactive visualization as "common currency"

This thesis proposes collaborative planning (Healey 1997; 2006) as the most appropriate approach for stakeholder participation in landscape planning. Healey (2006) described collaborative planning as participation practices that are more 'enabling' than 'controlling', which focus on the needs and demands of the people, and which emphasize an active understanding of democracy (Healey 2006). In collaborative planning, all stakeholders have equal shares in the development of the planning strategy. Key concepts are a fair and mutual dialogue and consensus-building. Provided that participation is implemented in a collaborative way, it is still necessary to counter the inherent communication biases that result from different knowledge levels of different stakeholder groups and experts.

There are strong arguments that visualization tools facilitate the dialogue, increase fairness and transparency (Al-Kodmany 1999; Bishop and Lange 2005; Sheppard and Meitner 2005). In a disperse planning world, visualization may become the "common currency" (Appleton 2001) that brings planners, politicians and the public together. Visualizations can "give us the opportunity to see, experience and understand environmental changes before they occur. Through the ability to share this experience and the potential for exploration, visualization will help communities (of whatever size) to build consensus and make decisions about their future" (Lange and Bishop 2005: 3).

In the context of collaborative planning, the integration of the landscape visualizations in the discussion is as important as the quality of the representation, because the objective of collaborative planning is an open dialogue, not an one-way presentation. That means, the participants anticipate some visual feedback and therefore, interactive landscape visualizations are needed. As Danahy (2001) and Orland et al. (2001) argue, it is also a matter of legitimation. If people are to be in control of the planning process, they will need to be in control of the tools as well. In consequence, it is the basic assumption of this thesis that interactivity is a key requirement for the meaningful integration of landscape visualizations in collaborative planning.

1.2.2 Definition of basic terms

For the further understanding, it is necessary to define the key terms in advance. The following terms are discussed in detail in the literature review in chapter 3.

> *"**Visualization** is the action of forming a mental image or becoming aware of something through graphical aids," (Blaser et al. 2000: 4).*

In contrast to traditional visualization methods, such as sketching or photomanipulation, this thesis refers to computer-generated landscape visualizations. These are based on geodata and make it possible to show 3D perspective views from different viewpoints and from abstract to photo-realistic levels of realism (Ervin 2001; Sheppard and Salter 2004).

> ***Landscape visualizations** represent the visual landscape in 3D perspective views and with varying degrees of realism. The presentation of landscape visualizations can be static or dynamic, on different levels of interactivity and on immersive or non-immersive displays (Sheppard and Salter 2004; Bishop and Lange 2005).*

This thesis focuses on interactivity. A literature review showed that a generally accepted definition of interaction is almost impossible because the term is widely used, and its meaning varies for each discipline. Originally, the term interaction was derived from the Latin "inter – between" and "agere – acting", and it has been used in sociology to describe the two-way communication between two or more people (human-human interaction). A key attribute of human interaction is that the participants share a common objective for their action, therefore collaborative planning is a good example of human-human interaction.

> *In sociology, **interaction** is the two-way communication between two or more people (Bollman 2002).*

The term interaction has been adopted for human-computer interaction (HCI), a rather new field of computer science, where interactions describe the actions between a human user and a computer. The derived term interactivity refers to the capacity of landscape visualization tools to support interactions. In geovisualization, Fuhrmann (2001) refers to human-computer interaction and defines the term as follows:

> *In geovisualization, **interaction** is "a series of goal-oriented actions that take place in a three-dimensional space (the representational space) and that are determined by the interrelation between human and computer,"* (Fuhrmann 2001:192).

1.2.3 Positioning in the research context

The literature on participation and collaborative planning provides the criteria to assess the impact of interactive landscape visualizations on the participation process. This study is thereby distinctive from studies in human-computer interaction because the participation process is the focus and not the individual.

In 1987, Zube et al. (1987) had already included computer-generated visualizations in his overview on the prospects of landscape visualization. Since then, one of the most important factors of landscape visualizations, the level of realism (see chapter 3.2.1), ranging from abstract to photo-realistic, has been the subject of studies by Lange (2001) and Appleton (2001). In comparison to the role of realism, the role of interactivity is less described. At the conference, Our Visual Landscape, several authors addressed the need for more dynamic and interactive landscape visualizations. Ervin (2001), Danahy (2001), and Orland et al. (2001) claimed that interactivity is particularly promising to support participation in collaborative learning and decision-making, but there is no comprehensive theory on the role of interactivity in the field of landscape visualization. Therefore, it is suggested to consult the related disciplines of cartography and geovisualization for additional input. Models for the cognitive and communicative functions of interactivity can be drawn from the research on interactive maps (MacEachren and Taylor 1994; Buziek et al. 2000; Dransch 2000; MacEachren and Kraak 2001; Buziek 2003; Dykes et al. 2005). Typologies of interactive functions in electronic atlases (Ormeling 1996; Hurni 2005, 2006, 2007) also provide a starting point for the classification of interaction in landscape visualization.

In order to formulate a general visualization methodology for interactivity, more applied research on the impact of interaction with landscape visualizations in planning is needed. An early study by Al-Kodmany (1999) compared an interactive Geographic Information System (GIS) to sketches and the use of maps. The GIS facilitated the late planning phases most, whereas only sketching was interactive enough to serve early visioning. Current research by the Collaborative for Advanced Landscape Planning (CALP) (Sheppard 2004; Salter 2005; Sheppard and Meitner 2005; Lewis and Sheppard 2006; Salter et al., unpublished) provided the first evidence that interactions with landscape visualizations could also benefit other phases in the participation process. In particular, in a collaborative stakeholder workshop on the siting of wind turbines, Lange and Hehl-Lange (2005) observed that real-time movement through the proposal supported the cognition of the proposal in its spatial context. Von Haaren et al. (2005) and Warren-Kretzschmar (2007) tested various types of landscape visualizations, including different levels of interactivity, in the Interactive Landscape Plan for Königslutter am Elm. Warren-Kretzschmar comes to the conclusion that the interactivity of landscape visualizations will become more important for the dialogue with citizens than the further development of higher levels of realism. This dissertation continues current research in landscape visualization with the focus on interactivity.

1.3 Need for applied research on the impact of interactivity and user preferences

Since Zube et al. (1987), a lot of progress has taken place, although rapid technical development is leaving the theory behind. Today, the basic technology is in place, but there is still a lack of empirical evidence on the application of landscape visualizations in participation practice. Most existing studies give only anecdotal evidence on the impact of interactivity on the actual process and outcome of participation. In their conclusion, Bishop and Lange (2005) demand more research on practical experiences in the public use of landscape visualizations. The practical experience with landscape visualizations has to be analysed for both the planning process and the outcome. In comparison to the planning process, evidence of visualization impact on planning outcomes is even rarer in existing research. If any impact of interactive visualizations could be identified in the final plan documents, research on landscape visualization would advance considerably.

However, it is not sufficient to analyse the process alone, a more user-centred approach is needed in parallel. In the initial problem definition (chapter 1.1), the communication biases between different user groups were identified as a key problem in participatory landscape planning. In this context, it has been suggested to address different user groups specifically in geovisualization with regard to their needs (Dykes et al. 2005). Therefore, research on user preferences with regard to interactivity is needed parallel to the analysis of the impact.

1.4 Research questions

In order to consider both the planning context and user requirements, two research questions are included in this thesis. Thus, the role of interactivity in landscape visualization is analysed from two perspectives. The benefits of interactive landscape visualization for the participation process is of key interest for planning. This view is complemented by an user-centred approach, i.e., that the user assessment of different interactive landscape visualizations is considered as well.

The first research question asks what impact different types of interactions with landscape visualizations have in collaborative planning. It is particularly interesting how far different types of interactions facilitate the process and improve the outcome, because tools are needed to overcome the communication biases in participation.

> **First research question:**
> **How do different types of interactions with landscape visualizations facilitate the process and improve the outcome of collaborative planning?**

A typology of interactions is provided in chapter 3.5 of the literature review. The positive and the negative impact is analysed with regard to the collaborative process as well as its outcomes. The criteria to assess the benefits for process and outcomes are derived from the literature review on collaborative planning in chapter 2.4. The first research question is addressed in the qualitative multiple-case study in chapters 7 and 8.

The second research question asks whether different user groups vary in their preferences for different types of interactions. The objective is to identify which groups vary in their preferences for different types of interactions.

> **Second research question:**
> **Are there any relationships between user group characteristics and user preferences for different types of interactions?**

Hypotheses on possibly distinctive group characteristics, e.g., age and gender, are derived in chapter 4. The second research question is addressed in the quantitative survey in chapter 9.

1.5 Research objectives

The first two objectives contribute to theory-building in landscape visualization. In this context, the research gap on the role of interactivity is addressed. Objectives are to identify the benefits and limitations of different types of interactions from the planning perspective, and to identify different user group preferences. This research thereby complements the existing research by Lange (1999), who addressed the level of realism, and the related PhD thesis by Wissen (2007), who addressed the impact of different types of representation.

The third to fifth objectives are recommendations for the practical use of interactive landscape visualizations in planning workshops. In this context, the research complements the existing guidelines by Warren-Kretzschmar (2007) and Sheppard (2001, 2005c). Furthermore, recommendations are given, on how the field of computer graphics may respond to the user needs in collaborative planning and to the needs of different user groups. The research methods, which were developed for this thesis, are also tested for their transferability to other tasks in landscape visualization. The sixth objective seeks for a general outlook on the future role of interactive landscape visualizations in planning participation.

In summary, the objectives are to

1. Identify the benefits and limitations of different types of interactions for the quality of collaborative planning.
2. Identify user characteristics that are correlated to user preferences for different types of interactions.
3. Provide recommendations for planners, workshop facilitators, and visualization navigators on how to apply interactive visualization techniques in collaborative planning settings.

4. Provide recommendations for software developers and interface designers, on where to direct the future development of interactive landscape visualization.
5. Provide recommendations for future research in landscape visualization.
6. Discuss the future implications that interactive visualization tools may have for planning participation.

1.6 Scope of the research question

Planning needs reliable evidence on the quality that interactive landscape visualizations add to the collaborative planning process and this evidence has to be collected from a planning perspective. If the benefits of landscape visualization as a tool for dialogue can be verified, practical recommendations can be given as well. The research aims to contribute to both theory-building in landscape visualization and to the practical application of landscape visualizations in workshops.

In contrast, cost-benefit and usability issues of visualization technology will be covered by the software industry and the market as soon as there is a need for these tools (Sheppard 2005:79). Therefore, issues of cost-benefit and usability are not included in this research. Because the workshops take place in small groups, online tools are not included in the study either. The importance of online visualization tools will certainly grow in future, but collaborative planning requires face-to-face dialogue.

1.6.1 The VisuLands project – opportunities and constraints

This thesis is based on research that was conducted during the EU project VisuLands. The main objective of the VisuLands project was to develop and test interactive landscape visualizations as new tools for public participation in landscape planning. These tools are based on geodata and they allow the spatial analysis and flexible visualization of the current state as well as future scenario alternatives. In order to combine the assessment of the visual qualities of the landscape with other aspects of sustainability, the visualizations were presented in combination with a set of indicators that were developed through the project (Miller et al. 2006). In collaboration with this research, a master's thesis on user responses to visualization tools (Hislop 2005) and a PhD thesis on the information intensity in different visualization types (Wissen 2007) evolved from the VisuLands project.

The VisuLands project offered unique access to ongoing participation processes in practice, but it also limited the control over the research. It must be pointed out that all observations and interviews took place in a real-world context, where the researchers had only limited control over the variables because stakeholders, facilitators and research partners regulated the procedure.

1.7 Thesis outline

The literature review addresses the state of research in collaborative planning in chapter 2 and landscape visualization in chapter 3. Participation programs, methods and techniques are discussed as far as they are relevant for the case study, especially workshops and visualizations. The literature review on collaborative planning results in five key characteristics of participation and describes the shift towards collaborative approaches in participation. The literature review on landscape visualization focusses on interactivity. It starts with a classification of landscape visualizations with regard to their level of virtuality (Heim 1998), i.e., information intensity, immersion, intelligence, interface and interactivity. The cognitive and communicative functions of interactivity are then addressed in detail with references to cartography and cognitive psychology. The review of the cartographic literature results in a preliminary typology of interactivity.

Altogether, the results from both literature reviews on participation and interactive landscape visualization lead to the formulation of the research hypotheses in chapter 4. Chapter 5 explains the selection of the UNESCO Biosphere Entlebuch as case study site. In the first part of chapter 6, the database, scenario, and visualization methods are explained for all three case studies. The research methods are explained in the second part of the sixth chapter. Three research methods are applied, i.e., qualitative single case analyses, a qualitative cross-case analysis, and a quantitative survey of user preferences. In chapter 7, the three cases, i.e., the series of collaborative workshops on tourism, agriculture and forestry, are described and analysed individually. The cross-case analysis in chapter 8 brings the three cases together and investigates similarities and differences across them. Together, the single case studies and the cross-case analysis allow an answer the first research question. The second research question is addressed in the quantitative survey on user preferences of different types of interactions in chapter 9.

In the final chapter, the potential benefits of interactivity in landscape visualizations are assessed from the planning perspective and with regard to the initial hypotheses. Recommendations for planning practice as well as research and development are given. The thesis ends with a review of the research objectives and an outlook on the future role of interactivity in landscape visualization.

2. Literature review: Participation and collaborative planning

The concept of participation in planning theory is the basis for this dissertation and distinguishes it from interaction studies in human-computer interaction or cartography. In contrast to these related disciplines, it is not the usability of the landscape visualizations but their contribution to the participation process that is the focus of the analysis. Therefore, it is the objective of the literature review on participation to derive criteria to assess the benefits of interactive landscape visualizations.

2.1 Five questions on participation in practice

In the following, the main aspects of participation are assigned to the five questions: who, what, how, how far, and why. This classification is based on the similar structure by Selle (2000), but the understanding of different levels of participation and their terminology refers to Arnstein (1969), van Lammeren and Hoogerwerf (2003) and Beckley et al. (2006). The resulting characteristics of participation are the basis for the criteria for the subsequent assessment of interactive visualization tools in chapter 2.4.

2.1.1 Why participation? Reasons for participation

In its tradition, planning has referred to various theories from the fields of economic planning, physical planning and public administration and policy analysis. In the management of public administration, participation has evolved as a style of governance since the 1960s. In this context, participation means active involvement in spatial decision-making processes. Initially, participation was the response to increasing claims for active citizen involvement in local decision-making. This idea was first formulated in American and British planning in papers by Davidoff's "Advocacy and pluralism in planning" (1965), Gans (1969), and Arnstein's "Ladder of Citizen Participation" (1969), who demanded citizen empowerment as a countervailing power to administration.

There are two main lines of argumentation for participatory planning approaches. The first argumentation refers to the initial idea of citizen empowerment through participation and justifies participation as a requirement for the legitimation of planning decisions (Offe 1972). Especially on a local level, where planning decisions have a direct impact on people's lives, participation is needed to monitor political decisions in a representative democracy. The second argumentation, which is inductive, refers to the effectiveness of planning practice and the quality of the planning outcome. In a shared power world, local administration is increasingly dependent on the support of local citizens as well as external investment. Conventional planning approaches have difficulties in achieving this support and, often, proposals are blocked through legal objections or they fail because key stakeholders refuse their cooperation.

The term participation includes a rather broad variety of concepts and characteristics that have changed considerably over the years. The following chapters refer to Forester (1989), who argued in "Planning in the Face of Power" that planning has to counter communication biases, and to Healey's (1997) influential work "Collaborative Planning". Healey (1997; 2006) promoted the idea of collaborative planning, which involves the sharing of power among stakeholders and the principles of dialogue and consensus-building as the most democratic and effective form of participation. The characteristics and methods of collaborative planning set the requirements and criteria for the assessment of the interactive visualization tools in this dissertation. Selle (1994: 11) also argued that "planning is communication", but he had a more pragmatic approach. Based on an inductive analysis of current trends, Selle (1994; 2000; 2005) described the (re)discovery of communication in planning for the German planning context.

In comparison to other countries, the Swiss direct democracy already ensures a high level of citizen control, because citizens can vote on major development projects and this form of democracy surely facilitates participation. If a proposal is approved by the general public, it is important that the local stakeholders support its implementation because landscapes are not formed by a single actor but through land use by multiple stakeholders. If local stakeholders participate in shaping the landscape management strategy, the quality of the outcome is likely to improve and the later implementation becomes more likely as well (Luz 2000). Here, participation processes offer various chances to increase the effectiveness of planning:

- Overcoming distrust in the planning.
- Contribution of local knowledge to the planning decision, i.e., getting a more realistic view.
- Recognising diverse interests of local people.
- Higher acceptance and support of planning decisions among people through consensus-building.
- Better support of the implementation of planning decisions.

(Healey 1997; Luz 2000; Selle 2000)

2.1.2 Who? Diversity addressed through an inclusionary process

The choice of participants involves questions about roles, power and equal rights. It must be recognised that there is rarely a homogeneous group of participants and diverse groups of stakeholders with different roles are affected by planning issues. In participation, the concept of stakeholders has been applied to planning in order to demonstrate that participants have certain interests or stakes. Stakeholders can be individual persons or interest groups, organisations or private companies, and often stakeholders hold multiple stakes (Beckley et al. 2006). According to Selle (2000), planning stakeholders can be assigned to one of the three groups: state, business or public. Within each of these groups, stakeholders have different abilities depending on their education, social context and everyday life situation. These differences among various stakeholders must be acknowledged in the participation process.

Healey (1997) calls for an "inclusionary" process that addresses issues of justice and sustainability. An inclusionary process is an open voluntary process with equal chances, in which the diversity of the stakeholders is addressed. The process must not be confined to an "elite circle", but everybody must have the chance to participate. On the other hand, it is not useful to aim participant measures at an abstract general public, because such measures will easily fail to address the specific needs of different stakeholders. Instead, it might be more useful to address a fair selection of different stakeholder groups (Selle 1994). Furthermore, stakeholders have different needs than members of the general public. The general public first needs to be addressed in an affective way, whereas stakeholders and experts require support in evaluation and decision-making tasks. Therefore, it may be useful to work in separate groups, if specific cognitive needs are addressed or if it is necessary to support minorities in expressing their needs. In this context, appropriate tools are needed to address different groups with regard to their specific needs. With regard to landscape visualizations, these needs may differ with regard to gender, age, and individual skills, such as map reading skills (see chapter 2.4.1).

2.1.3 What? Relevance of the topic

What is the planning issue under discussion? Issues and objectives have to be defined precisely and transparently. If the issues of a participation process are clear, people will be able to assess the benefits of participation and the relevance for their everyday life (Selle 2000). Usually, the more specific the problem, the better the participants know the area and the stronger they are affected, the more they will be involved (Bischof et al. 1996). Still, planning authorities and the public may differ in their perceptions of problems; local people might identify different issues as relevant to them. Therefore, the interactive visualization tools have to be flexible enough to address diverse perceptions and unexpected changes in the agenda.

2.1.4 How far? Levels of participation

2.1.4.1 Arnstein's ladder of participation

Arnstein (1969) was the first to describe different levels of participation. With regard to her "ladder of citizen participation", any attempts at manipulation or therapy cannot be regarded as participation at all. These terms still evolve from the context of their time, today administrations rarely try to "therapy" the public anymore. However, there might still be manipulation, not only through the administration, but also through private investors and other stakeholders. Arnstein describes informing, consultation and placation as "degrees of tokenism" which means that people take part in the planning process, but without any real decision power. According to Arnstein, real participation

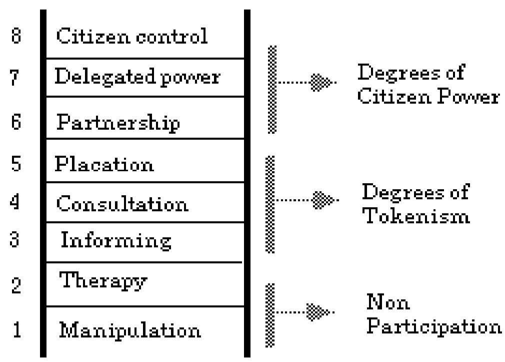


Figure 2.1: Arnstein's ladder of citizen participation (Arnstein 1969: 216).

involves the cooperative sharing of power, i.e., in the form of partnership, delegated power and citizen control.

Arnstein's ladder of participation has to be seen in the context of its time. When she set up the ladder, participation was mainly an issue for citizens claiming more democratic rights. Today, the conflict between citizens on the one side and government on the other has resolved into a more complex situation with multiple stakeholders. Various authors tried to acknowledge the changed situation with modified "ladders of participation" with different emphases (van Lammeren and Hoogerwerf 2003; Beckley et al. 2006).

2.1.4.2 Continuum of participation

Van Lammeren and Hoogerwerf (2003) and Beckley et al. (2006) summarise the most influential classifications of today and identify five common levels of participation. These levels are not exclusive in relation to each other, so that Beckley et al. (2006) order them as a "continuum of participation" rather than a ladder.

Level of Participation	**Information Exchange**	**Consultation**	**Advice**	**Cooperation**	**Co-Decision**

Table 2.1: Basic levels of participation, ordered as a continuum with an increasing level of participation from left to right (Beckley et al. 2006: 25).

By ***information exchange***, van Lammeren and Hoogerwerf (2003) refer to an one-way communication process, in which one party informs the other. Comprehensive and fair information is a prerequisite for meaningful participation and although information on its own is not sufficient for the democratic legitimation of a project, it is the basis for further levels of participation. In contrast to information, ***consultation*** is a two-sided process, in which the public is asked for feedback, e.g., questionnaires or forms, but without a binding character for the planning authorities. In this classification, ***advise*** involves a stronger commitment of the planning authority to take the comments into account. Often, this kind of participation is organised in the form of an advisory board. It is only ***cooperation*** in which all planning stakeholders have equal shares in the development of planning strategies. Collaboration requires a fair and mutual dialogue and joint working relationship, which are described in detail in the following paragraphs. In ***co-decision***, the responsibility is partly or even completely delegated to the public. Apparently, collaboration and co-decision overlap and cooperation includes a certain degree of co-decision by definition.

2.1.4.2 Participation and group size

Each of the previously listed levels has individual strengths and weaknesses, depending on the stage of planning and the group size. The main argument is that large numbers of people can effectively participate on the levels of information or consultation only, whereas truly cooperative work and co-decision-making require small and stable groups to reach a consensus (van Lammeren and Hoogerwerf 2003; Selle 1994).

2.1.5 How? Focus on the participation process

How can a consensus be achieved in a dispersed context of various stakeholders with different interests, powers and possibilities? First of all, appropriate arenas have to be constructed where all stakeholders can be involved in a convenient way, and which are equipped with sufficient staff and funding (Healey 1997; Buchecker et al. 2003; Rösener et al. 2005). Practically, the arena includes issues such as appropriate timing that fits all participants, announcements and invitations to the target groups, and appropriate technical support, from flip charts to maps and high-end visualization tools, if necessary.

The basic principle of collaborative planning is the consensus-oriented dialogue. Healey (1997) states that the only way to reach consensus is an interactive dialogue with an open end, i.e. the planning authority must not provide the final outcome in advance. As Sanoff (2000) comments, consensus-building is crucial to collaborative planning and this involves a shared sense of purpose, the sharing of information, visioning and the creative generation of ideas and alternatives.

Healey (1997; 2000; 2006) notes that consensus is not the most important outcome of collaborative planning, but only a means to an end. The overall objective is that people learn through interaction with each other and that they use their new knowledge to change things.

2.2 Collaborative planning as an approach to participation in multi-stakeholder contexts

The philosopher Habermas' (1981) "**Theory of Communicative Action**" has been most influential for the shift in planning towards more communication. In his theory of communicative action, Habermas formulated a vision for consensus-oriented communication. In order to facilitate consensus-oriented communication, he derived four ethical norms for communication, i.e. comprehensiveness, objective truth, normative correctness and subjective truth. Forester (1989) had a deductive approach, in which he adopted Habermas' theory to planning in order to understand planning as a communicative process. Transferring Habermas, Forester (1989) argues that communication is crucial for any planning process, but that communication in planning is inherently biased. Reasons for this bias are the structural, i.e. the institutional and personal, influences from the planning context. Forester analysed the role of planners in this setting and states that planning professionals are so-called gatekeepers. Planners are in control of the information, so they can use their position to either facilitate or prohibit the communication process. Forester reasons that planning has to counter the existing communication bias and transfers Habermas' ethic norms of communication (comprehensiveness, objective and subjective truth, correctness) to planning practices. In order to apply these norms in a consensus-oriented communication process, planners have to teach planning participants and they need communicative tools for collaborative work and for the mediation of conflicts.

2.2.1 The "communicative turn"

Like Forester, Healey (1997) also referred to Habermas´ Theory of Communicative Action and she emphasized that planning strategies are the outcome of a social communication process under specific conditions. Today, these conditions are shaped by a multi-stakeholder society and she asked how planning could achieve sustainable results in such a context. Based on the assumption that knowledge is constituted through socially interactive processes, policies and plans have to be seen as actively constructed by people. That means people learn about their views in a social context and through interaction with others. Their views are likely to be diverse and can be brought together either in competitive interest bargaining or in collaborative consensus-building (Healey 1997). This communication process can take many forms, e.g., in words or pictures. Healey (2000) calls the shift towards a higher priority of communication in planning the "***communicative turn***".

Healey (1997; 2006) terms the various approaches in participation that are characterized by the sharing of power, group learning and a consensus-oriented style of communication as "***collaborative planning***". The main objective of collaborative planning is not a particular plan but to ensure an effective and democratically legitimate process. It has to be ensured that all relevant stakeholders have equal opportunities to participate and that diverse interests are represented in the process. Collaborative planning is only meaningful if the issues are relevant to the everyday-life environment and if people can effectively make decisions on the important issues. Therefore, it is necessary to open the decision-making process to everybody and to provide sufficient arenas, institutions, and tools for a constructive dialogue. In collaborative planning, the focus is not on the production of an attractive image but on the participation process. Correspondingly, the following statement can be applied to the use of visualization tools:

> *"The focus is on the processes through which participants come together, build understanding and trust among themselves, and develop ownership of the strategy, rather than the specific production of decision-criteria or an attractive image" (Healey 1997: 249).*

In summary, collaborative planning is a participation style or rather an approach to increase the legitimation and effectiveness of participation in dispersed and diverse stakeholder contexts. Pre-requirements are credible and transparent information transfers across all stakeholders. An inclusionary process, built on dialogue and consensus, is fundamental to achieving learning outcome. However, in practice, collaborative planning is rarely observed in its pure form, but in combination with conventional bureaucratic or technocratic, with formal or informal approaches. Thereby, collaborative planning may include various levels of participation (Healey; Selle, personal communication).

Characteristics of collaborative planning	
Governance context	Dynamic situation Dispersed power Fading trust in the government and experts Diverse public
Communication	Interactive, explorative
Why?	To achieve an effective and legitimate strategy
Who?	Involvement of all relevant stakeholders ("inclusion") Planner as facilitator
What?	Problems that are relevant to the people
How far?	High level of participation, allowing collaboration and co-decision
How?	Provide an appropriate arena and sufficient funding and staff Balance different knowledge levels Ensure a credible and transparent process Facilitate dialogue and consensus-building

Table 2.1: Collaborative Planning (partly with reference to a presentation by Healey 1999)

2.2.2 Discussion on the limitations of collaborative planning

In response to the approach of collaborative planning by Healey (1997), Rydin (1998) contributed some critical comments on the limitations of collaborative planning in practice. Rydin's statements created considerable response in the British planning literature and started a rich discussion on the success of participation in general.

Rydin (1998) doubts the potential for creating consensus out of conflicts. Habermas (1981) assumes that consensus is inherent to the communicative act by definition and it is only prevented by negative conditions. In contrast, Rydin (1998) argues that some conflicts cannot be solved by consensus. Instead of creating a "false" consensus, in which the weakest stakeholders have to bear the disadvantage, the differences need to be acknowledged and accommodated. In her retrospective, Healey (2006) agrees that her original concept of collaboration was too much focussed on consensus.

Secondly, Rydin (1998) is sceptical of the chances for an equal relationship between experts and lay persons without any paternalism and distrust. In Rydin`s point of view, it is unrealistic that planners could fulfil their tasks in giving expertise as well as enabling and empowering people in one. He argues that both roles conflict each other, especially as professionals have interests of their own. To make it even more complex, the use of visualization tools will bring additional experts, e.g. a visualization navigator, into the process and this role has to be questioned just as the role of the planner before. On the other hand, expert input is needed to facilitate a meaningful collaboration among local stakeholders beyond their everyday experiences. In conclusion, the transparent distinction of the different roles and a neutral facilitator can help to clarify the relations between the various participants.

Selle (2005) provides a more recent analysis of the failures of planning participation. At a time when participation has become part of the planning mainstream, participation is officially supported by the authorities but often misused as a “plastic instrument” without any effective impact on the built environment. The low relevance of participation processes is often the consequence of the shrinking powers of planning authorities. If key decisions are made by anonymous stakeholders in the economic sector and not by the planning authorities, public participation processes will not have an impact.

Despite their objections, both Rydin (1998) and Selle (1994) agree that the participation of people in planning must be facilitated and they see participatory potential in bottom-up initiatives. However, the discussion shows that some failures of participation today are *not* technologically resolvable, but are a matter of general social and political tendencies and engagement. Interactive visualizations may contribute to a better informed process and facilitate dialogue among diverse stakeholders, but visualizations cannot make up for the lack of a participatory culture in general.

In this dissertation, the concept of collaborative planning is selected as the guideline to participation. The criteria for the assessment of interactive landscape visualizations are chosen in accordance to the characteristics of collaborative planning. Also, methods and procedures are chosen that fulfill the requirements of collaborative planning according to Healey (1997; 2006).

2.3 Participation programs, processes and tools

During the short tradition of participation in planning, a broad set of participation programs, processes and tools have been developed. Before the methods and techniques from the case study are introduced, it is necessary to distinguish public participation tools, processes and programs:

- "Public participation programs refer to organization-wide strategies and delivery infrastructure."
- "Public participation processes involve the use of specific tools to accomplish discrete planning or consultation activities."
- "Public participation tools are distinct techniques or mechanisms such as workshops or surveys." (Beckley et al. 2006: 16)

According to the definition, ***public participation programs*** are more general guidelines, e.g., from an organisation. Relevant programs for the case study site, the UNESCO Biosphere Entlebuch, are the UN programs on sustainable development, the Sevilla strategy for Biosphere Reserves, the Swiss constitution, and the Swiss Spatial Planning Bill.

Beckley et al. (2006) define ***public participation processes*** as a series of events or as a mixture of various participation mechanisms and tools, e.g., the combination of collaborative workshops and information events. The public involvement process in a forest management plan, analysed in the case study, is a good example of such a process. It involves public meetings, a series of collaborative workshops, task forces, and a final public meeting.

Finally, Beckley et al. (2006) summarise various techniques and mechanisms of public participation, ranging from workshops and focus groups to websites, as ***public participation tools***. These tools may differ in their degree of participation, interactivity, costs and barriers. Some require direct contact (workshops, forums, etc.), others are indirect (online tools, phone surveys), some are more formal (public consultations), others are more informal (design charrettes). Above all, there are strong arguments for visual support tools, especially in making topics and results visually comprehensible for different stakeholder groups.

2.3.1 Participation programs in the international and Swiss planning framework

United Nations: Rio Declaration, Aarhus Convention and Sevilla Strategy

On the international level, the Rio Declaration on Environment and Development, adopted at the 1992 United Nations Conference on Environment and Development (UNCED), is the most influential program that addresses participation. Agenda 21, presented in Rio de Janeiro in 1992, summarises the previous development of an UN program on action for sustainability. In Agenda 21, participation is defined as a key requirement for sustainable processes. The rights of the public to open access to information, to participation in decision-making processes and legal rights to their issues of the environment, are confirmed in the UNECE "Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters", also called the Aarhus Convention (UNECE 1998). The ideas on sustainability and participation have significantly influenced the formulation of the UNESCO (1996) Sevilla Strategy and the criteria for the designation of Biosphere Reserves.

European Union: European Landscape Convention

The Council of Europe established participation in landscape development through the European Landscape Convention 2000. The convention not only calls for raising awareness on the value of the landscape but also for participation in the management and planning of landscape change (Council of Europe 2000). Switzerland ratified all three programs, although the Aarhus Convention and the European Landscape Convention have not been adopted by the Swiss parliament yet.

Switzerland: Direct democracy and public involvement

On the national level, direct democracy allows Swiss citizens to challenge any federal law by calling a referendum, provided that at least 50,000 citizens support the referendum by signature. With the support of 100,000 voters, it is also possible to put an amendment to the constitution in place (popular initiative). Local decisions, including minor planning proposals, are decided by the local community assembly. Therefore, the local assembly is an institutionalized forum of direct participation with a long history and a key decision-making institution in landscape planning as well (Lange and Hehl-Lange 2005).

Public involvement in planning strategies and zoning maps is handled more conventionally. Article 4 of the Swiss Spatial Planning Bill defines that federal, cantonal and local authorities have to provide opportunities for public involvement when adopting planning strategies, cantonal guiding plans or local zoning maps. Before a strategy becomes effective, environmental organisations have the right of appeal by legal means in planning proposals. Lange and Hehl-Lange (2005) point out that the right of appeal has been used successfully by environmental organisations and a number of controversial planning schemes were stopped this way. More collaborative approaches are only covered in the form of additional informal processes without obligatory character (Schmid 1999).

In summary, Switzerland has a strong tradition of direct participation on all levels. In addition, planning law includes not only formal regulations for public involvement but also encourages informal means of collaboration. Nevertheless, the processes in rural landscape development are often blocked (Buchecker et al. 2003). If the quality of the processes is to be improved , it is necessary to analyse the actual processes and enhance the tools.

2.3.2 Participation processes

Selle (1994) and Bischoff et al. (1996) point out that only collaborative settings offer interactive involvement. At the same time, collaboration inherently leads to exclusion because it is only practicable in small and stable groups. Bischoff et al. (1996: 11) says that collaborative participation needs to be "integrated into a communicative setting". Such a setting starts with information offers on the decision environment as well as a broad public dialogue on the perception of the general problem. With these activating measures, it is possible to reach target groups who would not participate otherwise. Bischoff et al. (1996) suggest setting up collaborative workshops in the next step in order to analyse the problem, set objectives and develop planning alternatives. Later, the results from the collaborative groups are assessed in the wider public again. In table 2.2, the typical stages of a planning process are linked to the objectives of the participation process.

Planning stage	Objectives of the participation process
1. Decision environment - Legal and institutional context - Political objectives	Create a culture of participation Information about the participation process
2. Problem perception - Problem formulation	Provide initial information
3. Problem analysis (Current state) - Assets - Analysis	Exchange information Assess the current state
4. Analysis of resources and instruments - Scope and potential	Exchange information Assess the current state
5. Objectives	Define issues and goals
6. Objectives-means consideration (how to get from the current state to the target state)	Develop options / solutions
7. Assessment of planning alternatives - Assessment of values - Making a decision with regard to objectives and means	Evaluation
8. Transferring the planning alternative into a program - Resources, instruments, stakeholders, limitations	Co-decision-making / recommendations
9. Implementation	Acceptance and support
10. Plan- (Outcome) and Process- Evaluation (iterative process with the previous steps)	

Table 2.2: Typical sequences of a planning process, based on system theory (Läpple 2003; Hislop 2004).

2.3.3 Participation tools

The overview of tools for participation in table 2.3 is based on the work by Hislop et al. (2001), who assign common participatory tools to the different stages in the planning process. According to Hislop et al. (2001), passive and one-way information measures like newsletters and presentations seem to be sufficient for the initial information phase, whereas the later phases will require more interactive organisation, facilitation and visualization techniques (see also Dorcey et al. 1994). Tools that were also used in the case study, are printed in red.

Provide initial information	Gather information	Define issues and goals	Set evaluation criteria	Develop options/ solutions	Evaluation	Decision-making
• Position papers • Newsletters • Advertisements • Non-interactive display • Newspaper articles • Letters of notification • Mail-outs/printed information • Websites • Public presentations • Exhibition	• Surveys • Case study review • Interactive displays • Toll-free lines • Open houses • Comment sheets • Websites • Mail surveys • Interviews	• Visioning sessions • Brainstorming • Round tables • Town hall meetings • Discussion papers • Consultant papers	• Workshops • Focus group • Forums • Citizen jury • Steering committee	• Workshops • Focus group • Forums • Citizen juries • Open house with provisions for comments • Written/interview survey • Internet surveys • Papers • Panel debate	• Public advisory committees • Steering committees with appointed members • Citizen juries • Scenario testing with or without visualization • Referendum • Charrettes • Task force	• Public advisory committees • Citizen juries • Tribunal • Task force • Mediation

Table 2.3: Appropriate tools for different stages in a participatory planning process (shortened version, adapted from Beckley et al. 2006). The red tools were used in the case study in chapter 7.

2.3.3.1 Tools: organisation techniques

The tools from table 2.3 that are printed in red are described in further detail as far as they are relevant for the study:

a) Workshop

In a workshop, the participants collaborate on a specific issue with clear goals and a limited time frame (Beckley et al. 2006). Workshops may take place in many variants and involve various other group work tools, including visualizations. Hislop et al. (2004) suggest that workshops are excellent for identifying criteria and the analysis of alternatives. However, workshops are rather demanding in terms of preparation and a professional facilitator is needed. Furthermore, it should be noted that workshops are only effective up to a certain maximum number of participants, i.e., it may not be an appropriate approach for broad public involvement. Typical stages of a workshop are introduction, input presentation, brainstorming, discussion, decision-making (Ackermann 1996).

b) Forum

In comparison to a workshop, forums are regular meetings that take place over the long term and often involve participants from stakeholder groups with a mutual concern. Forums are a well-proven method to involve relevant stakeholders early in the planning process and to build up knowledge and trust over time. A disadvantage is that forums are not a good platform to create short-term action (Bischoff et al. 1996; Hislop et al. 2004). In the case study, many participants in the workshops were recruited from well established forums in the region.

c) Exhibition

Although exhibitions are not a collaborative method, they are a suitable tool to explain the background of a project. Depending on the concept of the exhibition, whether it is focussed on information or on motivation, it might also include feedback opportunities. At an early stage of the participation process, exhibitions can serve to inform the public about the problem. Later, exhibitions are suitable tools to inform the general public about the available planning alternatives (Bischoff et al. 1996). In the case study, a local exhibition was the platform used to inform people about the project and to gather additional quantitative feedback on the visualization tools.

d) Intermediate organisations

Being more an element of infrastructure than a particular participation tool, intermediate organisations play an important role. Often, it is easier for intermediate organisations to build up trust among the public than it is for the local administration. Therefore, intermediate organisations can facilitate collaborative processes in a region and balance the interests of different stakeholders (Healey 1997). In the case study, the main partner is an intermediate organisation, the Regional Management of the UNESCO Entlebuch Biosphere Reserve.

2.3.3.2 Tools: facilitation techniques

The following facilitation techniques were applied in the study workshops:

a) Consensus building

Consensus plays a key role in collaborative planning and according to Hislop et al. (2004), there are various ways of consensus building. Consensus is reached when all stakeholders involved benefit from the solution and the group agrees enough to at least go on in the process. Characteristics of consensus building are mutual dialogue and equality, in that all stakeholders, lay people as well as experts, are partners on the same level. Apparently, a solution that is built on consensus will be more sustainable because all relevant stakeholders should support it. However, it may be argued that a consensus with benefits for all is not always possible. Even if it is possible, it will cost a lot of time and engagement to reach consensus among different stakeholders. Here, a professional and independent facilitator is crucial for successful consensus building (Hislop et al. 2004). Therefore, it is critical how the facilitator interacts with the visualization tools.

b) Scenario technique

Various future-oriented techniques have been adapted to planning from other fields of science, e.g., forecasts, modelling techniques, and the scenario technique. In contrast to forecasts, a scenario is the plausible description of how the future may unfold based on a set of 'what-if' propositions (Nakivenovic et al. 2000; Alcamo 2001). They are thought as 'realistic visions' (Reinhard 1990) and the objective is to make people think and discuss, not to give a precise image of the future. Therefore, the focus is on the inner consistency of the scenario storyline rather than on their likelihood to come true. The advantages of the scenario technique are that it supports thinking in alternatives (Stiens 1998) and accommodates alternative views of different stakeholders (figure 2.2). The openness of the method and the focus on qualitative approaches allows complex driving forces and their interdependencies over long planning intervals to be taken into consideration. In addition, qualitative and quantitative information can be combined and presented to lay people in a comprehensible way (Alcamo 2001).

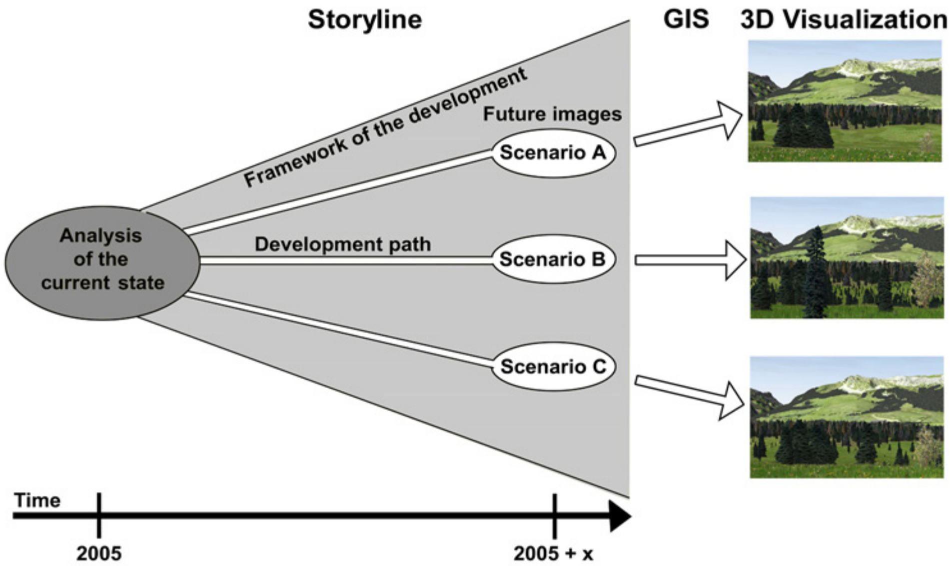


Figure 2.2: Alternative storylines of a planning scenario.

The openness of the scenario technique for subjective ideas and ideals also has some disadvantages. It makes the method vulnerable to misuse and errors, and the focus on qualitative methods raises the criticism of a lack of scientific proof. It is therefore important to make scenarios transparent and have them fulfil scientific criteria, i.e. to provide a clear structure and form, transparent documentation, and good quality presentation (Hansel and Lambrecht 1993).

Stiens (1998) suggests incorporating visual tools to make scenarios more transparent. With the term "scenario cartography", he refers to a method that communicates expert knowledge by using a comprehensive cartographic language, i.e., symbols and strongly generalized topographic elements. In this approach, the scenarios are based on empirical data, e.g., indicator analyses, and these data are filtered, compressed and visually processed by experts as input to the participatory development of trend scenarios. Stien's approach of "scenario cartography" may easily be transferred to the use of 3D visualizations. The combination of scenario method and 3D visualization has already been applied to landscape change by Tress and Tress (2003), Heißenhuber et al. (2004), and Berry (2006), and is also applied in the multiple-case study in chapters 7 and 8.

2.3.3.3 Tools: visualization tools

Readings from architecture, planning, cartography, psychology and education provide various suggestions on the use of visualizations as a moderation tool. For the German-speaking countries, Seifert's (2005) "Visualisieren – Präsentieren – Moderieren" (visualising – presenting – facilitating) is such a guideline, in which various visualization methods, i.e., text, sketches, diagrams, etc., are described. With regard to the different stages of the planning process, visualizations may be used to illustrate questions, to summarise contributions from the discussion, to analyse problems, to illustrate links between driving-forces and to vision measures, to name just a few. Above all, visualizations are a good means for the facilitator to focus on the key points, summarise, and enhance a shared picture.

In planning, landscape visualizations gain an even more important role because they provide spatial references and visual qualities. Visualizations on planning topics may also include temporal and quantitative data (Koschitz 1993). Al-Kodmany (1999) provided the first case study on the application of computer-based visualization techniques to enhance planning participation. In the findings of the case study, he pointed out that different visualization techniques suit different stages of the planning process. One of the most effective tools he tested for the promotion of public participation was an interactive Geographic Information System (GIS). Peng (2001) postulated that GIS has to provide functions for exploration, evaluation, scenario building and forums in order to serve the needs of participation. Moreover, he cautioned that traditional GIS may be perceived as top-down, technicist, elitist and, in the end, non-participatory. In contrast to GIS, interactive landscape visualizations offer additional participatory benefits, which are discussed in detail in chapter 3. However, they do not replace traditional visualization methods, but rather extend them (Warren-Kretzschmar 2007).

2.3.4 Code of visualization ethics

Many technical and human variables, e.g., the background of the user and the actual setup, determine the perception and interpretation of visualizations. Design factors, such as the level of reality, the choice of perspectives, the type of display and the design of the interactive features, all involve ethical considerations.

2.3.4.1 Visualizations are not neutral

Neither visualization experts nor landscape planners are neutral (see chapter 2.2.2, Rydin 1998). This makes it even more important to involve a neutral facilitator in the participation process and to make the expert contributions transparent. In visualization, MacFarlane et al. (2005) point out that a better understanding of the role of the visualization experts is needed for a better understanding of the impact of visualizations on participatory processes and outcomes. Despite all attempts to enhance the usability of the visualization tools, the production of interactive landscape models still requires a lot of technical expertise and gives the authors of the visualizations significant power. The author of the visualization filters the basic data, makes decisions on alternative scenarios and creates an individual conception of the reality, which does not necessarily match the conception of the viewer. McQuillan (1998: 16) states concisely that "*honesty is simply 'telling it like we see it' and admitting the inadequacy of any particular vision – our own included*."

How far can technology support transparency? First of all, it is an important step towards more objectiveness if landscape visualizations are based on geodata (Lange 1999). Interactivity promises additional benefits through giving the users more control of the process. Real-time navigation, for example, allows the user to choose different perspectives. Furthermore, users can choose the level of realism and customize the representation to their individual preferences, they can supplement the visual imagery through statistical data, or they can access the underlying database. However, interactivity is also a matter of design decisions. Therefore, the choice of interactive features may still produce bias, confusion, or may disadvantage people with a low level of computer literacy. In consequence, interactivity can only be the technical part of the solution.

2.3.4.2 Interim code of ethics

In response to the various concerns about a lack of validity in landscape visualization, Sheppard formulated an interim code of ethics in 2001. Since then, the code has been extended to fit purposes such as the visualization of climate change (Sheppard 2005c).

General principles
Accuracy: Realistic visualizations should simulate the actual or expected appearance of the landscape as closely as possible […]; visualizations should be truthful to the data available at the time.
Representativeness: Visualizations should represent the typical or important range of views, conditions, and time-frames in the landscape that would be experienced with the actual project, and provide viewers with a range of viewing conditions.
Visual clarity: The details, components, and overall content of the visualization should be clearly communicated.
Interest: The visualization should be defensible by following a consistent and documented procedure, by making the simulation process and assumptions transparent to the viewer, by clearly describing the expected level of accuracy and uncertainty, and by avoiding obvious errors and omissions in the imagery.
Access to visual information: Visualizations (and associated information) that are consistent with the above principles should be made readily accessible to the public via a variety of formats and communication channels.

Table 2.4: Interim code of ethics (Sheppard 2001; Sheppard 2005c).

2.4 Qualities of collaborative planning

In summary, planning participation is needed for two reasons, first, as means for more democratic decision-making and second, for more effective planning processes and outcomes. The paradigm shift, i.e., the "communicative turn" (Healey 1997), to perceive planning as an act of communicative action has particularly fostered the importance of collaborative participation styles that are consensus-oriented and build on the sharing of power and group learning. After the communicative turn, the dialogue between diverse stakeholders becomes crucial. How may visualization tools serve dialogue-oriented collaborative participation approaches?

2.4.1 Inclusiveness (process)

Healey (1997) has defined "inclusiveness" (see chapter 2.2.1) as one of the key characteristics of collaborative planning. Especially in an increasingly diverse multi-stakeholder world, inclusiveness, i.e., the active involvement of all stakeholder groups, is of great importance. If the diversity of stakeholders is properly acknowledged, tools are needed that address different levels of knowledge, different interests and different styles of learning. This includes the creation of an enabling environment with appropriate resources, institutional and legal backup and, finally, tools that support different stakeholder groups. However, very technical and complex computer tools may impose additional barriers that prevent groups with low computer literacy from participating. Interactive tools have to be analysed whether they address and serve diverse needs, or contribute to equal opportunities and a balanced information basis for all users with regard to their gender, age, and map-reading skills.

2.4.2 Enrichment of information (process)

Friedman (1987) taught that planning is about relating knowledge to action. A rich information basis and, therefore, improved knowledge, is also the start to improved action. The conception of information in knowledge building is addressed in chapter 3.4, and the issue of information intensity is addressed in detail by Wissen (2007).

In landscape planning, factual information may include the position, relations and attributes of landscape elements, as well as thematic information, on diverse scales. In comparison to other fields of planning, landscape planning is particularly complex, because landscape issues are not static but dynamic and change over time. As a consequence, it has been suggested that interactive visualizations will communicate landscape information that is more comprehensible than static visualizations (Bishop and Lange 2005). However, extensive interactivity may distract the user so much that the key message gets lost (see chapter 3.4).

Sheppard (2006) adds an emotional component to the information process. According to him, visualizations are an important means to engage people's emotions on a local and personal level, because landscape preferences are not strictly rational but often emotional. Especially in awareness-building, it is important to consider the emotional dimension of visualizations. There is evidence that realistic landscape visualizations evoke affective response and therefore enrich the process (Wissen et al., in press). Such emotional engagement is not necessarily positive, and in more sensitive situations, it is recommended to avoid any emotional bias in order to ensure the objectivity and defensibility of the discussion. In conclusion, to what degree the interactive tools facilitate a two-way information exchange on landscape dynamics and change has to be analysed, including both rational and emotional responses. In contrast to the knowledge that people gain from "learning", the "enrichment of information" refers to the amount and types of information that are communicated during the participation process.

2.4.3 Dialogue (process)

According to Habermas (1981) and Healey (1997), consensus is constructed through dialogue. A constructive dialogue requires equal opportunities for all participants and their (inter-)active involvement, if it is to contribute to consensus-building. In consequence, discoursive visualization tools must not “railroad” the participants to a predefined track, but allow an open-ended process. Therefore, discoursive tools have to be flexible enough to respond to alternative perspectives in a dialogue without distracting the people.

2.4.4 Credibility and transparency (process)

“Truth” is one of Habermas (1981) key points of communicative ethics. In planning, the complex stakeholder settings with conflicting interests and potential bias require rules for a transparent decision-making process. Credibility and transparency apply to all stages, ranging from the choice of participants, and the selection of input information to the assessment of planning alternatives (Selle 2000). Bishop and Lange (2005), Danahy (2001), Orland and Uusitalo (2001) argue that interactive visualizations are potentially more credible and transparent than prepared static visualizations. In contrast to static images, interactive real-time visualizations allow viewing a planning scheme from different perspectives. Interactive links to statistical data may further support the credibility of the landscape visualization (Hehl-Lange 2001).

However, the tools are still very complex expert tools and involve numerous design decisions, which influence the perception of the landscape visualization (see chapter 3.4). In conclusion, collaborative planning (see chapter 2.2) requires landscape visualizations to be technologically revisable and presentations have to be ethically correct (tables 2.4). The users should be interviewed to discover how credible they perceive the tools to be.

2.4.5 Consensus (outcome)

Consensus is the main objective of collaborative planning (Healey 1997) and it is also one of the major difficulties (see chapter 2.2.2, Rydin 1998). Tools are needed that illustrate arguments, show conflicts and document the agreement. For the analysis of the tools, it is important whether the tools are able to facilitate the consensus-building process. Hereby, it may be assumed that the spatial visualization of conflicts and arguments, i.e., the provision of a shared image, will reveal differences, misunderstandings and agreement.

2.4.6 Learning (outcome)

Based on Habermas' (1983) theory of communicative action, it can be assumed that people learn through communication with others. Learning through communication depends on group dynamics, i.e., the learning outcome is shared. In contrast to "enrichment", "learning" is more focussed on the outcome of participation rather than the process. In the context of this dissertation, the learning outcome is the knowledge built from the enrichment of information during the process. Behavioural changes could be learning outcome of a better informed process, for example. Therefore, the outcome in the form of plans, strategies and other decisions, need to be analysed for new knowledge that was created through interactive learning processes.

3. Literature review: Interactivity in landscape visualization

3.1 Landscape visualization

The literature on landscape planning includes a rich discussion on the potential benefits of computer-generated landscape visualization in planning participation. In this context, various authors from landscape planning, forest management and other environment-related fields (Danahy 2001; Orland and Uusitalo 2001; Bishop and Lange 2005) argue that interactivity in landscape visualization facilitates participation. The chapter starts with an overview of the various distinctions of landscape visualizations (Sheppard and Salter 2004; Bishop and Lange 2005) and the role of interactivity in this context (chapters 3.1 to 3.3). On basis of cognitive psychology and cartography, the benefits of interactivity for individual cognition (MacEachren 1995; Dransch 1995; Dransch 1997c; Buziek et al. 2000; Buziek 2003) as well as communication (Dransch 2000) are described in chapter 3.4. In chapter 3.5, specific planning interactions are classified in a functional typology, based on Hurni (2005; 2006).

3.1.1 Definition of landscape visualization

The following chapter starts with a discussion of the term “landscape visualization” and illustrates its historic as well as current meaning. “Landscape visualization” is composed of the terms landscape and visualization. First, “landscape” refers to a part of the earth's surface which is described through pictorial and functional aspects. Landscape is not perceived equally but landscape perception is determined through individually subjective factors (Lange 1999). Secondly, “visualization” is the act of forming an image from objects, data and phenomena with graphical aids (Bollmann 2002). Zube et al. (1987) provided an overview of historic to recent techniques of landscape visualization, ranging from ancient drawings to today's computer animations. They point out that visualizations are always models, i.e., representations of reality with varying degrees of realism (see figure 3.1).

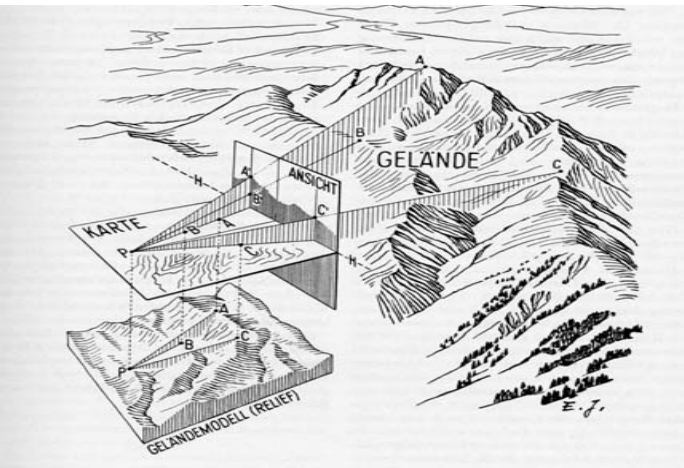


Figure 3.1: Historic synopsis of terrain view, map and terrain model (image: Imhof 1958 or 1968, map collection ETH Zurich), illustrating the representation of reality in a model.

In the 19th century, the landscape architect Repton already included a simple form of interactivity in his "red books": the viewer can turn the page between status quo and the future state (figure 3.2).

Figure 3.2: Before-/ after sketches in a „Red Book" by Repton (photo: Hochschule Rapperswil, year and title unknown).

Today, the term "landscape visualization" is commonly used for computer-generated representations of perspective landscape views (Sheppard and Salter 2004). As landscape visualizations refer to actual places, there is a strong argument that landscape visualizations in planning should always be based on geospatial data to ensure their validity (Appleton et al. 2002). With respect to their geospatial referencing, landscape visualizations are a specific type of geovisualization. The International Cartographic Association (ICA) Commission on Visualization and Virtual Environments defines the term geovisualization in a broad way: "Visualization in scientific computing, cartography, image analysis, information analysis, exploratory data analysis and geographic information systems (GIS) to provide theory, methods, and tools for visual exploration, analysis, synthesis, and presentation of geospatial data (any data having geospatial referencing)" (MacEachren and Kraak 2001).

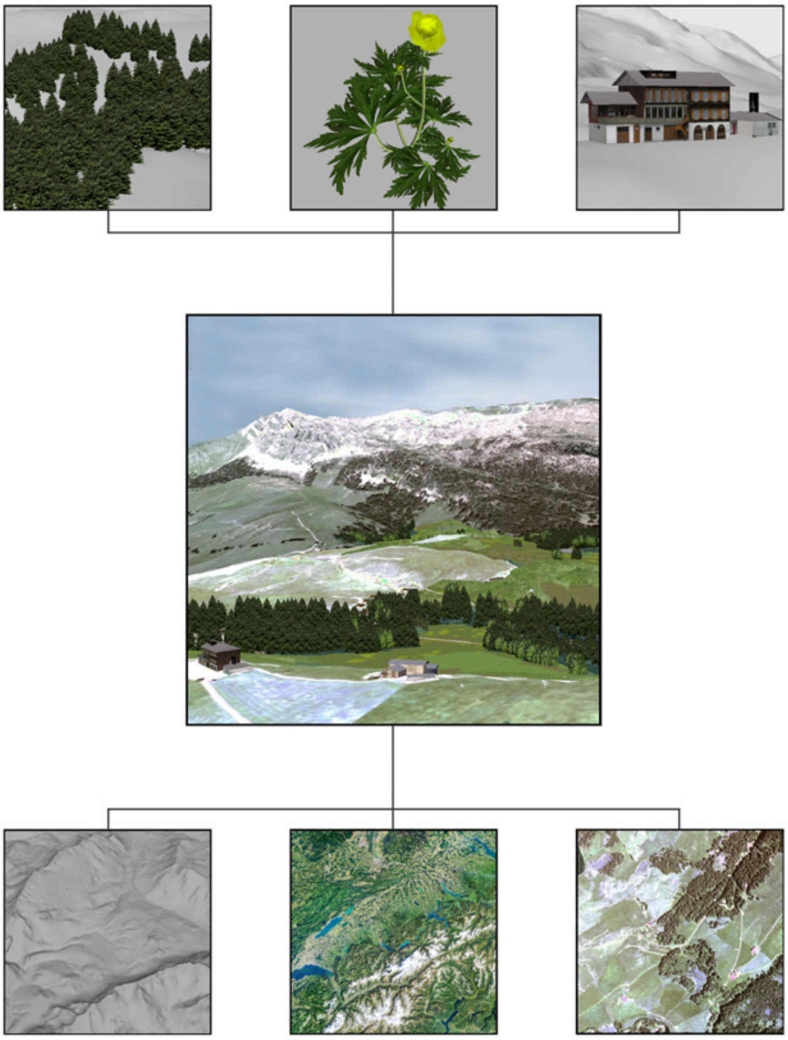


Figure 3.3: Landscape visualization with the basic landscape elements (clockwise from the lower left to the upper left): terrain, orthophoto, satellite image, building objects, individual plants and vegetation (Lange et al. 2003).

Landscape visualizations have to represent the visual qualities of a landscape on basis of the terrain in combination with a geotexture, i.e., a geospecific photo or geotypical ground textures. The key landscape elements, e.g., built objects, vegetation, water, animals, people (figure 3.3; cf. Ervin 2001 for details on landscape elements in visualization) are represented as sprites (billboards) or detailed polygon models. In this thesis, the term "landscape model" refers to the underlying geodata, whereas "landscape visualization" refers to the visual representation of such a model.

Vegetation is particularly important for the visual representation of the landscape. Even the elaboration of individual plants may be necessary to communicate the visual character of a landscape. However, vegetation is the biggest challenge in creating landscape visualizations (Deussen 2003). In geovisualization, vegetation is generalized by types in order to be distinctive – following the key principles of cartography (see figures 3.4 and 3.5).

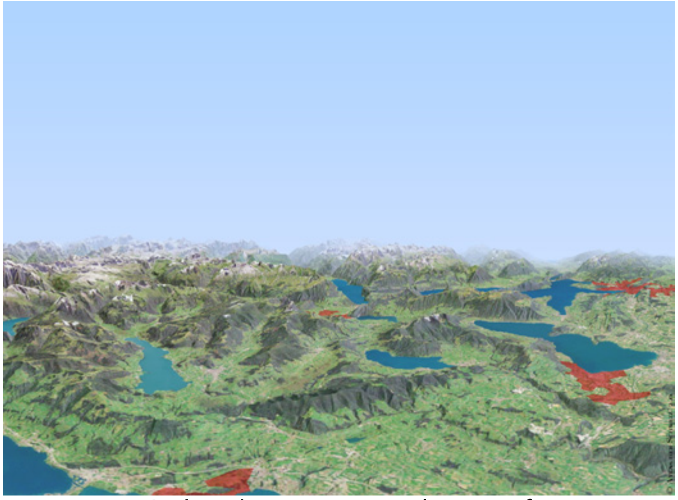


Figure 3.4: Rather abstract geovisualization of a terrain model with satellite image, vegetation and buildings represented by color types (image: Atlas der Schweiz 2004).

Figure 3.5: Photo-realistic landscape visualization, with the emphasis on distinctive vegetation and building objects (image: Schroth, Wissen, Mambretti 2006; rendered in 3D Studio Max).

In summary, the thesis refers to the following definition:

> ***Landscape visualizations*** *are specific forms of geovisualization, which represent the visual landscape in perspective 3D views and with varying degrees of realism. The presentation of landscape visualizations can be static or dynamic, on different levels of interactivity and on immersive or non-immersive displays (cf. Sheppard and Salter 2004; Bishop and Lange 2005).*

In the case study, it is necessary to describe the analysed landscape visualizations in detail. For that purpose, Bishop and Lange (2005) identify a number of distinctions in order to describe the differences in visualization options, including dynamics, the level of information density or realism, immersion, "intelligence" and interactivity. These factors are well established in the cartographic context, which provides the following two classifications. First, visual variables (Bertin 1967) and second, the correlation between reality and virtual representation, i.e., the level of "virtuality", are discussed in the next section.

3.1.2 Distinction of visualization objects by visual variables

In landscape visualization, visualization objects are the equivalents to mapping objects in two-dimensional maps. If specific visualization objects are described, the cartographic concept of graphic variables is helpful. Originally, Bertin (1967) defined a set of variables for 2D maps before Häberling (2003) transferred the concept of variables to three-dimensional topographic maps and Buziek (2003) to interactive maps. For static 2D maps, Bertin (1967) classified the various design options for a map object into eight visual variables: the x- and y- position coordinates, size, shape, brightness, pattern, color and direction. This basic typology became the origin of all further classifications in cartography and is still important, though not sufficient, for the description of objects in landscape visualizations.

In three-dimensional perspective representations, some of Bertin's variables change their functions. Scale, for example, is perceived differently with regard to the perspective. The classification of visual variables for three-dimensional representations is still in its beginning and Häberling (2003) was one of the first to identify variables that are applicable to 3D topographic maps. According to Häberling, the variables can be classified into twelve aspects. These aspects are the modeling of terrain, topography and orientation objects (compass, coordinates, scale, etc.); representations, texture, text objects, object animation, projection, camera, lighting, shadowing, and atmospheric effects. Each aspect includes further variables, e.g., the texture is defined by structure, transparency, material, pattern, orientation, etc. For the complete list of design aspects and variables, refer to Häberling (2003: 54-56).

Dynamics are defined as the change of one or more variables of an object. Technically, the perception of change is created through animation, i.e., a sequence of images that creates the illusion of change. If the position changes, the change is perceived as movement (Dransch 1997a; Buziek et al. 2000). For simplification, Buziek (2003) suggests defining “change” itself as a meta-variable that applies to all visual variables. The concepts of dynamic and interactivity are linked to each other, if the user controls a dynamic visualization, it is called interactive. In this sense, walking as a form of interactive navigation is the continuous change of the variable “position”. However, Buziek (2003) states that there is no agreed set of variables for interactivity that could be comparable to Bertin’s set of visual variables.

3.2 Distinction of landscape visualizations by the level of virtuality

1. **I**nformation intensity (realism)
2. **I**mmersion
3. **I**ntelligence
4. **I**nterface
5. **I**nteractivity

Table 3.1: The five "**I**"s of virtuality (cf. Heim 1998; MacEachren et al. 1999; von Lammeren and Hoogerwerf 2003)

The term "***virtuality***" was used by Heim (1998) to describe the factors that virtual environments share with real environments. According to Heim (1998), these factors can be classified in information intensity, immersion and interactivity. Later, MacEachren et al. (1999) extended the list by a fourth "I", the "intelligence of objects" (see table 3.1). Van Lammeren and Hoogerwerf (2003) as well as Bishop and Lange (2005) apply the "4I"s to landscape visualization. If all four factors apply to a visualization, it is called a ***virtual environment (VE)***, or a virtual landscape (MacEachren et al. 1999; Bollmann 2002). In the context of this work, the list is extended by the "interface" as the fifth factor, because all interactions with a virtual environment are transmitted through some kind of interface. Therefore, the interface has a major impact on how the virtual environment is perceived in comparison to reality. The five characteristics of virtuality are used throughout this thesis to describe the analysed landscape visualizations.

3.2.1 Information intensity or realism

MacEachren et al. (1999), based on Heim (1998), defined information intensity as the amount of detail with which objects are represented in the visualization. In the context of landscape visualization, Bishop and Lange (2005) equated the original term "information intensity" with "realism".

3.2.1.1 Realism - abstraction

Information intensity or, the level of realism, describes how closely the displayed image resembles reality (Appleyard 1977; Sheppard 1989; Ervin 2001; Lange 2001; Paar et al. 2004). The opposite of realism is abstraction, which is the "purposeful omission of certain details" (Kalay 2004: 88). As it is impossible to represent reality in its full scope, every landscape visualization is also an abstraction of reality. Abstraction extracts and distills the meaning of the message, focusing the viewers attention on specific information. That means, in order to abstract a landscape visualization, the visualization author has not only to consider the message and target audience and but also needs expertise on the landscape elements (Ervin 2001). Finally, realism and abstraction are not mutually exclusive concepts because realistic and abstract depictions of landscape elements can be combined in the same hybrid visualization.

Based on Sherman and Craig (2003), Belveze and Miller (2005) as well as Bodum (2005) propose similar typologies for the different levels of realism in landscape visualization. The typology by

Bodum (2005) is illustrated in figure 3.6 and distinguishes symbolic (symbols represent a specific type of object), iconic (naïve but pictorial images that resemble real objects); indexed (pictorial representations that represent a specific type of object) and verisimilar representations (individually different objects). An example of a landscape visualization in the different levels of realism is given in figure 3.7; the symbolic level is used in three-dimensional maps and in geovisualization.

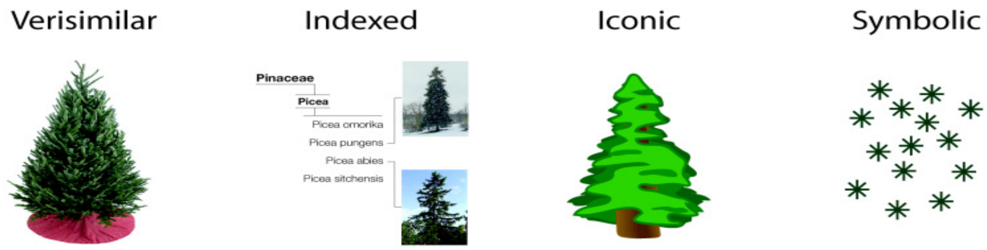
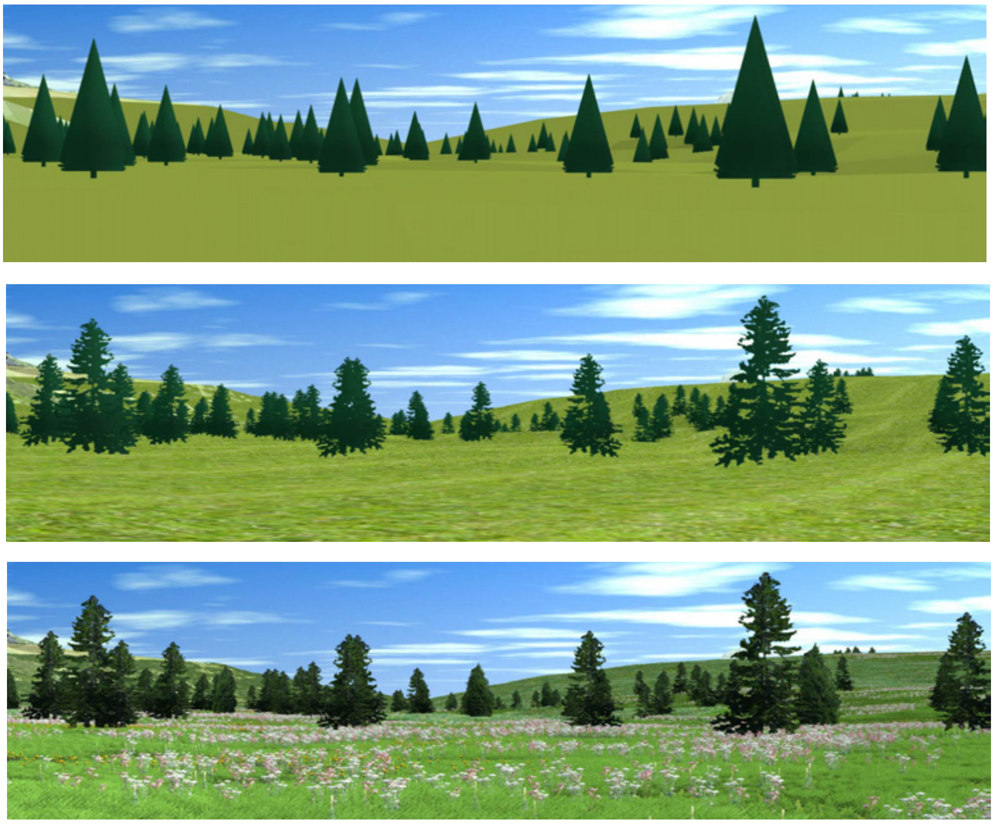


Figure 3.6: Example of a pine tree in different levels of realism: verisimilar, indexed, iconic, symbolic (Bodum 2005: 397).



Iconic

Indexed

Verisimilar

Figure 3.7: Typical example of the case study landscape with different levels of abstraction (image: VisuLands / Hofschreuder 2004).

3.2.1.2 Apparent realism

From the view of planning, the key question is when to use more realistic or more abstract visualizations. It has been a common argument that realistic visualizations support non-experts in relating to the depicted landscape and the imagination of the visual landscape (Lange 1999; Lange 2001; Appleton 2001). Furthermore, it has been suggested that realistic landscape visualizations evoke more affective response and foster engagement (Nicholson-Cole 2005; Sheppard 2005a, Salter et al. unpublished). In comparison, abstraction provides filters by which information is selected, discarded or highlighted (Ervin 2001). These functions allow the different stages of a planning proposal to be highlighted, for example, (see the technique of "non-photorealistic rendering" in chapter 3.3.1).

As a disadvantage, high levels of realism, so-called photorealism, can also produce misunderstandings and confusion. Sheppard (2001) as well as Lange (2005) are concerned that realistic landscape visualizations can be cognitively misleading if the "apparent realism" (Salter and Sheppard 2004: 496) implies a higher accuracy than the underlying data provides. In this context, accuracy is the degree of conformity between the visualization and reality. The problem is that the data from planning scenarios is usually very vague, especially in the beginning of a planning process. Then, abstract visualizations may fit the early conceptual planning stages better and refer more credibly to incomplete data sets. If the level of realism can be altered interactively, it can be adjusted to different planning stages and to the accuracy of the underlying data.

3.2.1.3 Realism and interactivity

Technologically, a high level of realism works at the expense of interactivity. A general rule says that the higher the level of interactivity gets, the lower the level of realism will be. Therefore, images with a very high level of realism are usually rendered as static images. The rapid development of computer graphic cards made it possible to test real-time landscape visualizations with a very high level of realism in this case study. For that purpose, the software has to continuously reduce the overall geometry by level-of-detail (LOD) management (see chapter 3.3.1).

Schirra and Scholz (1998) propose more interactive representation styles for computer visualization in general. Bishop and Lange (2005) show that the diverse users in planning demand different styles of visual representation depending on individual experience, information needs and planning stage. Interactivity may help to fit these diverse needs in a better way, if "multiple users can choose the view that best suits their experience or professional background and information needs" (Bishop and Lange 2005: 32).

3.2.2 Immersion

According to MacEachren et al. (1999: 2), immersion "describes the sensation of 'being in' the environment." They continue with "immersion is limited through the stimulation of senses." The landscape visualizations in this thesis only refer to the visual sense, not to the tactile or audio senses. Within the visual experience, degrees of immersion can be distinguished with regard to the display. A simple form of an immersive environment was used in the case study and is shown in figure 3.8. The panoramic display covers a 180° view where the user can interact with the landscape visualization by turning his head.

Figure 3.8: Panoramic screen as part of an immersive environment that provides a 180° view of the landscape (case study exhibition at 150 year ETH anniversary).

3.2.3 Intelligent landscape objects

The "intelligence of objects" is defined by MacEachren et al. (1999) as the behaviour of objects and the degree that their behaviour corresponds with the real world. The virtuality of a landscape visualization will increase, for example, if the sun is moving along a physically correct course. If "intelligent" landscape visualizations respond to the change of parameters, planning stakeholders can test alternative scenarios and learn through interaction with the model. Therefore, Ervin (2006) demands that landscape visualizations merge with ecological models that simulate ecological dynamic processes over time and visually-oriented, spatial 3D models. Such intelligent landscape visualizations will provide an interactive "sandbox" for the collaborative creation of future landscapes.

3.2.4 Interface

The concept of the interface applies to all interactions between a user and a computer because the interface is the gateway, the linking "face", through which the interaction is transmitted. In this context, "face" has the meaning of a boundary between two elements and interactions take place across this face (Cartwright et al. 1999). The following chapter describes how the interface affects interactions with landscape visualizations.

3.2.4.1 Definition of interfaces

Cartwright et al. (2001) state that it is not the technology that is interactive, but the interface. In cartography, the term interface can be used in two ways, either addressing the user interface of a cartographic computer application or the model as an interface to the world (Cartwright et al. 1999). With regard to the first meaning, human-computer interactions usually take place through a graphical user interface (GUI) on the display. The second meaning indicates that users not only interact with the landscape visualizations through interfaces. At the same time, the landscape metaphor is an interface to the underlying geodata itself (Döllner et al. 2005).

3.2.4.2 Interactive interfaces in landscape planning

Both, interface design and interaction design have to find solutions to support group work (Cartwright et al. 2001; Schneider 2002). For planning, interfaces are needed that support two-way communications (Orland et al. 2001) in order to allow a dialogue. The Collaborative for Advanced Landscape Planning (CALP) at the UBC Vancouver designs and tests interfaces specifically for landscape visualization. At CALP, Salter (2005) focused on the graphical user interface and designed, built and evaluated a prototype landscape information interface to communicate spatial, temporal, visible and non-visible landscape information to non-expert users (figure 3.9). This prototype did not provide full functionality, but the main interactions were demonstrated through pre-rendered and animated images. His evaluation showed that the interface in figure 3.9 is successful in the communication of complex spatial and temporal data and in the illustration of the relationships between visual landscape quality and ecological indicators.

In the case study, prototypes similar to the one by Salter (2005) were built. Figure 3.10 shows a tested prototype that supports users in the development of alternative scenarios. Please refer to the enclosed CD-ROM for an interactive version of the prototype. The prototype was built so that various indicators can be weighted with the indicator slider bars. In response to a change of the slider bar, the number of urban or forest units in the landscape image changes. In this way, the relationship between indicators and the visual landscape is illustrated.

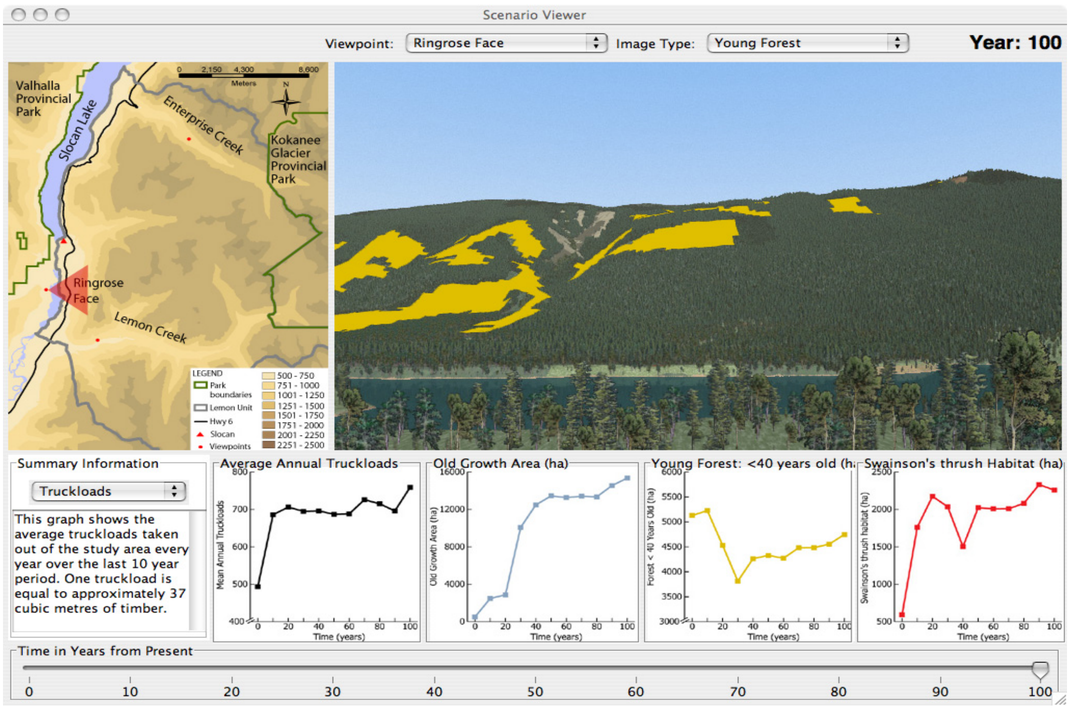


Figure 3.9: Prototype interface for interactive landscape visualizations that combine a 2D map, 3D perspective views, text and indicator diagrams (Salter 2005).

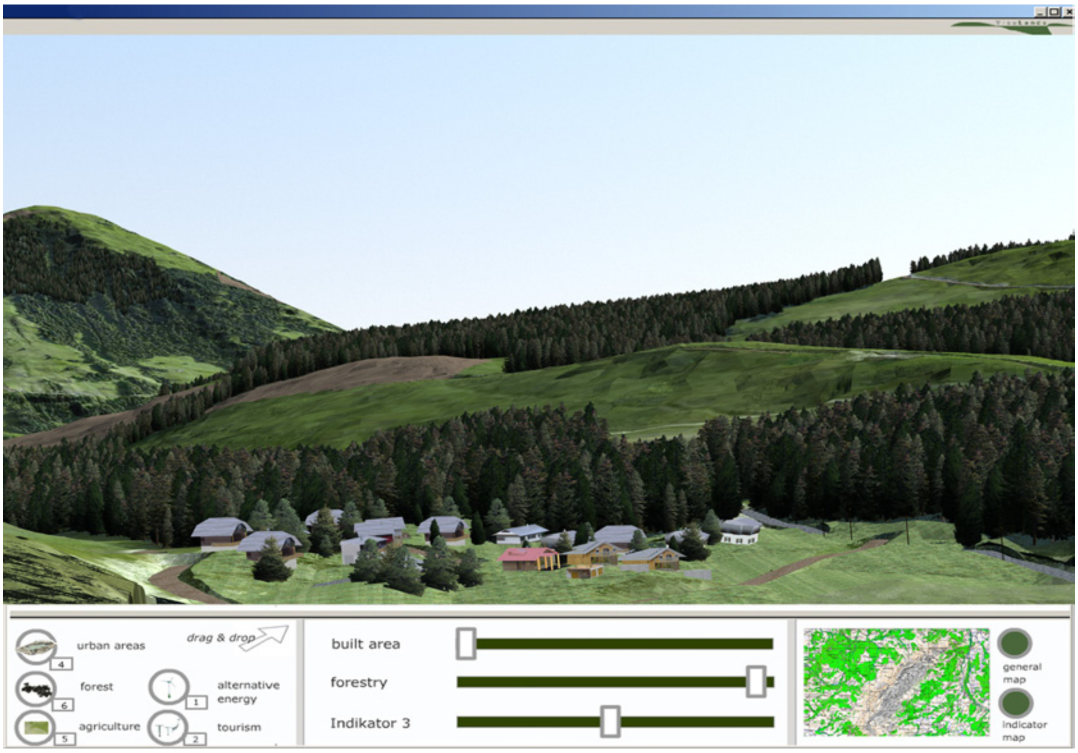


Figure 3.10: Prototype interface of a visualization tool for the interactive assessment of indicators in combination with the visual image (Lange et al. 2004b).

3.2.5 Interactivity

Originally, Heim (1998) defined human-computer interaction in a strict sense as the ability of the user to change his position and perspective. MacEachren et al. (1999) extended Heim's definition by adding various kinds of interaction that allow users to manipulate the visualization. Similar to MacEachren et al., this study refers to the definition by Fuhrmann (2001), who defined interaction as a series of goal-oriented actions that are determined by the interrelation between human and computer:

> *Interactions are "a series of goal-oriented actions that take place in a three-dimensional space (the representational space) and that are determined by the interrelation between human and computer" (Fuhrmann 2001:192).*

The derived term ***interactivity*** refers to the capacity of a computer system to support interactions or as Crampton (2002: 88) defined it, interactivity involves "a system that changes its visual data display in response to user input." In the context of virtuality, the perception of landscapes benefits from interactivity. On the basis of cognitive science, Danahy (2001: 126) argued that the human visual system "requires a combination of the peripheral vision, movement, motion parallax and binocular vision to fully decipher the spatial qualities of a landscape." He and Lange (2005) conclude that the perception of a virtual landscape by walking through it in real-time and by recognizing its dynamics like wind and water is much closer to the perception of a real landscape than a static image.

Figure 3.11: Screenshots of an interactive walk through the real-time visualization of a protected moorlandscape (Lenné3D; see the enclosed CD-ROM for a demo version).

Landscape visualizations further benefit from interactivity as a means of communication. Interactive landscape visualizations allow the exploration and communication of landscape changes and functional relationships within the landscape.

> *"Computers facilitate direct depiction of movement and change, multiple views of the same data, user interaction with maps, realism, false realism, and the mixing of maps with other graphics, text, and sound. […] allows visual thinking/map interaction to proceed in real time"* (MacEachren et al. 1992: 197).

3.2.5.1 Mediated interactivity

In mediated interactivity, a trained professional, called a "visualization navigator", executes the wishes of the participants on their behalf. That means, the visualizations are mediated through the technical interface and through the visualization navigator. This type of interactivity was chosen for this study for two reasons. First, mediated interactivity is more appropriate for the use in collaborative workshops because the participants primarily interact with each other and not with the computer: the computer is a tool in the background. Second, mediated interactivity makes it possible to apply a higher level of interactivity through the expertise of the visualization navigator. Alternative forms of collaborative interfaces are explored by Stock and Bishop (2007), who provide the participants with personal digital assistants to control the landscape model collaboratively.

As shown in figure 3.12, the interactions of the visualization navigator are not the only human-computer interactions in this setting, but stakeholders interact with the visualizations by watching, gestures and verbal references. Furthermore, the stakeholders, facilitator and visualization navigator interact with each other in the form of human-human interactions (figure 3.12). All these interactions, verbal or in the form of references and gestures, are measured and analysed in order to record the group processes (chapter 8).

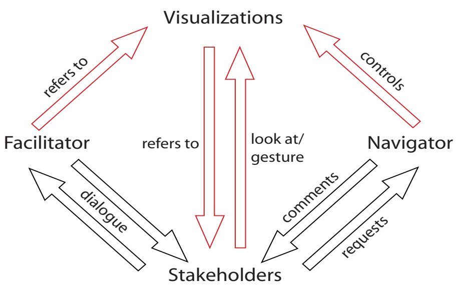


Figure 3.12: Mediated interactivity with human-human (black) and human-computer (red) interactions.

3.2.5.2 Basic levels of dynamics and interactivity in landscape visualization

During the production of landscape visualizations, the level of dynamics and interactivity is chosen with regard to the intended use of the visualizations, the planning topic and the target group. Muhar (2001) points out that different types of landscape visualizations also require different types of software. Therefore, Sheppard and Salter (2004) classify basic landscape visualization types with regard to their level of dynamics and interactivity. Dynamics and interactivity are linked in the way that dynamic visualization is interactive if it is controlled by the user. In other words, a flower moving in the wind is dynamic, but picking a flower is interactive. The four levels of interactivity, listed in table 3.2, are used in the case study part of this thesis. The static images serve as the baseline reference for the analysis of the interactive features.

Levels of interactivity are not only distinguished in landscape visualization, but also for interactive multimedia atlases. Although atlases have a different target group and use more cartographic representations than landscape visualizations, both have developed similar interaction techniques. The literature on interactive multimedia atlases enriches the discussion of landscape visualizations through the definition of levels of interactivity with regard to their analytical functionality (Schneider 2002; Cron 2006; Hurni 2006; 2007). Transferred to landscape visualization, the combination of real-time navigation and analytical GIS functions is added to the typology in table 3.2 as the highest level of interactivity. In his comparison of view-only atlases and interactive atlases, Ormeling (1997) suggests that different levels of dynamics and interactivity serve different communicative functions. While static images are final products for presentations, highly dynamic and interactive real-time environments are an interface to the underlying data, built for collaboration. These functions are added in the fourth column of table 3.2 and will be discussed in more detail in chapters 3.3 to 3.6.

Level of Dynamics	Level of Interactivity	Sample Applications	Communicative Functions
Static images	Low: selecting, viewing or touching the image	Printed posters, static images	Visualization as a final product for presentation
Limited animation	Middle: start, pause, reward and backward play	Pre-rendered sequences or panoramas	Visualization as a final product, though allowing various views.
Real-time	High: real-time navigation	Virtual landscapes that allow the user to navigate freely	Visualization as a final product, though allowing free selection of perspectives.
Analytical real-time	Very high: real-time navigation plus advanced analytical interactions with the landscape and underlying data	GIS systems with landscape visualization components	Visualization as an interface for collaboration

Table 3.2: Basic levels of dynamics and interactivity of landscape visualizations (based on Ormeling 1997; Schneider 2002; Sheppard and Salter 2004; Cron 2006; Hurni 2006; 2007).

3.3 Technical foundations of interactive landscape visualization

Technically, it is a complex problem to make landscapes interactive and accessible in real-time because it is necessary to render enough images per second to create the illusion of movement. Real-time visualization also requires a trade-off between the level of realism and computer performance because the more details are needed, the more calculations are necessary. This chapter describes the major technological developments that made interactions with landscapes (chapter 3.3.1) and realistic vegetation (chapter 3.3.2) possible in real-time visualization. Other technologies, e.g., the modelling of houses, are more established and well-documented (e.g., in Ervin and Hasbrouk 2001), so that they are not described in detail.

3.3.1 Real-time interaction techniques

The following real-time rendering techniques (table 3.3) are of special interest for planning applications in geovisualization. The description of the techniques mainly refers to Döllner (2005b).

Technique	Implementation in interactive functions
a) Advanced rendering techniques	Graphic effects that increase realism in real-time
b) Level-of-detail management	Enhanced level-of-detail management with multi-resolution modeling
c) Non-photorealistic rendering	Availability of various non-photorealistic rendering styles
d) Dynamic texture generation	Performance enhancement for the representation of vector data
e) Multi-texturing	Performance enhancement for the representation of data overlays
f) Smart navigation	Constraints prevent inappropriate perspectives
g) Navigation widgets	Object-oriented implementation of navigation metaphors

Table 3.3: Current real-time techniques and their implementation in interactive functions.

a) Advanced rendering techniques

Advanced rendering techniques utilise the capabilities of modern graphic processor units to increase the degree of realism in real-time visualizations. Multi-pass rendering and programmable shading enable effects such as light reflection (important for the representation of water), shadows and bump mapping in real-time.

b) Level-of-detail management

Level-of-detail management adjusts the amount of visible detail in relation to the viewer's position. As a result, the workload in real-time visualization is reduced and performance increased. Level-of-detail management techniques have been developed for specific purposes, i.e., digital terrain models (DTM), city models and vegetation. These are more efficient in storing and retrieving pre-rendered levels of detail and further increase the performance of real-time landscapes (Döllner 2005b).

c) Non-photorealistic rendering (NPR)

The progress in non-photorealistic rendering techniques makes it possible to render the same dataset in different styles, e.g., not only photorealistic, but also in a sketchy or cartoon style. As a result, the users can interactively customize different representation styles. Rekittke et al. (2004) point out that many of the commercially available rendering styles are not suitable for serious communication. In ongoing PhD research by Coconu et al. (2005), shaders are developed particularly for the abstract representation of vegetation and landscapes. These shaders make it possible to choose between different styles and to mix them in real-time (see figures 3.13 and 3.14).

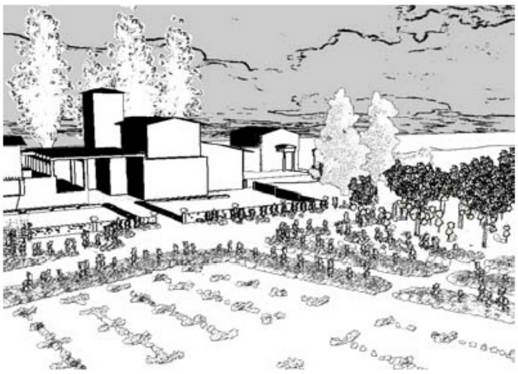


Figure 3.13: Non-photorealistic landscape representation (Coconu et al. 2005).

Figure 3.14: Hybrid visualization with the planning proposal in a non-photorealistic style and the spatial context in a realistic style (Rekittke et al. 2004).

d) Dynamic texture generation

Dynamic texture generation, i.e., the generation of textures in real-time, can improve the level-of-detail management. In relation to the camera distance, dynamic textures can be used to create suitable vegetation textures. Dynamic texture generation is also a preferred technique for mapping vector data. Instead of representing vectors as line objects, a rasterized texture of the vector data is draped over the terrain. With this technique, various thematic texture layers can be combined in real-time. Considering that most planning materials are in the form of vector data, the advantage is obvious. Finally, dynamic textures make it possible to conduct simple spatial analyses in real-time. In the present study, interactive elevation analyses were requested in two workshops and with this technology, it was possible to conduct them without delays.

e) Multi-texturing

Texturing is another basic technique in computer visualization, i.e., the application of a material onto a geometry. However, interactive geovisualizations involve specific demands for texturing. First of all, large textures such as orthophotos have to keep their georeference. Second, most planning applications require the overlay of different layers of information, e.g., an orthophoto and a picture of the zoning plan. By multi-texturing, the software combines various texture layers in screen space (see figure 3.15).

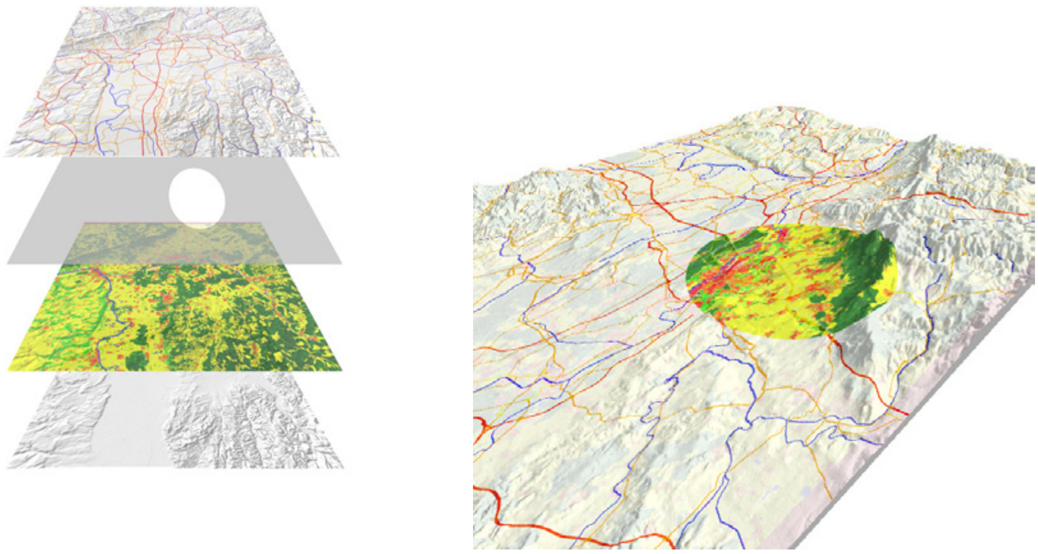


Figure 3.15: Principle of multi-texturing applied to terrain surfaces (Döllner 2005: 331).

Left: Multiple 2D textures represent independent layers of information, e.g., digital terrain model, shading, land-use information, and street networks; artificial textures represent masks and blending filters.

Right: The final image results from combining texture layers in screen space.

f) Navigation widgets

Döllner (2005b) proposes implementing the various navigation metaphors and orientation aids, illustrated in chapter 3.5.1, through widgets. In this context, widgets are closed programming objects, which are transferable to other software applications. They have been implemented not only for navigation purposes but also for orientation maps, landmarks, flight-paths, measurement and lens functions.

g) Smart navigation

So-called "smart navigation" techniques assist users in navigation by leading their attention to predefined areas of interest (Döllner 2005a) and preventing them from getting lost. A basic form of smart navigation stops users if they start leaving the landscape model by accident. By interaction design, visualization authors can put the user into control of the visualization, while at the same time ensuring the usability of the model.

3.3.2 Real-time landscapes close to reality

In geovisualization, vegetation is represented by 2D and 3D symbols and explicit models are only used as exceptions. In contrast, landscape planning requires real-time landscapes that are close to reality and show botanically correct patterns (Paar 2006). In conventional software, vegetation was visualized by simple billboards and the distribution of the vegetation often lacked any botanical foundation. In the following section, the process of preparing realistic vegetation for a real-time application is briefly described, from the modelling of an individual plant to the calculation of the distribution of plants in an area.

a) Plant modelling

The first attempt to reproduce the structure of plants through algorithms was the set of rules developed by Lindenmayer and Prusinkiewicz (1990), called L-grammar (Muhar 2001). Since the formulation of the L-grammar system, rule-based as well as procedural methods, which define a plant by parameters (e.g., the number of branches) have further been developed. The state-of-the-art in plant modelling is described in Deussen (2003a; 2003b). He refers to the software "Xfrog", which works with a combination of rule-based and procedural techniques (figure 3.16). With this approach, a plant is built from "simple" components, i.e., tree (stem), horn (twigs), leaf and several "modifier" objects (revo, wreath, phiball, etc.). The structure graph assigns a hierarchy with specific rules to the components. If the parameters for branches are modified, the sub-ordered leafs (children components) will change as well. Examples for such rules are the spatial distribution of branches (ramification), and various forms of tropism, i.e., the deformation of a plant in one direction through gravitation (gravitropism) or through light (phototropism) (Deussen 2003a; 2003b).

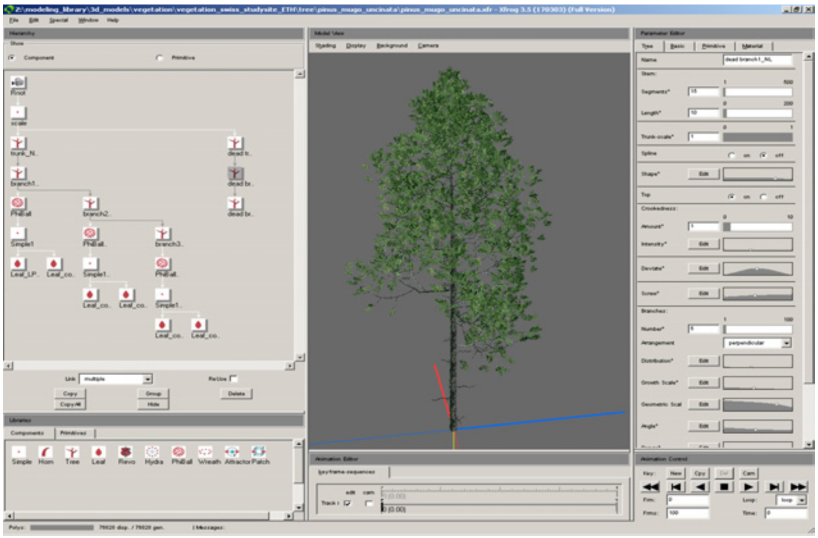
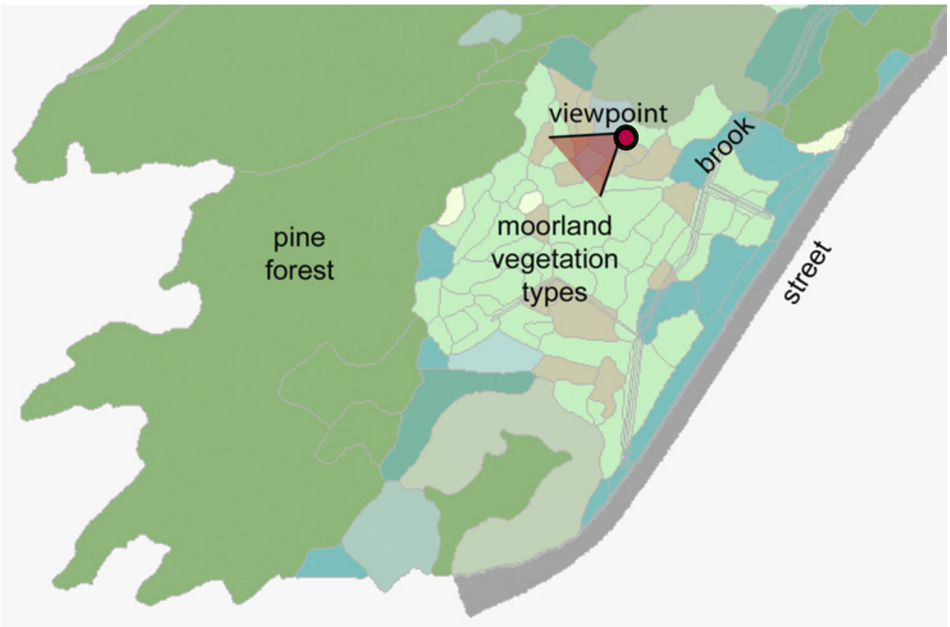


Figure 3.16: Modelling interface of Xfrog, integrating rule-based and procedural techniques.

Figure 3.17: 3D model of a Trollius Europaeus as wireframe (left) and textured model (right).

b) Vegetation modelling

In real-time environments, vegetation is represented in various levels of aggregation, i.e., individual plants (figure 3.17) or plant communities and large-scale areas with various plant communities (figure 3.18 and 3.19). A realistic level-of-detail management has to show detailed 3D models of the plants in the foreground (billboards appear coarse from close distances) as shown in figure 3.19, plants with reduced geometries in the middle ground, and billboards in the background. However, such a realistic landscape easily includes millions of plants in a scene.



Figures 3.18: The map shows the diversity of the vegetation zones in a protected moorland in the case study area.

Figure 3.19: Screenshot from the real-time landscape model, calculated on the basis of figure 3.18. A real-time demo can be installed from the attached CD-ROM (image: Lenné3D 2004).

The first step in the modelling of vegetation, or rather the „phytosociological units“ (Röhricht 2005), is to create a realistic distribution of plants on the terrain. The necessary algorithms were implemented by Röhricht (2005) in the "oik" module of the Lenné3D software. The calculation takes place in two steps: First, homogeneous parts of the overall area, so-called "geoCells", are identified from pedological maps (soil type), relief data and vegetation-referenced spatial data. In a second step, the location of every plant model within the "geoCell" is computed with regard to the sociability (the relative tendency or disposition to associate with other plants*)* of the particular species. The result is a distribution map as shown in figure 3.20. As Röhricht points out, a sophisticated database of phytosociological (vegetation) data is needed so that the reference releves, or vegetation maps, can be allocated to the "geoCells". In addition to the scientific phytosociological foundation, the system can incorporate explicit input in the form of locations by coordinates, Braun-Blanquet cover scale values, distribution patterns, imported vector data, and a mix of all these. Braun-Blanquet is a common key to describe the abundance (botanically: frequency of occurrence) and the cover per square meter by plant species, named after the Swiss botanist Braun-Blanquet.

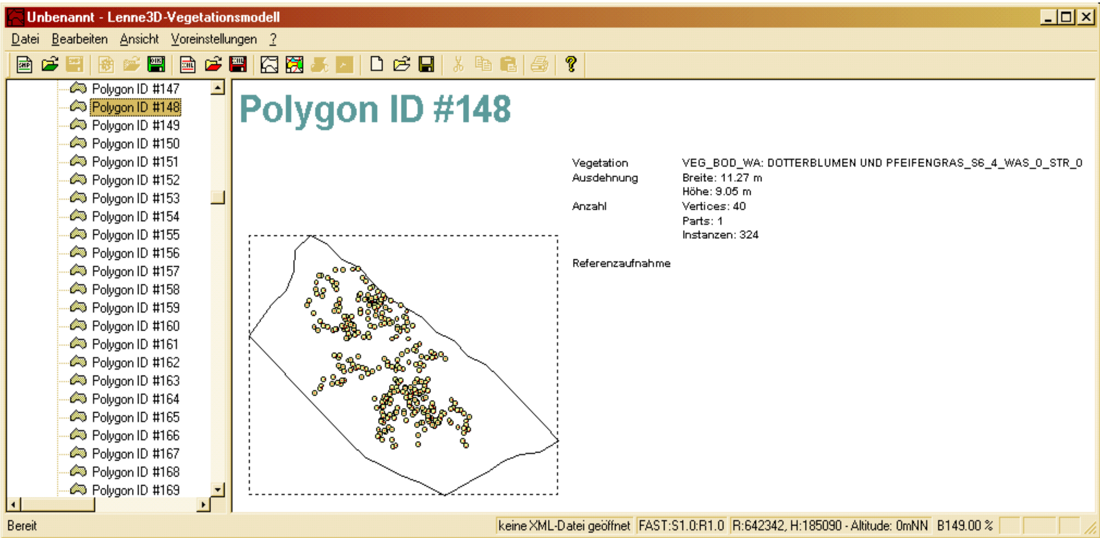


Figure 3.20: Screenshot of a typical output from the "oik" module, showing the possible distribution of *Caltha palustris* and *Molinia caerulea* in a given polygon with predefined characteristics.

In summary, the representation of vegetation in computer graphics uses statistical distribution methods (not every plant location could refer to its equivalent in reality) in combination with phytosociological information to create realistic distribution patterns. Various phytosociological units, or rather vegetation units, are assigned to the equivalent parts of the terrain with regard to geodata, e.g., an alluvial forest will grow next to a river. As a result, the virtual plants are arranged in patterns that look as they might appear in reality. In this manner, an interface is provided for stakeholder inputs, e.g., a map with plants could be imported by using the SVG graphic format and combined with the model of the existing vegetation. Because the virtual landscape is running in real-time, changes and alternative scenarios can be explored on demand. This suggests that the technology is further converging with the needs of collaborative planning.

3.4 The role of interactivity in cognition and communication

Summarizing the previous chapters, interactivity benefits human cognition as well as the communication process. As starting point, relevant theories from cartography are consulted.

3.4.1 The interactive shift in cartographic communication

The traditional model of ***cartographic communication*** was based on a sender-recipient relationship (Bollmann 2002). New technologies in computer graphics have extended the opportunities of visualization so far that it is reasonable to talk about a paradigm shift in cartographic communication. Today, a static model of communication is no longer in line with interactive mapping systems. These go beyond the control of their author, so that the user becomes both cartographer and user at the same time (shown in figure 3.21). Of course, a cartographer prepares the map use environment and designs the user interface. In contrast to static media, the map user can now create his own concept of reality working with the interactive map in iterative feedback loops (Peterson 1995).

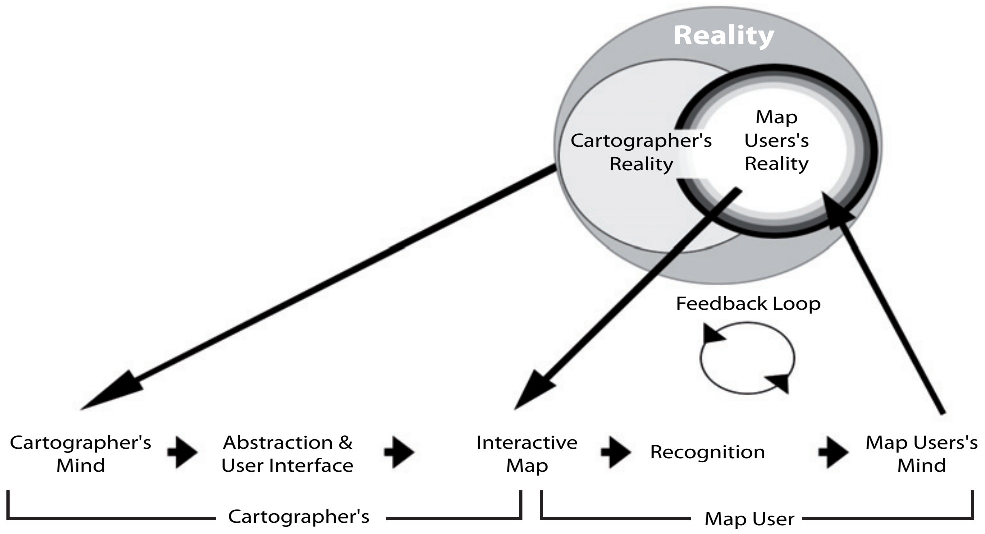


Figure 3.21: Model of cartographic communication incorporating interaction. In this model, the cartographer provides a general map use environment, but the map user controls what is depicted and how (Peterson 1995: 6).

In the model by Peterson (figure 3.21), the interactive map can easily be replaced by interactive landscape visualizations without changing the propositions. Interestingly, the paradigm shift towards more participation by the user in cartography shows parallels to the "communicative turn" observed in planning. It can be assumed that more participative visualization uses will also fit more participative planning purposes. Whereas visualizations were traditionally used as the "icing on the cake" that helped sell a proposal, they are now increasingly becoming part of the participation process (Lange and Hehl-Lange 2006). Both planning and cartography have the same premises: "The computer is being used not only as a tool to help make maps on paper or search a data-base, but as a medium of communication" (Peterson 2005: 9).

3.4.2 The map use cube

MacEachren and Taylor (1994) discussed communication in the context of data relations, map use and interactions. With regard to DiBiase (1992), they distinguished three major functions of visual communication and visual exploration, i.e., presentation, analysis and exploration. The assumption of the "map use cube" model is that exploratory and analytical functions involve high levels of interactivity which are suitable for smaller groups or individuals (cf. Chapter 3.2.5 on basic levels of interactivity). In contrast, landscape visualizations for the broad public are presented on a rather low level of interactivity. In between, transitions exist between varying levels of interaction and usage contexts. The collaborative workshops are located between the public and private realms (figure 3.22).

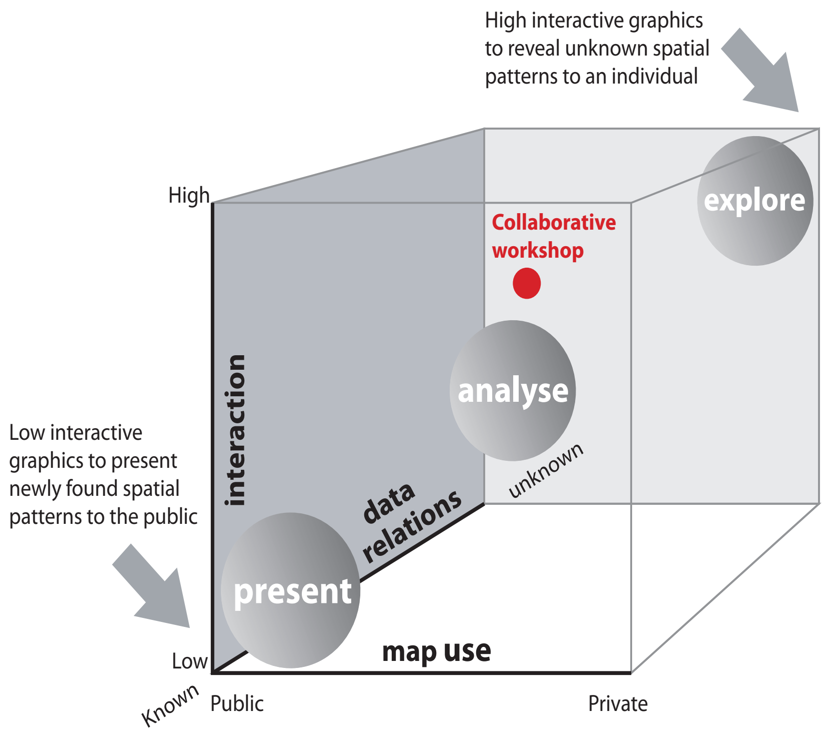


Figure 3.22: Map use cube (MacEachren and Taylor 1994; Kraak and Ormeling 1997).

According to the map use cube, visualizations can be used as tools for private to public data exploration. The following two chapters answer the question, of how interactivity may benefit individual cognition ("private" end of the map-use-axis in figure 3.22) and group communication ("public" end of the map-use-axis).

3.4.3 Cognitive benefits of interactivity

Although visual cognition has been subject to intense research, there is still no full understanding of the human brain and various theories compete with each other. Among the rival theories in cognitive psychology, the "information processing model of visual cognition" is rather well acknowledged and has been adapted to cartography by Peterson (1995) and MacEachren (1995). From the field of media psychology, Hasebrook (1995) contributes a model of knowledge building. Dransch

(1997b) and Buziek (2000) apply the various models to cartography in order to explain the impact of dynamics and interaction in knowledge building.

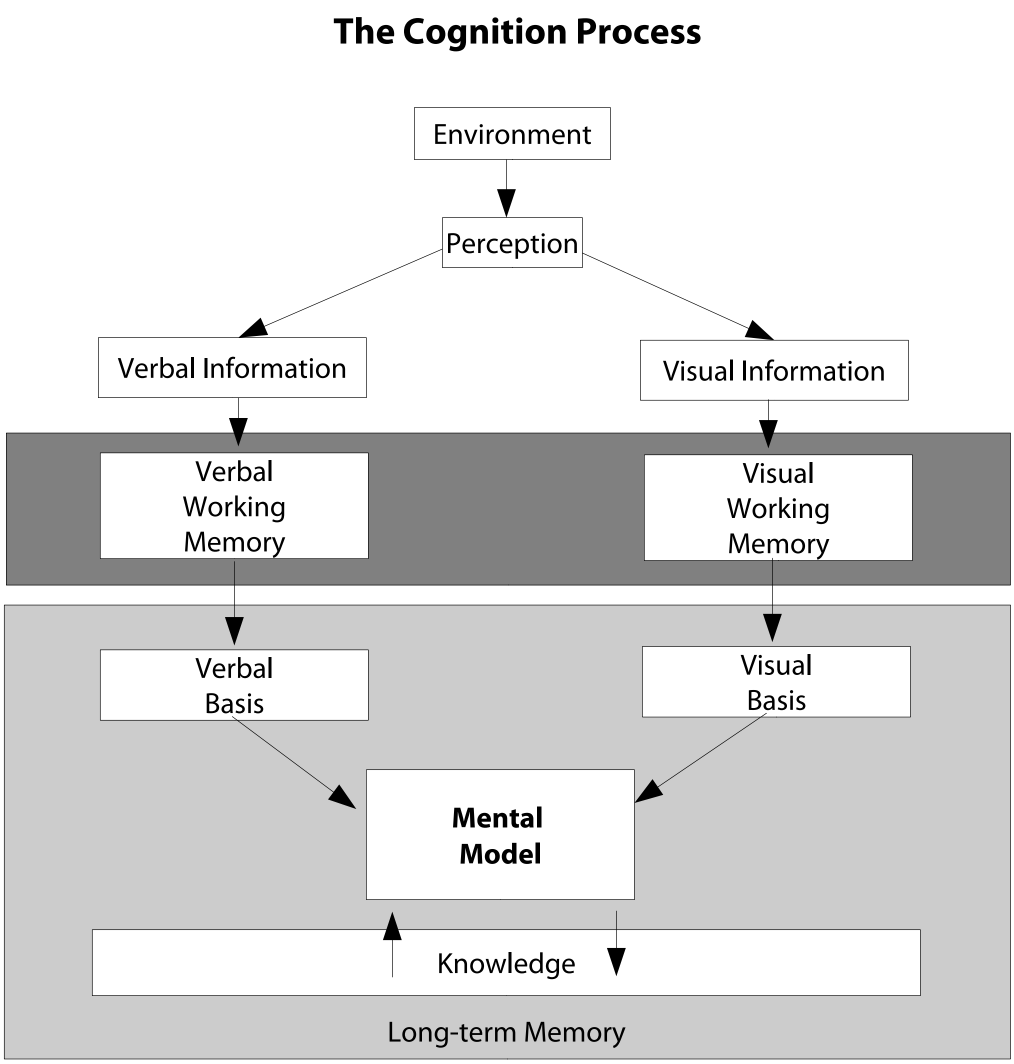


Figure 3.23: The stage model of the cognition process with regard to Hasebrook (1995).

The information processing model is based on the idea that information is processed through different memory stages (Neisser 1976; Kosslyn et al. 1978; Paivio 1986; MacEachren 1995). Here, the layout of a computer with its input devices, RAM short-term working memory and hard-drive for long-term memory is a helpful analogy to the stage model of visual cognition (figure 3.23).

In the first step of ***perception***, visual features are extracted and identified in the primary visual cortex. In the second step, patterns are extracted from the initially perceived features by processes of pattern perception and pattern matching (figure 3.23). The perceived patterns are further transferred to the visual working memory. Experiments show that the working memory consists of two storage areas, the visual working memory and the verbal working memory, so that linguistic and pictorial information are processed separately.

The processes of ***knowledge building*** are explained in the work by Hasebrook (1995) in media psychology and its interpretation by Dransch (1997b) and Buziek (2000). Related theories are dual coding by Paivio (1986), propositional coding by Pylyshyn (1981), and semantic knowledge building by Müller (1987) and Ballstaedt (1990). Buziek (2000) provides a comprehensive overview of these theories and their implications for interactive and dynamic cartography. The theories continue the visual cognition process by explaining the processes that lead to knowledge building. Visual working memory is limited and, according to experiments, it can only store approximately seven information units at the same time. This is an approximate number, which may change under different circumstances and with different individuals. Information from visual working memory is eliminated after a few seconds if it is not selected for further knowledge building. In the selection process, the incoming visual patterns are compared to patterns already stored in long-term memory. The information from the verbal working memory is processed in parallel. Dransch (2000b) points out that information that is processed by both visual and verbal working memory, is more likely to be considered during this selection process. This effect is called "double encoding" and explains why multimedia presentations are often more effective if they include verbal and visual media.

The comparison of verbal and visual information input with knowledge stored in long-term memory creates new knowledge, the so-called ***"mental model"***. The mental model is an internal representation, the "map in the head" as Peterson calls it (1995: 10). Obviously, the mental model may contain biases as well as emotions because it is built not only on perception but also on memories. The process of constructing a mental model can be applied to a group as well as to an individual, too. Then, the "***shared mental model***" refers to the shared understanding of an issue within a group. In a simple way, a shared mental model exists if all participants think about a phenomenon in a very similar way (Klimoski and Mohammed 1994). How does interactivity support the construction of the mental model? Seven assumptions of potential cognitive benefits through interactivity are listed in table 3.4 and discussed on the basis of theories and research examples from cartography and landscape visualization.

Interactivity supports cognition through
a) Highlighting information
b) Landscape perception from various perspectives
c) Investigation of functional relationships between multiple objects
d) Effectiveness of knowledge building through mental models
e) Exploration and communication of space-time features
f) Learning by doing
g) Learning through double encoding

Table 3.4: Individual cognitive benefits of interactivity.

It is important to design the interactions and the interface to be as usable as possible (Edsall and Sidney 2005). Otherwise, the benefits of interactivity may be neutralized through its additional cognitive costs. Except for this restriction, cognitive science provides various arguments that interactivity supports cognition and knowledge building (see Dransch 2000).

a) Highlighting information

First, interactivity is a promising tool to highlight specific information. Peterson (1995) showed that the human neural subsystem is specialised for the processing of visual motion. It is evident that dynamic representations such as blinking symbols or moving objects are processed with priority and automatically raise awareness. If the cartographer controls such dynamics in the planning process, he can highlight an issue with regard to the planning needs.

b) Landscape perception from various perspectives

With regard to perspective representations, motion is necessary for the comprehensive perception of depth cues and, in consequence, for landscape perception. In contrast, perspective static images only communicate “part of the picture” and objects might be blocked or the particular perspective might distort the size and position of certain objects. Therefore, the sense of space requires the representation of at least two or more perspectives or the ability to navigate interactively through the model (Buziek 2000; Lange 2005). Tress and Tress (2003) used photomontages in stakeholder workshops on landscape change scenarios in Denmark. The images were static but the analysis of qualitative interviews and group discussions indicated that the perspective of a moving observer would have been favoured by the users as a means of landscape perception.

c) Investigation of functional relationships between multiple objects

For the exploration of relationships among multiple objects, Ware and Plumlee (2005) propose zooming and linked windows, because both navigation types help the user to retain the context. However, both methods imply additional perceptual and cognitive costs. In general, it is necessary to consider the limited visual working memory and not to overload it through navigation tasks. In the words of Ware and Plumlee (2005: 570), “If the navigation itself takes a long time and consumes significant perceptual and cognitive resources, this will leave fewer resources for decision-making.”

d) Effectiveness of knowledge building through mental models

Knowledge building is highly selective and a lot of information gets lost in the process. Individual action supports knowledge building because people are more likely to build knowledge from information that they interact with. When people work with a landscape visualization, if they change parameters or view it from different perspectives and on different scales, they are more likely to build a mental model from it. In conclusion, Buziek (2000) formulates the hypothesis that interactive visualizations increase the effectiveness of knowledge building.

e) Exploration and communication of space-time features

MacEachren (1995) proposes interactivity, particularly for the analysis of space-time features, i.e., for the comparison of features across different time periods. He states that static representations of temporal processes might even be counterproductive because they communicate the wrong conception. Again, interactivity could be the key to successful data exploration because going back and forth in time makes it easier to match patterns and to build relationships in short-term memory. However, the interaction imposes additional cognitive costs and Salter (2005) counters that static illustrations of temporal processes can be as effective (see Nienhaus and Döllner 2005). Therefore, special attention is paid to the perception of space-time features in the case study and to the relevance of temporal navigation (chapters 7 to 9).

The study by Jude et al. (2003) especially highlights the benefits of a high level of interactivity for the exploration of spatial scenarios. Jude et al. compared geodata-based static visualizations of historic and future changes of the North Norfolk coast line with an interactive real-time model. In comparison to previous studies, this case provides some anecdotal evidence that interactivity was the key for successful expert collaboration in the assessment of coastline changes. The researchers evaluated the visualization through expert interviews with coastal managers. The managers agreed that they required interactive real-time visualization that show temporal changes. They also requested the ability to drag and drop objects, i.e., interactions with the landscape. Interestingly, it was suggested to represent the uncertainty of the underlying models through interactive techniques as well.

f) Learning by doing

Multiple evidence suggests that actively working on a learning subject will increase the learning effect in comparison to passive reception (Issing and Klimsa 2002; Schon 1983). Colloquially, the effect is known as "learning by doing". With regard to landscape visualization, interactive landscape design could allow such "learning by doing". Then, it is important that the user receives feedback on the impact of his design. Such feedback can only be provided on basis of "intelligent" landscape models (Ervin, in press; Lindhult, in press).

g) Learning through double encoding

Dransch (2000b) points to the benefits of double encoding of information by delivering information both verbally and visually. If information is presented in parallel in both channels, the information is more likely to be selected for knowledge building. However, the learning outcome also depends on the context and the user. If the context is disadvantageous, the parallel presentation may instead interfere with learning. In conclusion, it is necessary to analyse the impact of the interactive visualizations in the case study in the context of their verbal presentation (Lange 2005).

3.4.4 Communicative benefits of interactivity

The previous chapter addressed the individual cognitive functions of interactivity. In collaborative planning, it is even more important to ask about the communicative benefits of interactive visualization as a tool in group work. In the field of media psychology, Weidenmann (1995) defines four key functions of visualization in communication (motivation, contextualization, demonstration, construction of mental models). Today, these functions are well established in other disciplines and Dransch (2000b) refers to it in cartography. Transferred to planning, the list can be further extended through the support of dialogue and transparency (see chapter 2). Adaptations to landscape visualization have been published in Wissen et al. (2005) and Schroth et al. (2005).

Interactivity supports communication through
a) Motivation of diverse target groups with diverse cognitive opportunities.
b) Contextualization of information in the group.
c) Demonstration of an idea or phenomenon.
d) Construction of a shared mental model.
e) Dialogue through interactive two-way communication.
f) Transparency and credibility of the visualization process.

Table 3.5: Communicative benefits of interactivity in group processes.

a) Motivation

First, interactive tools may foster the motivation of a group. As interactivity highlights information in individual cognition, an interactive presentation can raise the interest and attention of a group. A common expectation is that more attractive presentations will also recruit new participant groups. However, these expectations have not been verified by research.

b) Contextualization

Interactivity helps to put an argument, a proposal or an idea into its larger context. For example, a planning proposal can be contextualized by locating the proposal in a realistic environment. Particularly in spatial issues, it is important to help users putting new information into context.

Interactive links between landscape visualizations and indicator diagrams were also tested in the Bowen case study, documented by Salter et al. (unpublished). The interactive CommunityViz software was successfully used to link the presentation of a scenario-based multi-criteria analysis with indicators and an interactive model to visualize alternative residential densities. The use of contextualization for tools that combine visual landscape assessment and the quantitative assessment on basis of indicators is further discussed by Wissen et al. (in press).

c) Demonstration

Demonstration refers to the basic idea of visualization as an act of making something visible. People should get an idea or an image of a concept, a spatial relationship or other aspect of the physical environment. In group environments, interactions with the visualization may help create a shared understanding of the idea. Collaborative learning is the outcome of a successful demonstration.

In the Jänschwalde case study, Lange and Hehl-Lange (2006) demonstrated the long-term reclamation of a brown coal surface mine in Eastern Germany up to 2030. Although the visualizations were not presented interactively, the study successfully demonstrated the potential that landscape visualizations have to show landscape change over time and alternative designs.

In the Wittenham Clumps (UK) case study by Berry (2006), stakeholders discussed the possible impact of climate change on future landscape change with the help of photo-realistic landscape visualizations. It became apparent that localised landscapes helped elicit responses from the participants. The project leaders concluded that an interactive tool could provide a range of personalised scenarios to explore that might have further improved the process .

d) Construction of a shared mental model

Dransch (2000b) refers to the cognitive function of visualizations in that they facilitate the construction of shared mental models among people. A mental model is the representation of reality as it is constructed by an individual's mind. In group discussions, the construction of a shared mental model is an important step towards shared understanding and, finally, to consensus (Klimoski and Mohammed 1994).

The collaborative stakeholder workshops conducted by Lange and Hehl-Lange (2004) on the location of wind-turbines are comparable to the case study setting in this thesis and a good example, of how participants develop a shared mental model. Lange and Hehl-Lange applied an interactive virtual landscape model to examine possible locations of wind-turbines and to test the acceptance of the planning proposal. On the basis of qualitative observations and questionnaires, they show that the interactive 3D visualization in combination with the participatory approach effectively facilitated the collaborative work and communication between professionals and the public. Above all, participants favoured interactive walk-throughs (movement through landscape scenarios) and the opportunity to locate the wind turbines interactively in the model (interactions with the landscape). During the workshops, it became important to customize different positions of the sun because the wind turbines' shadow turned out to be a major issue (figure 3.24).

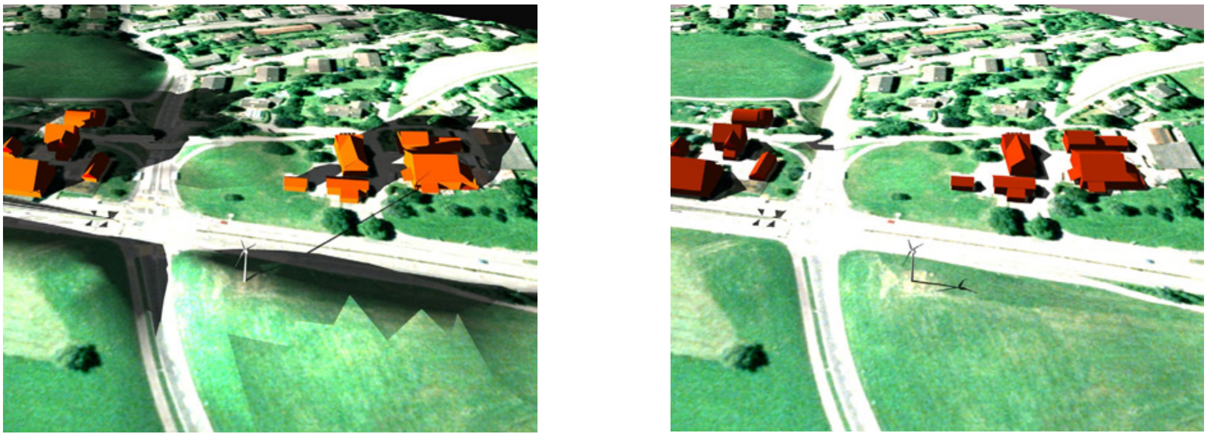


Figure 3.24: Interacting with the temporal dimension and customization of lights - the shadow of a wind-turbine in the early morning (left) and in the afternoon (right); (Lange and Hehl-Lange 2005).

e) Dialogue

Above all, interactivity allows providing the user with feedback to his or her actions – which is essential for any dialogue. Klosterman (1997) recognizes that the change in planning towards two-way communication requires tools that also support two-way communication through interactivity. Orland et al. (2001) suggest that interactive tools can increase participation and understanding, the quality of decision-making, the sense of ownership, and a greater range of proposals.

The benefits of static and dynamic landscape visualizations for the support of dialogues were tested by the 'Collaborative for Advanced Landscape Planning' (CALP) at the University of British Columbia (Sheppard 2004; Sheppard and Meitner 2005; Lewis and Sheppard 2006). Recent case studies took place in the Slocal Valley (British Columbia); in collaborative workshops on landscape change with indigenous communities of the Cheam Band in Fraser Valley; and for Snug Cove on Bowen Island. In questionnaires and informal comments, the dynamic 3D model was rated most helpful for its dynamic viewing capabilities, the representation of impact, and for facilitating group discussion (Campbell and Salter 2004).

f) Transparency and credibility

With regard to the discussion on the ethical use of landscape visualizations, interactivity may enhance the transparency and credibility of landscape visualizations by transferring additional control to the user (Sheppard 2001; 2005c). In the Baltimore 2030 case study, Kwartler (2005) compared why, how, and under which circumstances interactive visualizations enhanced participatory visioning processes and scenario development. The Baltimore study involved collaborative stakeholder workshops as well as large public meetings. In comparison to other research, the Baltimore 2030 study stands out due to the large quantitative sample. The 1200 participants of the public meetings were questioned in telephone interviews and the survey gives evidence that the interactive 3D model did support public participation by building public confidence.

g) Comprehensive study on interactive landscape visualization in participation

The "Interactive Landscape Plan Königslutter am Elm" is comparable to the present thesis in many aspects. In Königslutter, various visualization techniques were tested for their strengths and weaknesses in different participatory settings, ranging from formal public involvement to informal collaborative approaches. The results suggest a key role for interactivity in dialogues (von Haaren et al. 2005; Warren-Kretzschmar et al. 2005). Participants used the interactive landscape model to locate and illustrate their contributions. In comparison to maps, the landscape visualizations facilitated the discussion, helped retrieve local knowledge and opinions, and increased the acceptance of the plan. In terms of interactivity, before/after representations and thematic navigation between alternative layers supported the communication of scenario alternatives, the retrieval of feedback, and the formation of individual opinions (von Haaren et al. 2005; Warren-Kretzschmar et al. 2005).

Real-time navigation was requested because people wanted to choose their own viewpoints and perspectives. However, spatial navigation was still confusing and too fast. Furthermore, people criticized the lack of a temporal navigation component and the limitations in direct interaction with the landscape. Therefore, hand-drawn sketches proved to be more practical in the very early stages of the planning process (Paar and Rekittke 2005; von Haaren et al. 2005; Warren-Kretzschmar et al. 2005). Altogether, the Interactive Landscape Plan Königslutter am Elm is the most comprehensive application of landscape visualizations in a case study yet and provides a good starting point for how interactivity may support communication.

3.5 Functional typology of interactions with landscape visualizations

The typology of landscape visualizations in chapter 3.2.5 already provides a classification of interactions with regard to their level of interactivity, but the theory on landscape visualization does not provide any deeper typology. For that reason, the following functional typology of interactions draws on the research on electronic atlases, i.e., by Ormeling (1997) and the following publications by Borchert (1999), Schneider (2002), Hurni (2004; 2005; 2006; 2007), Sieber and Huber (2007). However, the transferability of these approaches is limited because atlases present a collection of prepared information in which 3D visualization is only included as a special function. Atlases are mainly designed for school education, so that learning and retrieval functions are the focus. In contrast, landscape visualization should facilitate the dialogue in collaborative planning. In order to acknowledge the specific functions of landscape visualizations, the literature on atlases is consulted together with the basic research agenda in landscape visualization by Ervin (2001).

In summary, different functional groups and sub-groups can be distinguished with regard to their functionality in atlases (Hurni 2005: 247). In this context, functionality refers to the capacity of interactions to fulfil functions in the cartographic process, e.g., navigation, analysis, and explorations, when using atlases (Cron 2006). The six functional groups that are relevant for landscape visualization are listed in table 3.6. Customization functions are listed separately in table 3.7 because the customization is traditionally done beforehand. However, the argument is that these functions will soon be available on demand as well, so that both tables will merge in the near future (Ervin, personal communication). Both lists are ordered with regard to the relevance of the functional group. Navigation comes first, because most other interactions depend on a basic navigation, e.g., GIS analysis requires zooming the analysis results.

Functional groups	**Functional sub-groups**	**Interactions**
Navigation	Spatial	Pedestrian, flight, click-and-fly, landmark, navigation, trackball, zoom, focus navigation (see chapter 3.3.1 for technical implementation)
	Temporal	Time steps, temporal animations: play/stop/rewind, time slider
	Thematic	Menu, index, search
	Scenario	Multidimensional, i.e., spatial, temporal and thematic, navigation for the exploration of scenario storylines
Contextualizing functions	Multiple windows	Combination of different types of information in juxtaposed windows, e.g., landscape visualization and non-visual information
	Indicator link	Hyperlinks to additional non-visual information, e.g., indicator data
	Overlays	Combination of various layers of raster and vector data, e.g., for zoning maps and topographic maps
GIS analysis functions	Spatial analysis	Simple GIS functions: elevation, slope, distance…
	Experimentation	The underlying model responds to parameter changes in real-time (the technology was not available in the present study).
Landscape editing		Sketch, create or edit landscape objects
Documentation		Export screenshots and movies, make annotations
Didactic functions		Didactic animations and tours, pre-defined points of interest

Table 3.6: Functional groups of interactions in landscape visualizations (cf. Ervin 2001; Hurni 2005; Hurni 2006).

Functional groups	**Functional sub-groups**	**Interactions**
Customization of the representation	Realism	Rendering styles (levels of realism)
	Lighting	Changing the parameters for lighting, e.g., position, strength and direction of the light sources
Customization of the interface		Digital rights management, customization of interactive functions (interaction design)

Table 3.7: Functional groups in the customization of landscape visualizations.

3.5.1 Spatial navigation

For 3D landscape visualizations used in collaborative planning, the movement through the landscape is fundamental. The various communicative and cognitive reasons have been explained in the previous chapters, i.e., collaborative planning requires flexible and dialogical tools (communicative benefits, see chapter 3.4.4). In addition, perception is enhanced by moving through the landscape (cognitive benefits, see chapter 3.4.3).

Planning literature provides a rich source of information on how human orientation in spatial navigation functions. In “The Image of the City”, Lynch (1960) describes how the human path-finding process is based on the individual mental model as a kind of reference system. If the path-finding process is to be transferred to virtual space, two instruments become important (Fuhrmann and MacEachren 2001), these are landmarks for orientation and navigation metaphors. In this context, landmarks are visualization objects that represent important orientation points, e.g., churches or mountain peaks. Navigation metaphors are concepts that relate movement in virtual space to modes of movement in the real world, e.g., by references to surface vehicles or air travel vehicles.

3.5.1.1 Navigation metaphors

Fuhrmann and MacEachren point out that each field of application needs specific navigation metaphors and, obviously, medical 3D visualizations require different metaphors than landscape visualizations, especially as navigation in landscape visualizations is not linear and rather complex. Most landscape scenarios are based on multidimensional data, so navigation has to follow alternating scenario storylines (see figure 2.2 in chapter 2.3) through space, time and theme. Particularly for lay people, user-friendly basic navigation is essential and has the highest priority above any other functionality (Schneider 2002). Which metaphors are appropriate for planning? A set of navigation metaphors was selected with regard to Döllner (2005b) and tested in the case study (chapters 7 and 8) on its benefits for collaborative planning.

a) Pedestrian navigation

The point of view from a pedestrian’s perspective, also called the egocentric view, is common in landscape planning because it seems more natural than a birds-eye-view.

b) Flight navigation

Flying metaphors are well-known from flight simulators and, in large models, flight navigation is more suitable for overcoming great distances than pedestrian navigation.

c) Click-&-Fly navigation

The viewer navigates by clicking a visual target and the computer will move towards this point. This navigation metaphor is useful for approaching a specific location quickly.

d) Bookmark navigation

The user can target pre-defined bookmarks, e.g., points-of-interest, and is guided towards these.

e) Trackball navigation

In trackball navigation, the camera is positioned on the surface of a virtual sphere, making it easy to both rotate and zoom.

f) Zoom navigation

The distance to a focus point can be decreased or increased interactively. Zoom is a standard function of most real-time applications and makes it possible to zoom into an area of interest, e.g., the property of a stakeholder, and to zoom back to the overview of the spatial context.

g) Focus navigation

Focus navigation enables the user to switch between different focus points. The user can select a new focus point by clicking it in the visualization. The camera will then rotate so that this point becomes the new centre of the view. The integration of focus navigation in the LandXplorer proved very helpful in the collaborative workshops because the visualization navigator could easily respond to wishes "to go to that point".

3.5.2 Temporal navigation

In the representation of temporal processes, alternate models of time can be distinguished (Edsall and Sidney 2005). Navigation through linear time is best supported through a "timeline representation" (figure 3.25), which helps exploring trends over time, going forwards and backwards or pausing at specific points in time.

Figure 3.25 Example of a timeline navigation interface.

3.5.3 Thematic navigation

Thematic navigation covers all interactions that allow the user to query specific topics, i.e., menu, index and search. Interactions for thematic navigation are a requirement for other interactions, but it only refers to the navigation between topics. In contrast, overlay allows the combination of different topical layers into a new one.

3.5.4 Scenario navigation

Neumann (2005) refers to the space/time/theme model by Ott and Swiaczny (2001). Neumann locates historic events by their spatial, temporal and thematic configuration. The approach is transferable to planning, especially with regard to the scenario method in planning. Figure 3.26 illustrates the various dimensions of a multidimensional problem according to Neumann. As the comparison of figure 2.2 with figure 3.26 shows, the alternative storylines of a planning scenario are comparable to the lines of development in Neumann's model. Therefore, the “what-if” scenarios in planning create an abstract space with five dimensions. In addition to the three spatial dimensions, scenario storylines have a temporal and a thematic dimension. Tools are needed that make these five dimensions perceptible.

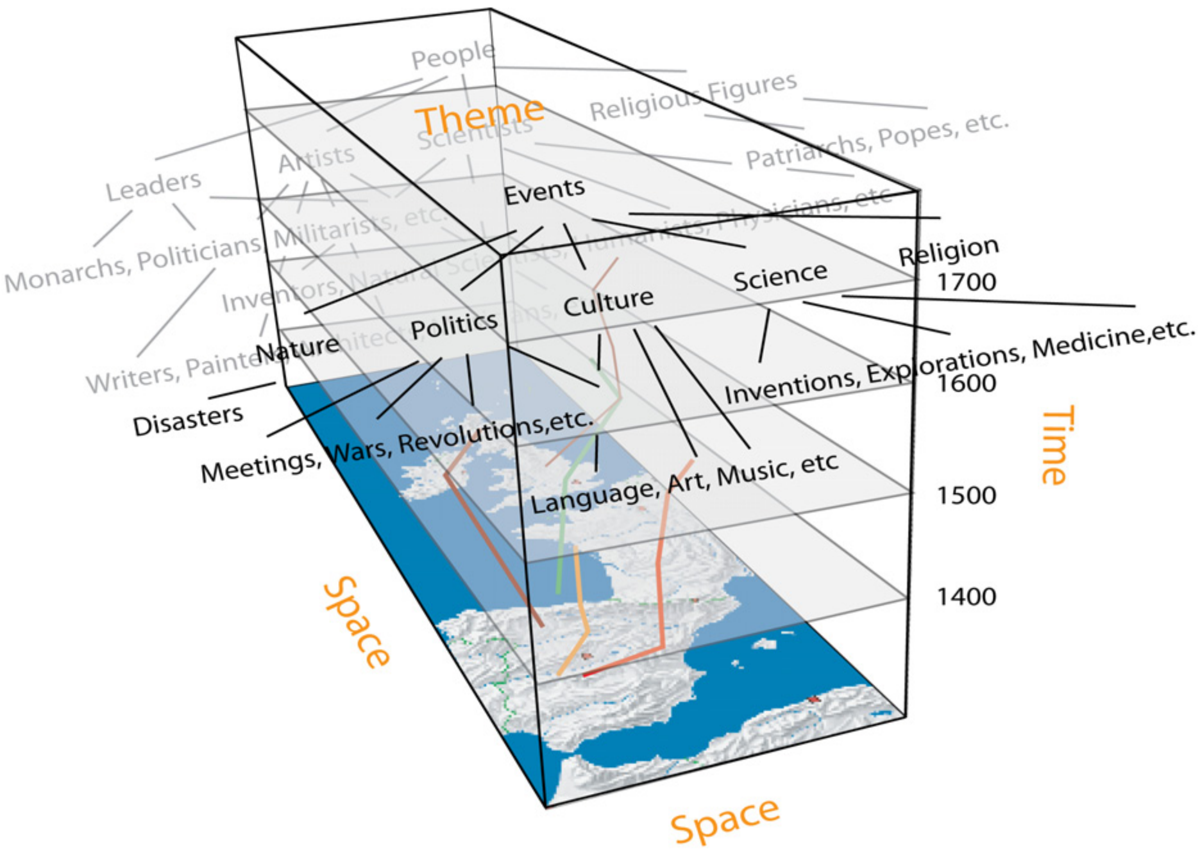


Figure 3.26: Space/Time/Theme model by Neumann (2005), in Hurni (2005).

For combined multi-dimensional spatial, temporal and thematical navigation, selected metaphors were tested in the case study in order to assess their benefits in collaborative planning processes. An early form of scenario navigation is the before/after visualization by Repton (see chapter 3.1) and his analogue ‘Redbooks’. Because the navigation through alternative scenarios is so important for decision-making in collaborative planning, it is introduced as a functional sub-group on its own: ***scenario navigation***.

3.5.5 Contextualizing interactions

For a comprehensive landscape assessment, ecological, economic, social and aesthetic information has to be evaluated. Interactions with the landscape promise communicative and cognitive benefits as they put information in its spatial context and support knowledge building. The necessary information is usually described by indicators, i.e., often “measurable” characteristics reflecting the state of the system. 3D visualizations are appropriate tools to assess landscape aesthetics by the visual quality of the landscape shown. There is a strong need to integrate the representation of the visual landscape with the ecological, economic and other indicators. In this way, the spatial relationship between data and location becomes explicit. Here, contextualizing interactions are a promising tool for the integration of visual landscape and landscape indicators (Hehl-Lange 2001; Wissen et al., in Press). Hehl-Lange provided an example of how landscape functions can be revealed to the viewer by showing non-visual information in the context of the realistic landscape visualization. In her research, the nocturnal flight paths of bats were shown as lines within the landscape and by following these paths, the user learnt about the habitat function for bats.

In an early classification of geovisualization, Crampton (2002) introduced “contextualizing interactions” as a class of its own. By “contextualizing”, Crampton (2002: 94) described interactions that put different pieces of information together in context with each other. For example, “contextualizing” includes the selection and comparison of data, the juxtaposition of multiple windows, the integration of non-visual data in a realistic visualization, the combination of multiple data layers as overlay, and hyperlinking (figure 3.27).

Of course, contextualizing interactions rely on navigation and zoom, so there are overlaps. Keeping the context during navigation is an important requisite for successful orientation. However, in comparison to navigation through different topics, contextualizing as a class of its own is defined as the act of combining different pieces of information. Particularly in planning, the contextualizing of visual information and indicators facilitates landscape assessment. Figure 3.27 illustrates an example from tourism, where the three-dimensional view of the location of hotels in a tourist destination is linked to diagrams of overnight stays by hyperlinks.

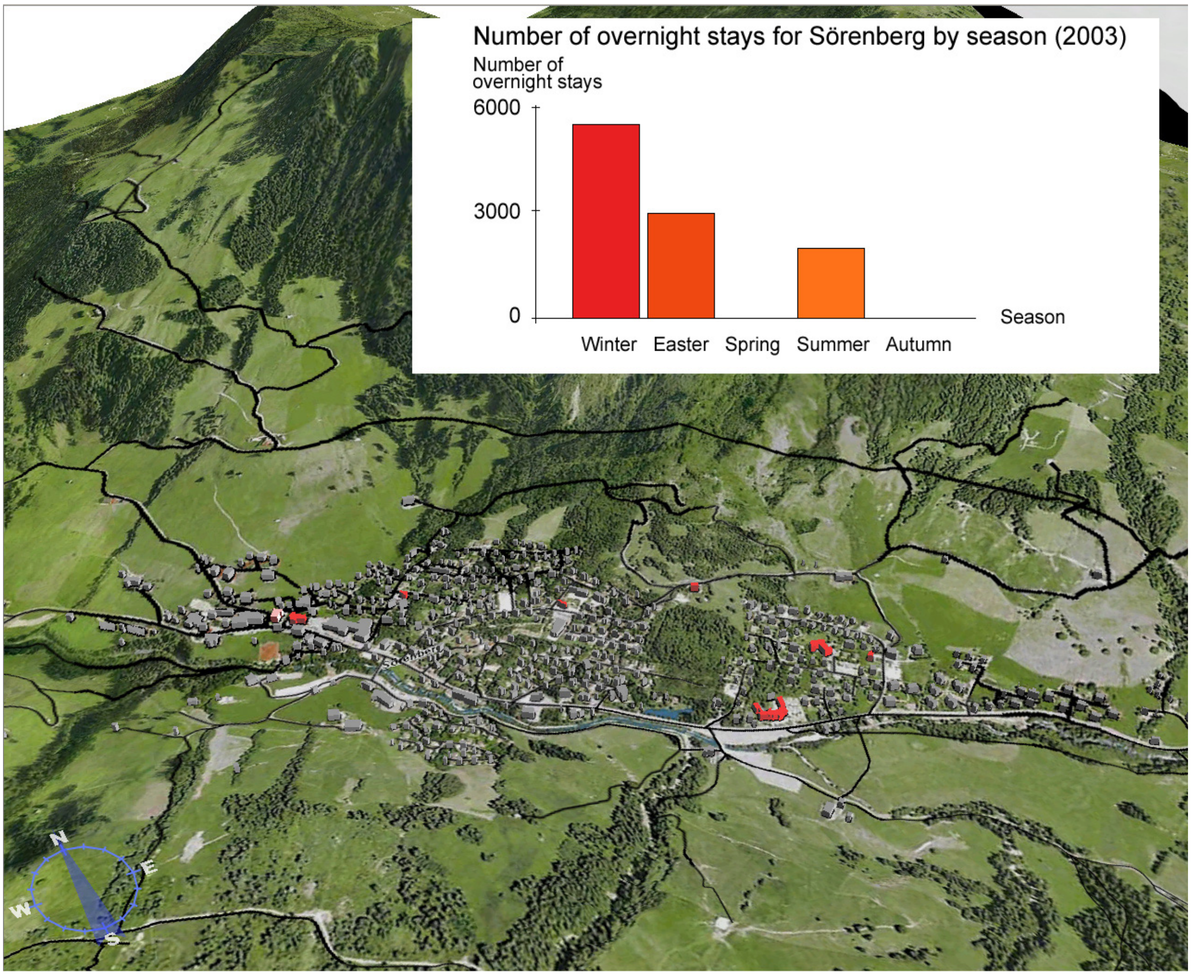


Figure 3.27: Contextualizing interaction. The example shows the 3D visualization of the village of Sörenberg. The red objects represent the corresponding hotels. The visualization is linked to the diagram of the numbers of overnight stays over seasons (upper right corner) by hyperlinks.

3.5.6 Spatial analysis in landscape visualization

Schneider (2002) analysed which spatial analyses in GIS are suitable for integration in atlas systems. For atlas systems, she observed a need for high usability and sophisticated visualizations, but a rather low priority for complex GIS analyses. Therefore, she suggested the inclusion of analyses on a very low level of complexity.

With regard to Schneider (2002), a low level of complexity may be preferable in planning as well, if working with lay people who have low levels of technical experience and limited time. Simple analyses could be applied in real-time and facilitate the collaboration process. The present study contains elevation and slope analyses (figure 3.28) as interactive GIS analysis functions. More complex analyses were prepared beforehand. However, which levels of GIS analysis are preferred by lay people and experts in landscape visualization, should be subject to further research.

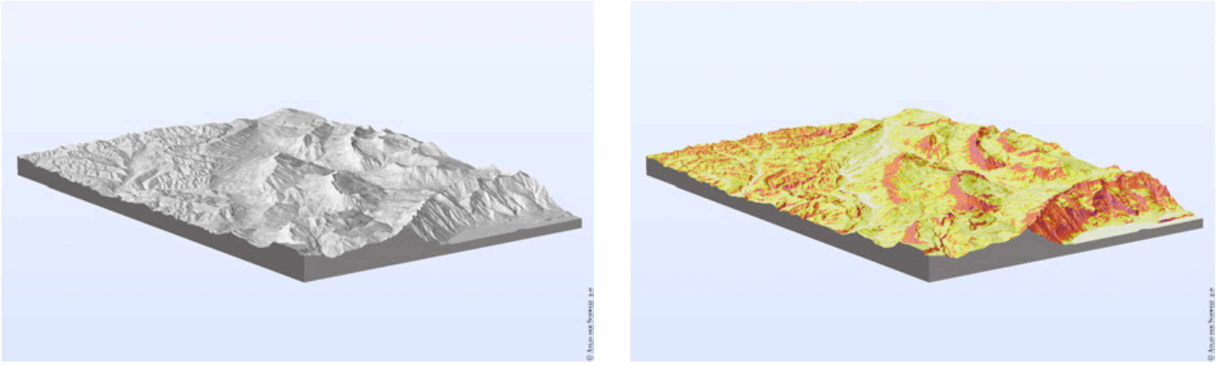


Figure 3.28: Result of a slope analysis in the "Atlas der Schweiz 2", rendered as dynamic color texture (see chapter 3.3.1). The two-dimensional texture is projected onto the DTM in real-time (image: Atlas der Schweiz 2006).

3.5.7 Landscape editing

Interactive landscape editing is likely to facilitate the learning outcome. Therefore, Ervin (2001) points out that interactive landscape editing in real-time is urgently required. The basic principles of interactive editing of a terrain surface are already in place (Bär 1995) and it is likely that such tools will become commonly available soon. This may fulfil the postulate by Lindhult (in press) that landscape editing has to allow creative design while minimizing the non-creative interaction tasks. Von Haaren et al. (2005) tested tools that allow the interactive planting of trees in real-time. According to the participant interviews, the planning stakeholders demanded further design and sketching opportunities. In the present study, landscape editing is tested in prototypes only.

3.5.8 Documentation

As shown by von Haaren et al. (2005), documentation is supported through interactive annotations within the landscape visualization. Documentation is particularly important to meet the formal requirements of planning and to give consideration to stakeholder input.

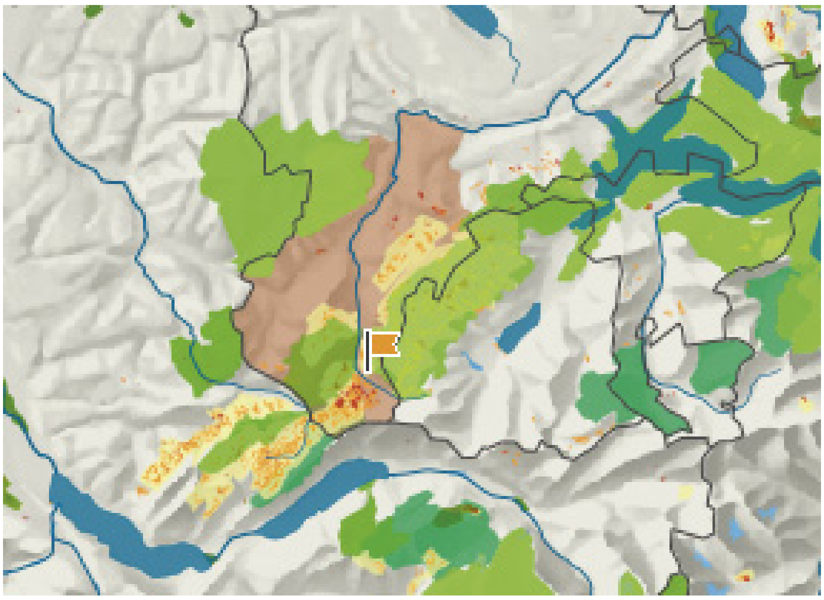


Figure 3.29: Example of an annotation (image: Atlas der Schweiz 2006).

3.5.9 Didactic functions

Didactic functions such as guided tours are particularly important for the use of landscape visualizations in interactive kiosk systems, where the user is guided through a prepared set of information. They are less important in mediated stakeholder meetings and, therefore, not discussed in detail.

3.5.10 Customization of the representation

Traditionally, the representation of landscape visualizations has been customized before a presentation. For that reason, the customization of the representation is not necessarily a functional group of interactions. However, the literature review suggests a need for more interactive representation styles (e.g., Rekittke et al. 2004) and interface design (Buurman 2005). Today, the advanced rendering techniques described in chapter 3.3.1 make it possible to change the level of realism without working on the database. Now, the user is able to change the representation on demand in accordance with the planning stage. For that reason, the customization of the representation style is included in the typology of interactions with landscape visualization (Ervin, personal communication).

3.5.11 Customization of the interface

Current visualization software is beginning to allow the customization, or rather personalization, of the graphic user interface as well. This function is very important in the visualization process because it helps the cartographer limit the cognitive costs for the users. Depending on the customization of the interface, i.e., the pre-selection of interactions, cartographers can facilitate or constrain the user's work. Edsall and Sidney (2005: 577) state that "the ways in which a user is allowed to manipulate the visualization and the data represented (through various interaction capabilities) are just as important as the ways the data are presented." Later, they conclude that "interaction itself is a form of symbolization in dynamic visualization applications," (Edsall and Sidney 2005: 579). In summary, there is much evidence that "interaction design" (Buurman 2005) will evolve as a key task in interactive landscape visualization.

Current trends suggest that in the long term, not only will the representation be subject to individual customization, but so will all the steps of the visualization process. Although there are concerns that the bottom-up "crowdsource production" may reduce the quality and reliability of maps, geospatial tools are likely to become more participatory (Crampton 2007).

4. Research hypotheses

On the basis of the literature review, it has been suggested that visualizations should be interactive if used as a participatory tool. From interactive atlas systems, it is known that different types of interactions serve different user needs. How then do different types of interactions with landscape visualizations serve the needs of collaborative planning?

4.1 First research question: Hypotheses on the benefits of different types of interaction for the quality of collaborative planning

The first research question on the role of different types of interactions has been prepared from the literature review on cognitive and communicative benefits of interactivity (chapter 3.4). The criteria for assessing the quality of the participation process are described in detail in chapter 2.4. Altogether, the following hypotheses relate the potential benefits of interactivity in landscape visualizations to the qualities of the collaborative process and outcomes:

- Interactivity facilitates an **inclusionary participation** process.
- Interactivity enriches **two-way information on landscape processes and change**.
    - Interactivity enriches the **factual dimension** of information on landscape change.
    - Interactivity enriches the **emotional dimension** of information on landscape change.
- Interactivity facilitates **engagement and dialogue**.
- Interactivity increases the **credibility and transparency** of landscape visualizations.
- Interactivity helps to build **consensus** among stakeholders with different interests and different perceptions.
- Interactivity facilitates collaborative **learning** from landscape visualizations.

In chapter 3.5, eight functional groups of interaction with landscape visualizations were defined. Now, this typology is used to help distinguish the term “interactivity” in the hypotheses. In the case study, the various data sources are analysed in order to identify relationships between a type of interaction and the qualities of collaborative planning, i.e., the two columns in table 4.1. Therefore, the hypotheses can be tested for different types of interactions as well.

In this typology, navigation is needed for all other interactions and gets special attention in the analysis. The other interactions, especially landscape editing and on-demand customization, are technologically in their beginnings and have only been tested as far as possible.

Types of interactions	Qualities of collaborative planning
• Navigation (spatial, temporal, thematic, scenario) • Contextualizing functions • GIS analysis functions • Landscape editing • Documentation • Didactic functions • Customization of the representation • Customization of the interface	• Inclusiveness • Enrichment of information (factual and emotional dimension) • Dialogue • Credibility and transparency • Consensus (outcome) • Learning (outcome)

Table 4.1: Matrix that shows the types of interactions and the qualities of collaborative planning in comparison. In the research, any item in the left column may relate to any item in the right one.

4.2 Second research question: Hypotheses on the correlation between user characteristics and interaction preferences

Collaborative planning is an open process and stakeholder groups can be very heterogeneous, with diverse backgrounds and different map-reading skills. Together with the stakeholders, experts and planning professionals (planners, surveyors, architects, etc.) are involved in collaborative planning processes. In order to answer the second research question on user preferences for different types of interaction, the British Forest Research Institute organized a stakeholder workshop in Edinburgh in January 2005 as part of the VisuLands project. Hislop (2005) prepared the proposal of the survey on behalf of the British Forest Research Institute. For each study site, one so-called "end-user" represented the local stakeholders. The Swiss research team was invited as guests and made suggestions during the discussion of the proposal. The final selection of the user characteristics was done by the stakeholders only. A more detailed description of the workshop is contained in Miller et al. (2006). The stakeholders selected gender, age, profession, affiliations to local stakeholder groups, place of residence, and map-reading skills as socio-demographic characteristics, although not all of these characteristics can be tested quantitatively because the target group does not provide appropriate subsamples. The resulting hypotheses read as follows:

- User preferences for different types of interactions are correlated to **gender**.
- User preferences for different types of interactions are correlated to **age**.
- User preferences for different types of interactions are correlated to **profession**.
- User preferences for different types of interactions are correlated to the **affiliation to a stakeholder group**.
- User preferences for different types of interactions are correlated to the **place of residence**.
- User preferences for different types of interactions are correlated to **map-reading skills**.

5. Study site description: Entlebuch UNESCO Biosphere Reserve

The VisuLands project coordinator and the supervisor of the Swiss team chose the Entlebuch UNESCO Biosphere Reserve (UBE) as the local study site where the visualization tools would be assessed in cooperation with local stakeholders. Two reasons affected the decision, the area's diverse and invaluable cultural landscape and the high relevance of public participation in the Biosphere organisation.

Figure 5.1: Typical moorlandscape with the Schrattenfluh in the background, location of the Entlebuch UNESCO Biosphere Reserve (map on the right).

The mountainous Entlebuch area (394 km2) is located in central Switzerland in the main valley between Lucerne and Bern (figure 5.1) and includes the eight municipalities of Entlebuch, Doppleschwand, Escholzmatt, Fluehli, Hasle, Marbach, Romoos and Schüpfheim. Its diverse agricultural landscape contains important habitats for plants and animals, for example, karst areas, forests and unique moorlands, including raised bogs and peat bogs (figures 5.1 and 5.2). Important landmarks are the Napf area and the Schrattenfluh (figure 5.1), a karst mountain with large caverns under national protection. The Kleine Emme river flows through the valley and is bordered by alluvial forests.

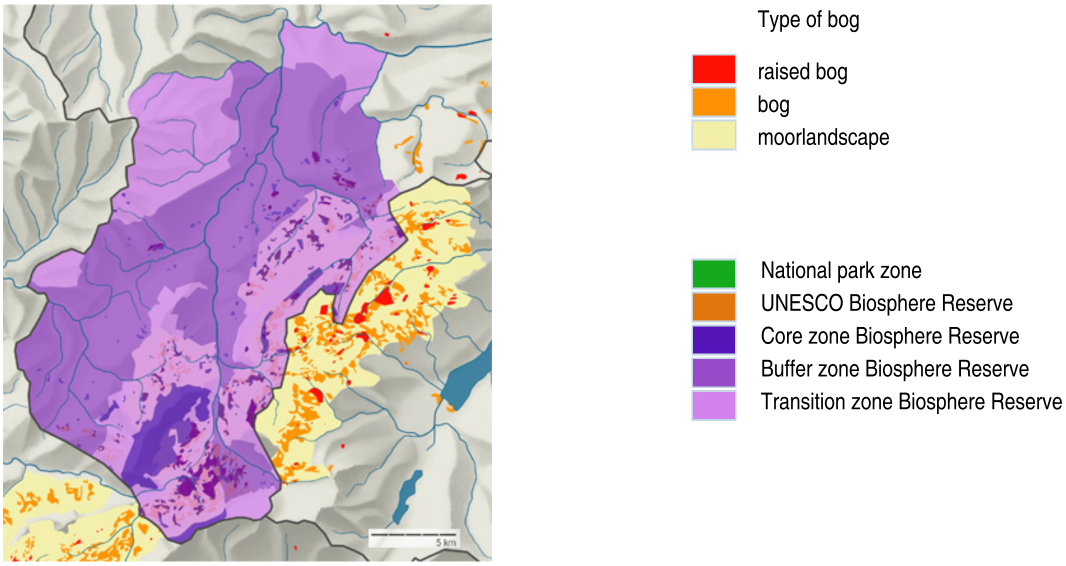


Figure 5.2: Moorlandscapes of national importance in the UBE (Atlas der Schweiz 2006).

	UBE		Canton of Lucerne		Switzerland	
Total Surface		394 km²		1493 km²		41285 km²
Agricultural utilizable area of land		30%		50%		24%
Alpine utilizable area of land wood spaces		18%		5%		13%
Spaces of settlements		42%		30%		31%
Unproductive spaces		3%		8%		7%
		7%		7%		25%
Population (2000)		16888		345367		7164444
Number of employees (2000)		7850		173327		3713970
1st Sector		39%		10%		6%
2nd Sector		24%		28%		28%
3rd Sector		37%		62%		66%
Number of farms (2000)		1096		5779		70537
Main occupation		74%		78%		70%
Change 1990-2000		-15%		-17%		-24%
Landscapes and bog biotopes of national importance	**Number of objects**	**Surface**	**Number of objects**	**Surface**	**Number of objects**	**Surface**
BLN objects	4	121 km²	12	261 km²	162	7807 km²
Protected bog land	4	112 km²	4	112 km²	89	873 km²
Raised bogs	44	171 ha	56	185 ha	513	15 km²
Peat bogs	61	1766 ha	94	2097 ha	1163	192 km²

Table 5.1: The Entlebuch UNESCO Biosphere Reserve in figures (Regional Management UBE 2002).

Table 5.1 shows the relevant figures that characterize the Entlebuch region. Land use, number of farms and the number of employees in the first and second sector illustrate that the overall number of people working in agriculture (mainly cattle) is far above the Swiss average. At the same time, a high percentage of the farm land is alpine area, which is difficult to manage and has a low yield. Therefore, it is not surprising that the Entlebuch is a peripheral, economically depressed region in the Swiss context, and some authors say that it has even been known as the "poorhouse" of Switzerland.

The land is hard to farm, but the Entlebuch contains one of the largest moorlandscapes in Switzerland (figures 5.1 and 5.2) and is recognized as a landscape of national importance. In 1987, about 27% of the area of Entlebuch, including 60% of the municipality of Flühli, were designated as protected moorland according to the Rothenturm initiative. In the Rothenturm initiative, the Swiss public voted in December 1987 to add a law on the protection of moorland of specific significance to the constitution. Due to this law, any construction or activities with an impact on the soil are strictly prohibited on moorland. In the following, strong objections against the protection rose among the farmers who feared restrictions to their work. The farmers felt ignored by the top-down implementation of the Rothenturm initiative and a very strong opposition against nature protection was raised. About ten years later, in September 2000, about 92% of the Entlebuch citizens voted in favour of the UNESCO Biosphere designation (Müller 2006). How did this astonishing change of public opinion happen?

5.1 Bottom-up participation as the key to acceptance and sustainable change

The planning processes before and after the constitution of the UBE have been subject to a number of student theses and publications (Büchi 1998; Schnorr 2002; Schmid 2004; Lange and Schroth 2005; Wallner 2005; Müller 2006). All authors agree that participation was the key to dissolving the conflict between agriculture and nature protection, and building trust and acceptance for the UNESCO Biosphere. When the controversy of the top-down protection laws became more and more blocked, the regional planning association launched a regional strategy on the sustainable development of the moorlandscape. After the constitution of the Biosphere Reserve, the former regional planning association was transferred to the Regional Management of the UBE. The regional strategy emphasized that the moorlandscape in this area is a cultural product, i.e., created through grazing cattle and cutting the grass. In terms of sustainability, it is necessary to secure the economic survival of the farmers in order to protect the moorland in its current form (Büchi 1998). In other words, as the local newspaper asked provocatively: “What to do with so much beauty?” (Hofstetter 1997). In order to find answers to this question, a lively public debate started and the regional planning association launched working groups. Most important, the opposition against moorland protection, especially farmers and members of the conservative party were not excluded but invited to participate in the sustainable development in forums and working groups.

Especially with its reference to the sustainable development of ecology, economy and local communities in a participatory way, the regional strategy was already close to the Biosphere criteria. Soon, the regional planning association launched the idea to apply for the designation as a UNESCO Biosphere Reserve. A general referendum was launched, after the Canton of Lucerne, which bears a share of the costs, demanded a confirmation that the project was supported by the local public. The referendum was approved in September 2001. Depending on the source, the numbers vary between 91% and 94% percent yes votes, which clearly shows the wide support the Biosphere Reserve gained. In comparison to other referendums, the turnout of voters was relative high at about 40% (Ruoss et al. 2002; Müller 2006). The process was accompanied by broad public information, discussions in the local newspaper and events throughout the area. According to Schnorr (2002) and Schmid (2004), the Biosphere management convinced the stakeholders in forums that the Biosphere label is an economic chance and not another repression. Only one year after the referendum, the Entlebuch area was designated as one of the first biosphere reserves based on the Sevilla Strategy (Ruoss et al. 2002). Today, the Biosphere label has enhanced the self-identification of the inhabitants, provided positive input to the economic development and is widely accepted. Due to this success, UNESCO assessed the bottom-up processes in the UBE as a best-practice example in participation (Schmid 2004).

5.1.1 Organisation of the Entlebuch UNESCO Biosphere Reserve

The Entlebuch UNESCO Biosphere Reserve is organised on two levels: strategic and operational (figure 5.3):

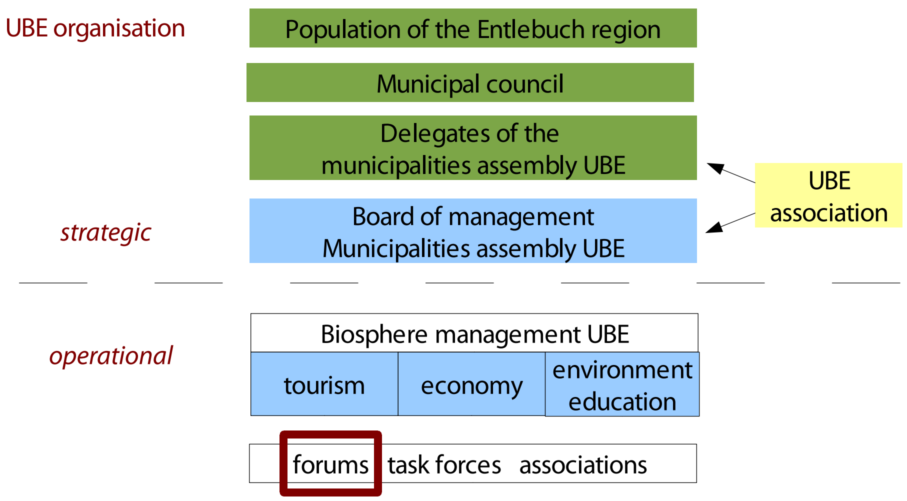


Figure 5.3: Organisation of the UBE, with the forums highlighted (translated from Ruoss et al. 2002).

On the strategic level, the UBE and its management are supervised by the managing board, which was elected by the local municipality council. This part of the organisation is the only one that has been criticised for a lack of participation (Schnorr 2002; Müller 2006). Alternatively, the direct election of the board by the local citizens was discussed but not implemented. On the operational level, the three regional managers, Bruno Schmid, Theo Schnider, and Dr. Engelbert Ruoss, initiated several social, economic and environmental projects during the following years. These projects were the origin of the forums, which now take place at the agriculture school in Schüpfheim (LBBZ).

5.1.2 Forums

The forums (figure 5.3) address current negative trends in population (age of the farming population), increasing demands for energy and natural resources (renewable resources), globalization of the economy and the effects of trade patterns on rural areas (cutback of agricultural subsidies). The same issues are on the agenda in other European regions (UNESCO 2006). Landscape development is a central topic in most of the forums because an aesthetic and ecologically stable landscape is recognized as the basis for a healthy life and, furthermore, provides natural capital for tourism and the promotion of regional products (Ruoss et al. 2002). The already established forums and workshops provided a good starting point for involving local communities in testing the visualization tools and gathering feedback.

5.2 Selection as study site

The request for research meets the goals of the UBE very well as research is an important requirement of UNESCO. Research activities in the UBE area were supported and coordinated by Dr. Engelbert Ruoss, who explained the objectives of participatory research in an interview with Mountain Research and Development (Ruoss 2001). In summary, the UBE focuses on transdisciplinary issues and working methods. The objective is to bring researchers and local population together, to involve local people in the research, and to confront researchers with the concerns of the public. During the course of the VisuLands project and this thesis, the principles of transdisciplinary research were implemented as often as possible, e.g., in group discussions. Moreover, the participatory structure of the Entlebuch UNESCO Biosphere Reserve and its participatory culture comply with the ideas of collaborative planning and provided the right context for testing the benefits of interactive landscape visualizations in a real planning process.

6. Visualization methods and research design

The research design of this thesis is based on a multiple-case study and a survey, which are used to analyse the role of interactive landscape visualizations. The following chapter introduces the applied scenario and visualization methods (6.1), the workshop procedures (6.2), and the research design (6.3 and 6.4).

6.1 Scenario and visualization methods

Extensive preparations preceded the workshops. First, a geodatabase was set up. Second, a 3D model of the area was created, and third, scenarios were built in GIS and visualized in the 3D landscape model for each workshop. Figure 6.1 illustrates the integration of landscape visualizations into a planning process according to Sheppard (1989) and reflects the case study procedures very well. A basic interactive landscape visualization workflow contains the geodatabase and a "landscape base model" both of which are prepared beforehand (1). Any additional interactions are applied to these basics throughout the workshop (2). The feedback loop is implemented through continuous revisions of the visualizations between the workshops. In some cases, analysis results needed to be prepared beforehand as well because the analysis took too long to be able to apply it on demand. Nevertheless, the use of a landscape base model can be suggested for the preparation of interactive workshops in general.

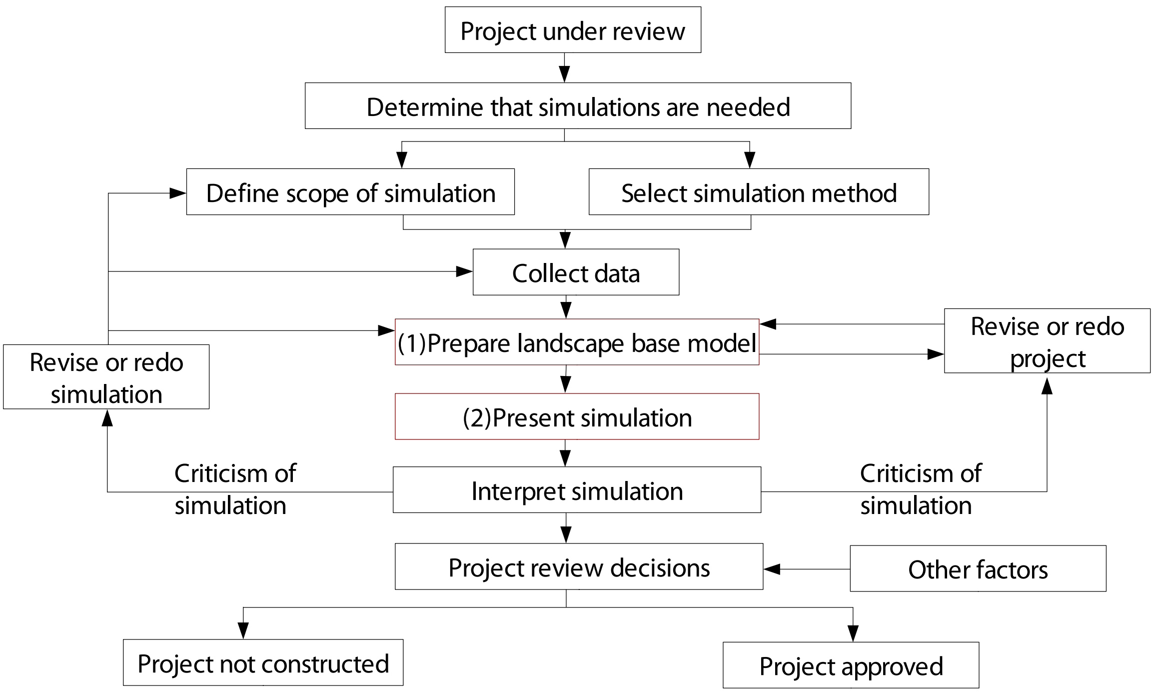


Figure 6.1: Simplified visualization process according to Sheppard (1989). The term "simulation" can be conceived as an "interactive landscape visualization" in the context of this work.

6.1.1 Database and landscape base model

The project database contains geodata, statistical data and customized 3D models. Although existing data was incorporated in the case study database, the purchase and integration of the data still consumed considerable resources and took several months. During the course of the project, additional orthophotos had to be taken because the original photos lacked quality. In return, the geodata, provided by the Canton Lucerne, has a high accuracy of 10m in the DTM and 0.5 m in the orthophotos. The orthophotos were taken in 1998 and 2003 and updated in 2005. The UNESCO Biosphere Reserve contributed a broad range of georeferenced thematic data on administrative boundaries, land use, zoning, population, agricultural units, geology, vegetation, cultural heritage, transport and water from their Biosphere geodatabase. For each case, additional statistical data was retrieved from the Cantonal Bureau of Statistics and from scientific institutions.

For the landscape model, customized buildings and vegetation models were modelled in two levels of detail, i.e., verisimilar and indexed (see figures 3.6 and 3.7 in chapter 3.2), using Xfrog, Cinema 4D and Sketchup software. The models were based on a photographic inventory of iconic buildings and key vegetation species that had been conducted at the beginning of the VisuLands project.

Finally, the geodata was imported into Visual Nature Studio, LandXplorer and Lenné3D. The basic landscape model contained the DTM, orthophotos and topographic map (1:25.000), a 3D city model of the village of Sörenberg (without textures), and vector data on basic vegetation (forest), infrastructure (streets) and topographic landscape elements (river). Additional thematic information was organised in layers on top of the landscape model. Each layer can be turned on or off on demand so that discrete landscape visualizations can be constructed on demand. The coloration of the vector data in LandXplorer follows a 14-color scheme that was defined beforehand, following the suggestions by the Swiss Society of Cartography (Spiess et al. 2002). The indicator data in Visual Nature Studio follows a different color scheme, developed by Wissen (2007).

6.1.2 Scenario methods

The visualization of future landscape changes is based on the scenario method as described in chapter 2.3.3. The scenarios include the analysis of the current state and its history, the spatial context with its structures and processes, the key driving forces, trends, indicators, and their spatial-functional relationships. The scenario results are ordered in time periods (including the base year in which the scenario starts). The scenarios are described as a development path with the description of step-wise changes, future visions or future images that are illustrative snapshots of the development path, and a storyline in the form of a narrative text of the actions (Stiens 1998; Scholles 2001). This qualitative storyline has to be translated into quantitative GIS data so that it can be visualized.

In the UBE case study site, a bottom-up participatory scenario-building approach is used to set up the storylines. The concepts are developed in cooperation with the UBE management and built on the series of moderated workshops that took place locally. The qualitative storylines are further enhanced by including statistical indicator data and scientific research results. Some of the indicators are: the number of overnight stays, traffic figures for tourism, occurrence of indicator species and economic indicators for agriculture. These are transferred into the spatially explicit GIS database in ESRI ArcGIS and form the basis for the 3D scenario visualization (Miller et al. 2006).

It is important to note that the development of scenarios and their visualization took place iteratively. That means, in a workshop series, the results of the first workshop were used to adjust the scenarios and landscape model for the second workshop and so on.

6.1.3 Visualization methods

The definition of landscape visualization in chapter 3.1 described the basic elements of a virtual landscape (figure 3.3). In technical terms, the landscape elements are represented by 3D geodata in form of a digital terrain model (DTM), 2D geodata that is draped onto the DTM (aerial photography, biotope map, topographic map), and 3D objects (CAD buildings with facade textures, 3D plant models). For a more detailed description of different data sources for three-dimensional models, please refer to Discoe (2005) and Döllner et al. 2005.

It was shown in chapter 3 that the choice of the visualization software determines the representation and interactivity of landscape visualizations. The pros and cons of current visualization packages are discussed in detail in an evaluation by Schroth et al. (2004). On this basis, two software packages were selected for the majority of the work, i.e., Visual Nature Studio (VNS) by 3D Nature Studio for static images and sequences and LandXplorer Studio by 3DGeo for interactive real-time visualizations. In the first agriculture workshop, the VNS model was exported to the real-time Virtual Terrain Project (VTP) and in the quantitative survey, the photorealistic real-time player Lenné3D was used in addition to LandXplorer.

6.1.3.1 Low to middle level of interactivity: Visual Nature Studio with animation software

Visual Nature Studio (VNS) is the most common high-end landscape renderer for static images (Geier et. al. 2001; Appleton 2001) because it offers enhanced support for GIS data and produces comparatively realistic images. The virtual landscape can be edited inside a so-called "WYSIWYG: What you see is what you get" editor or database. Importing geodata can be automated and templates support the production of alternative scenarios from the same landscape model. Vegetation is described by so-called "ecosystems" and is usually represented by textures and billboards, although single polygon models can be imported, too. The definition of "ecosystems" in VNS is purely technological and does not conform to the definitions of ecosystems in botany.

The animation function allows the pre-rendering of flightpaths and animations over time. The Scene Express extension, released in autumn 2003, adds conversions for various other real-time formats. In comparison to other software with GIS integration, VNS offers the most advanced features for editing and representing landscape scenarios through photorealistic images. The VNS scenarios were later animated in the PowerPoint presentation software (low level of interactivity) or with the Adobe multimedia authoring tool, Flash, which allows the design of complex interactions (figure 3.10 in chapter 3.2.4). The Scene Express extension was also used to export a real-time model to the Virtual Terrain Project player (figures 7.14 and 7.2).

6.1.3.2 High level of interactivity: LandXplorer Studio and Lenné3D

The project partners Hasso-Plattner-Institute Potsdam (LandXplorer) and ZALF/Konrad-Zuse-Institut Berlin (Lenné3D) developed two modules for landscape visualization, the LandXplorer Studio and the Lenné3D player. The LandXplorer is basically a geodata content management system that allows the user to compose, arrange, edit, and design 3D landscape models interactively (Döllner et al. 2005). All in all, LandXplorer provides a very high level of interactivity and a middle level-of-detail. In comparison, the related Lenné3D player module is optimised for the photorealistic representation of vegetation in real-time (see chapter 3.3.2 for the technical details of photorealistic real-time visualization). In terms of interactivity, Lenné3D provides mainly spatial navigation. The LandXplorer has to be used for other types of interactions.

6.1.3.3 VNS in comparison to LandXplorer

In the case study, VNS, LandXplorer, and Lenné3D were used to accommodate different levels and types of interactivity (see chapters 3.2 and 3.5). LandXplorer and VNS were used most often, while Lenné3D was only applied for the quantitative survey.

Functional groups of interactions	VNS	LandXplorer Studio
• Navigation (spatial, temporal, thematic, scenario)	With SceneExpress: spatial With Flash: temporal, scenario, thematic navigation	Spatial, thematic, scenario navigation; temporal navigation is limited
• Contextualizing functions (multiple windows, indicator link, overlays)	With Flash, yes	yes
• GIS analysis functions	no	yes
• Landscape editing	no	yes
• Documentation functions	no	yes
• Didactic functions	no	yes

Table 6.1: Implementation of different functional types of interactions with VNS and LandXplorer Studio.

In summary, most VNS images were static and had to be rendered and animated before the workshop. In LandXplorer, only the data layers were prepared before the workshop; the final visualizations were constructed through interactions on demand during the workshops. The details of visualization methods specific to each case are described in the case descriptions in chapter 7. The case descriptions also provide visual examples of the different interaction techniques.

6.2 Workshop procedures

The literature review on collaborative planning already highlighted the central role of the facilitator. In the case study, the sequencing of the workshops was determined by the facilitators. In contrast to the workshops described by Lange and Hehl-Lange (2005) and by Salter et al. (unpublished), these workshops were not organised by the research team but organised and facilitated locally by an independent intermediate organisation with the research team participating as external experts. This hands-on setting has the advantage that a current planning process can be analysed. However, the researchers have only limited control over the setting and the integration of the visualizations in the workshop sequence.

6.2.1 Workshop choreography

First, the case study does not intend to provide direct interactions between stakeholders and computers, but the interactions are mediated through the visualization navigator. As explained in chapter 3.2.5, mediated interactivity allows the application of a higher level of interactivity with lay people than direct interactions. They are also less distracting in a workshop setting of this size.

The detailed sequences of the workshops are described in the case descriptions in chapter 7, but two general functions of the visualizations can already be distinguished. Most workshops started with input sessions in which the landscape visualizations were used to explore spatial phenomena, to facilitate understanding of external input and to contribute to collaborative learning. During the scenario discussions, the visualizations were used to facilitate the dialogue, assess future scenarios, and support consensus-building.

6.2.2 Role of the facilitator and the visualization navigator

It was defined beforehand that the facilitator is in control of the workshop sequence, i.e., the facilitator formulates topics and questions, allocates the available time and decides on the use of visualizations, especially if they may hinder the discussion. For these reasons, visualizations were rarely used during brainstorming sessions because the facilitator did not want to distract people.

The facilitator agreed with the research team beforehand which landscape visualizations, data layers and interactions are prepared. This coordination proved necessary in order for the facilitator to integrate the visualizations into his sequence of the workshop. However, it should be noted that it was easier for the facilitator to use the visualizations than it was for the stakeholders, who did not know the available imagery and interactive functions.

The visualization navigator was supposed to stay in the background and did not actively participate in the discussion. However, the visualization navigator explained the visualization content as well as the interactions, if requested. In addition, the visualization navigator accompanied the scenario discussion discretely by choosing landscape views that illustrated the ongoing dialogue.

Figure 6.2 shows the interactions between the facilitator, stakeholders, visualization navigator and the visualization examples for the first case. In the example in the photo, a standard folding screen (280 x 210 cm) was used, an immersive display (840 x 210 cm) was only used in the second agriculture workshop. The verbal interaction between the stakeholders and the visualizations are a bit less frequent than the interactions between the facilitator and the visualizations. Most important, the figure highlights the central role of the facilitator in the case study setting.

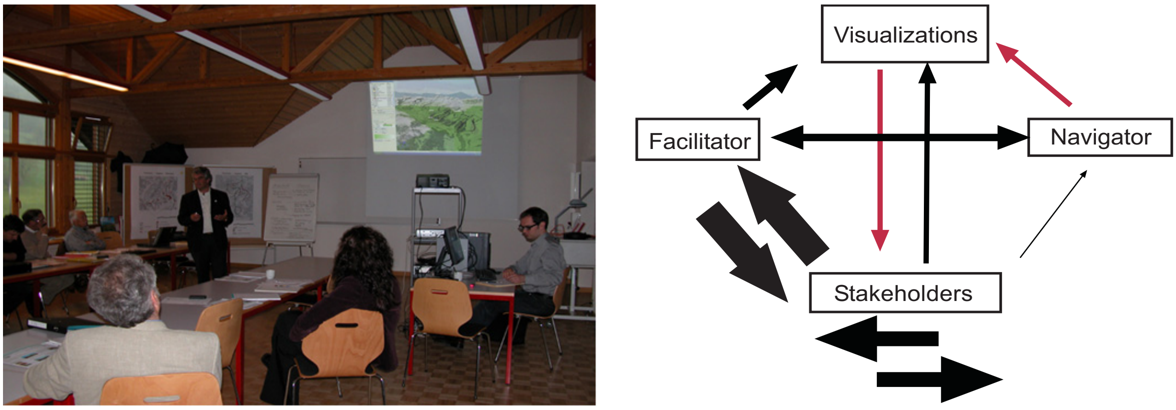


Figure 6.2: Interactions during the discussion, with verbal references in black and non-verbal in red (counted on the basis of transcripts and observations). The line width represents the frequency of interactions.

6.2.3 Time constraints and limitations in the visualization topic

Time pressure was a problem because the workshops had a strict time plan and not much time was available for participatory visualization. There were few chances to increase the amount of time available, because most stakeholders had to accommodate the workshops after their working hours. The strict scripting and beforehand co-ordination of the visualizations with the facilitator saved time. However, in most similar workshop settings, time is a constraining factor (cf. Salter et al.; unpublished).

Another limiting factor was the spatial relevance of the topics discussed, i.e., their scale and how far they could be mapped to a concrete spatial location. Often, stakeholders addressed fundamental issues without getting spatially specific. As long as the debate was on the level of goal definition, landscape visualizations were limited in their usefulness (cf. Warren-Kretzschmar 2007). However, as soon as the topic was brought down to the influence sphere of individual stakeholders, the visualization facilitated the discussion.

6.2.4 Ethical conduct

In general, the landscape visualizations were presented with regard for the code of ethical conduct by Sheppard (2005c), shown in table 6.2. Here, the interactive functions of the LandXplorer software played an important role in responding to community input and offering diverse viewpoints and perspectives.

Code of ethical conduct
[…] Use visualization tools and media (more than one if possible) that are appropriate for the purpose
Choose the appropriate level(s) of realism […]
Seek community input on viewpoints and landscape issues to address in the visualizations
Provide the viewer with a reasonable choice of viewpoints, view directions, view angles, viewing conditions, and time-frames appropriate to the area being visualized
Estimate and disclose the expected degree of error and uncertainty, indicating areas and possible visual consequences of the uncertainties.
Use more than one appropriate mode and means of access for the affected public
Present important non-visual information at the same time as the visual presentation, using a neutral delivery […]
Avoid seeking a particular response from the audience
Provide information describing how the visualization process was conducted and key assumptions/decisions taken […]

Table 6.2: Code of ethical conduct (Sheppard 2005c; shortened).

6.3 Research methods: Qualitative case study

The research methods for this thesis were adopted from the empirical social sciences. Two different research methods are applied to answer the two research questions. The qualitative case study method (chapter 6.3) responds to the first research question on the types of interactions. The quantitative survey method (chapter 6.4) is used to answer the second research questions on user preferences.

The issue of landscape visualization is highly context-sensitive, as Hislop (2004) and Appleton and Lovett (2005) showed. Especially in planning, the case study method proved to be an appropriate strategy for the analysis of contemporary phenomena in their real world planning context (Yin 1984; 2003; Feagin et al. 1991). A famous example of case studies is the "street corner society" by Whyte (1993), first published in 1943. As part of a case study, qualitative and quantitative methods are not exclusive. Instead, the iterative alternation of qualitative and quantitative parts enhances the analysis of human-computer interaction and is already common practice in the industry (Siegel and Dray 2003).

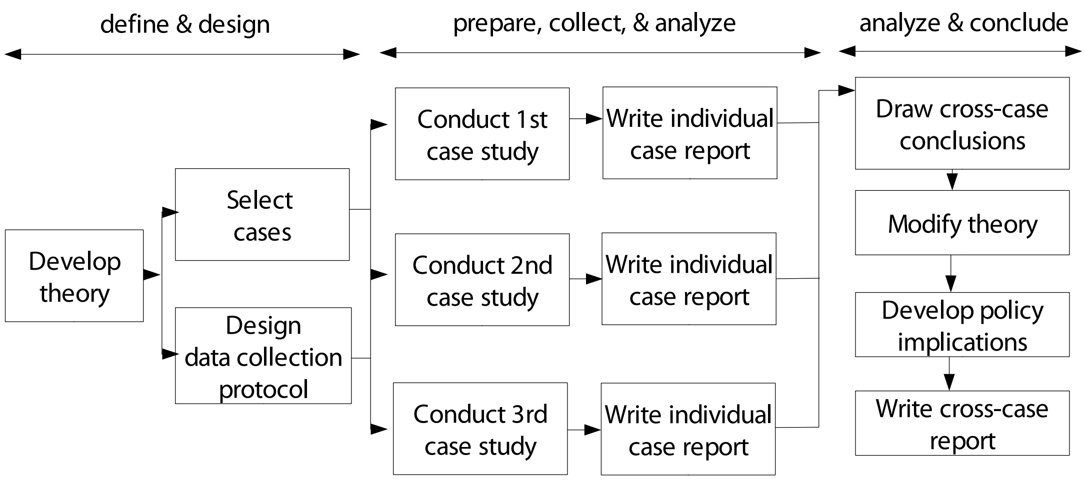


Figure 6.3: Case study method (Yin 2003: 50).

Figure 6.3 shows the basic steps in conducting a case study. The key steps, namely definition of cases, data collection, qualitative content analysis for writing the individual case reports, and cross-case conclusions, are described in the following chapters.

6.3.1 Definition of the cases and case-units

A multiple-case study design with three cases and a total of nine case-units (the individual work-shops) was chosen because it is more reliable and valid than a single case study. Each case was defined by a shared topic and a constant homogeneous group of participating stakeholders. The topics were chosen by the VisuLands team from a list which had been gathered in collaboration with the Biosphere manager Engelbert Ruoss and a representative of the Geodata Department of the Canton Lucerne: A workshop on tourism (part of the Tourism Forum), three workshops on agriculture (part of the agricultural forum), and a series of five workshops, which were part of the public involvement on the future forest management plan. According to the Biosphere management, these three topics are the currently most pressing local landscape-related issues in the UBE. Geographically, the workshops addressed the area of the UNESCO Biosphere Entlebuch (UBE), a region of about 400 km2 (see the case study site description in chapter 5) and all stakeholders live within this region.

The workshops were open to everybody, although the tourism and agriculture workshops recruited most of their participants from the related forums. The forums were well established and have been running since the foundation of the Biosphere Reserve. The tourism and agriculture workshops were hosted by the Biosphere management in the agricultural school of Schüpfheim (LBBZ) and facilitated by the research manager of the UNESCO Biosphere Entlebuch. All the workshops and forums established in the Entlebuch area fulfill the criteria of collaborative planning with regard to Healey (1997) and provide a good basis for testing the participatory potential of the visualization tools in practice .

Cases	**Tourism**	**Agriculture**	**Forestry**
Who?	Tourist board	Farmers	Forest owners
Why?	Setting up a sustainable future strategy for tourism	Development of alternative management strategies	Submissions to the Forest Management Plan
Level of participation	Informal collaborative settings, self-binding	Informal collaborative settings, self-binding	1. Information, consultation 2. Collaborative planning 3. Legally binding plan outcome
Integration into long-term participation	Part of the Tourism Forum	Part of the forum on agriculture	Public involvement process with formal and informal elements
What? (planning issue)	Climate change, infrastructure	Subsidies, management systems	Low market prices for timber, bark beetle damage in monocultures
How?	Collaborative workshops of about 10 to 15 people and a facilitator	Collaborative workshops of about 10 to 15 people and a facilitator	1. Public kick-off meeting 2. Sequential, sectoral group workshops with neutral facilitators and about 10 to 15 people 3. Final public meeting
How many workshops? (case units)			
- without visualizations	1	2	3
- with visualizations	1	2	2

Table 6.3: Comparative overview of the three cases.

In comparison to the tourism and agriculture workshops, the series of workshops on the future management plan took place in a slightly different context. The participation process was initiated by the Department of Agriculture and Forestry of the Canton Lucerne and the District Department of Forestry, though organised in collaboration with the UNESCO Biosphere Entlebuch as host. Neutral experts on forestry and moderation techniques were assigned as facilitators and the process started with a widely announced "kick-off meeting". A series of sector workshops on the key issues followed, before the results of the workshops were presented and discussed in a large final public meeting. The forest management participation process combined elements of institutional public involvement (public meeting, plan) with informal elements of collaborative planning (cooperative workshops). The participation process was widely announced and stakeholders from different stakeholder groups, i.e., forest owners, farmers, members of the Tourism Board, hunters, members of the wood forum, individual foresters and a delegate of the ProNatura non-profit nature conservation organisation attended the workshops. The participation process had a high priority for the Cantonal administration and received its attention and resources. Afterwards, the Canton included the outcome of the forestry workshops in the reviewed forest management plan. It is particularly interesting to include this participation process in the comparison of the multiple-case study because it is linked to a legal planning approval, whereas the workshops in the forums were informal and only self-binding for the participating stakeholders.

6.3.2 Data collection

Different qualitative data sources a) group discussions, b) expert interviews, c) direct observations, d) archival records, e) screenshots, and f) videos were collected for the cases. It is important to note that all data sources are included in the research database with transcripts for all verbal sources. The research database is provided as a separate book and as an electronic document on the enclosed CD-ROM.

a) Group discussions

The empirical focus of the study is on group dynamics in collaborative workshops and the needs of its participants and facilitator. Actual user feedback was collected through a combination of group discussions, expert interviews, and observations. In this context, the group discussions are particularly interesting because the researchers not only receive information from it, they also get into dialogue with the research subjects. As part of an iterative research design, the users get the opportunity to give suggestions on the tool development. Most of all, group discussion is a method that reveals group dynamics best because meaning is produced through the interactions of the participants (Bohnensack 2003). Because the whole workshop discussion is treated as a group discussion, it is possible to reproduce the structure of the dialogue and to analyse the impact of the interactions with the visualizations in this dialogue. In most workshops, the groups were interviewed on their perceived benefit of the visualizations afterwards. These discussions of about 10 minutes followed a common interview guideline and were group discussions, too. The focus of the data collection was on the actual planning discussion. A disadvantage is that the results of the group discussions are rather limited in their generalizability. Therefore, the generalization of the overall study is improved by triangulation of multiple data sources (chapter 6.3.3) and across the three cases.

The workshop meetings are all documented in detailed protocols that followed a general guideline. In addition, parts of the discussions were recorded on tape and transcribed, although sensitive parts could not be recorded on tape in order to respect peoples concerns. In the transcription, dialect expressions were translated into their common language meaning. In three workshops, participants agreed to take video footage in addition, which is a promising additional data source (see the case study database overview in appendix 1). In general, it is assumed that the outcomes from the group discussions are group meanings. After a first image is discussed in the group, the cognition of the 2nd (3rd, 4th ...) images is already mediated by the group context. If an individual explicitly reacted differently, it is noted in the analysis (individual response).

b) Expert interviews

With regard to collaborative planning, the facilitators are the experts in term of the process – in contrast to the stakeholders or scientists who may be experts in the actual planning issue. The strength of expert interviews as a method of data collection is to retrieve "contextual knowledge" (Meuser and Nagel 1991: 445), here, knowledge on the interactions of the participants. In this function, expert interviews are a valuable complement that gives an additional perspective on the process. The comparability of the different expert interviews was strengthened by the use of a shared interview guideline (see appendix 3), although the guidelines are not fully comparable because the VisuLands project altered them from case one to cases two and three. Single open interviews with randomly chosen participants provided additional anecdotal evidence, although the number of interviews is rather low (see the case study database in appendix 1). When the interviews were recorded and transcribed, most interviews were transcribed without dialect, but quotes were transcribed in dialect if the meaning would change otherwise.

c) Direct observations

Additional information was gained through direct observation by multiple observers. Similar to the interviews, the observations followed a shared guideline (see appendix 3).

d) Archival records

Protocols from previous workshops were retrieved to provide information about the case history and earlier workshops.

e) Screenshots

During the workshops, key scenes were recorded as screenshots. Furthermore, the GIS projects were stored until the end of the analysis so that each visualization could be reconstructed. After the thesis is finished, the geodata has to be deleted due to data rights.

f) Video

The video analysis used codes in the form of gestures or physical interactions to describe behavioural response. Such gestures are defined by Lewis and Sheppard (2006: 14): "Look at Image; Stare at/Study Image; Refer to Image; Gesture/Wave at Image; Point at Image; [...] The number of interactions is an indicator of engagement, and perhaps of comfort with a particular visual medium: [...]" In combination with the group discussion transcripts, the non-verbal interactions provide a comprehensive view of the communication process. The approach is limited in this case because large parts of the workshops could not be recorded on video in order to respect the participants' privacy (see the case study database overview in appendix 1).

g) Notation of references to the case study database

Each transcript or protocol has a number in the case study database, its reference number. The notation (P2; 78:80) refers to the primary document P2, lines 78 to 80. Document and line numbers are included in the printed version of the case study database (see case study database book) and can be queried in any html browser in the digital version (see the enclosed CD-ROM).

6.3.3 Qualitative content analysis

In the analysis, the various data sources are linked to the research questions. In this thesis, the "qualitative content analysis" was chosen as the main analytical approach for the qualitative multiple-case study because the method is well established for the analysis of communication processes (Mayring 2003).

The text-based transcriptions of the group discussions and interviews are the major data sources of the qualitative content analysis. A code is assigned based on the research question, the texts are summarised, re-structured according to typologies and theoretical hypotheses, and further analysed in a second iteration. Special attention is paid to the method of data triangulation (Mayring 2003; cf. explication), which allows linking the dialogue (transcripts), the description of the visual interactions (screenshots, type and time of the interaction), and people's behaviour (gestures).

Analytical steps

a) **Coding:** Codes are assigned to the transcripts of observations, group discussions, and expert interviews.
b) **Identification of key moments:** Based on the workshop sequence, key moments of the discussion are identified.
c) **Key moment analysis:** The key moment analysis brings two analytical methods together, "data triangulation" and "chain of evidence". All codes (observations, group discussions, expert interviews) that refer to the same key moment are summarised in a table and linked to the corresponding visualization screenshots and descriptions of interactions (data triangu-

lation). Then, so-called "chains of evidence" are formulated to explain the visualization outcome.

d) **Discussion of the results:** The results are discussed with regard to the hypotheses, formulated in chapter 4.

a) Coding the dialogue transcripts

Coding relates the data to the theoretical hypotheses. Coding also helps to distinguish the different types of responses, e.g., group and individual, positive and negative, short-term and long-term, behavioural and verbal. In this thesis, codes are derived in two ways, inductive (from the data) and deductive (from theory). In order to increase the validity of the analysis, the Swiss VisuLands team derived codes from the data by first clustering and comparing (Strauss 1994; Wissen 2007). The result was a very detailed list of codes, which has been further classified with regard to the research question and its hypotheses. The final result of the iterative classification of codes is summarised in appendix 4. Additional codes were used to distinguish "group" and "individual responses", "process" and "outcome", and to describe the process and important events. The codes "3D-2D", "interface", "level of realism", "design", "immersion", "participation process", "map use", "social-cultural context", and "setting" indicate observations on the context.

b) Identification of key moments

A crucial analytical step is the identification of key moments with regard to observed changes in behaviour. If the transcripts and observation protocols point to an increased appearance of watching, unease, gestures or references towards the visualization, this moment is triggered as a key moment (cf. Lewis and Sheppard 2006). If the group discussion protocol shows an important change in the discussion, e.g., a change of topic or a sudden conflict, the moment might also be triggered as key moment. Then the impact of interactivity is analysed for this moment on the basis of the corresponding data triangulation (figures 6.4 and 6.5).

c) Key moment analysis

The key moment analysis is based on two analytical methods, data triangulation and chains of evidence (figure 6.5). In this context, the term "triangulation" refers to the method from empirical social sciences in which an issue is analysed from diverse theoretical points of view. In this sense, the integration of diverse data sources is a specific form of triangulation (Flick 2004). Here, the view of the researcher (observations) is extended by the view of the participants (interviews, group discussions) and by expert interviews with the facilitators. Data triangulation allows the incorporation of different perspectives on the subject (figure 6.4).

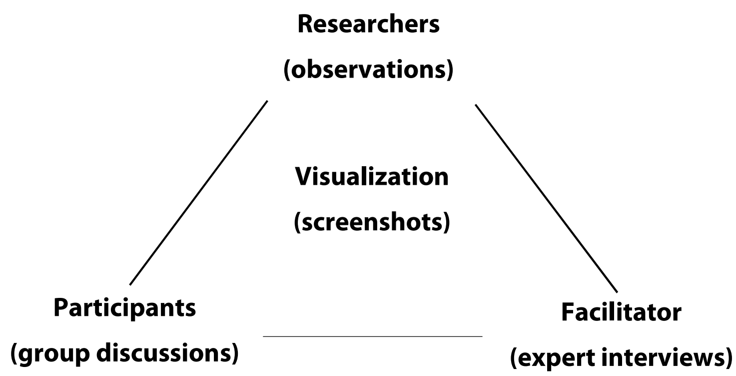


Figure 6.4: Triangulation of different data sources (cf. Flick 2004).

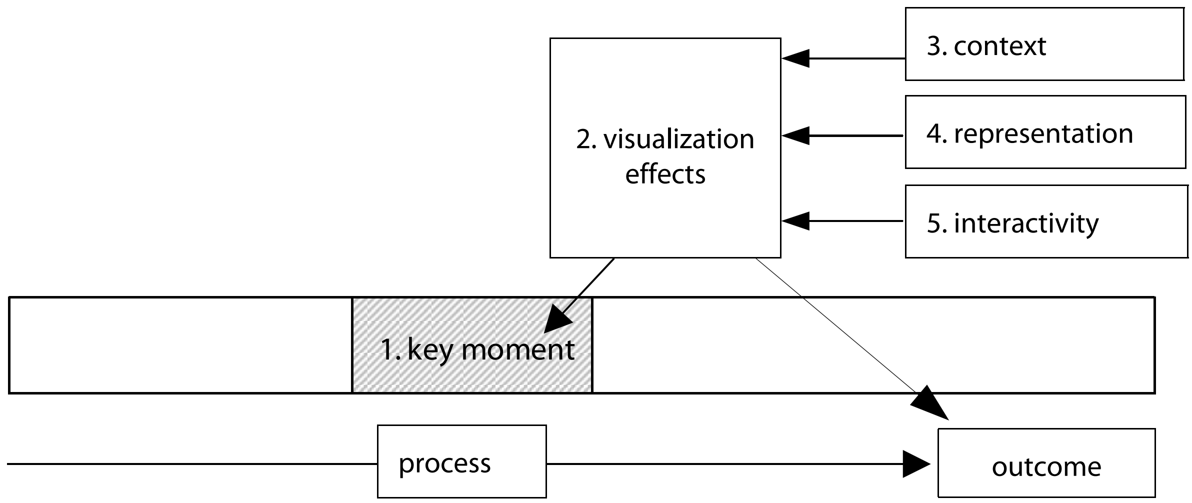


Figure 6.5: Describing the role of interactivity through a chain of evidence.

First, it is important to locate the key moments (1) in the discussion process. With respect to the dialogue, the interactive visualizations were not necessarily dominant in the overall process but they were central to the information transfer. Second, the observed visualizations effects (2) are described. An interpretation is necessary to discover, which aspects of the effects are related to interactivity and which are caused by other context variables. Please note that the coding of visualization effects was discussed within the VisuLands project team. The interpretation of the effects with regard to different representation types (4) is the subject of a related PhD thesis by Wissen (2007). In comparison, this thesis focuses on the interpretation of the role of interactivity (5). The interpretation is based on the data source triangulation and on the literature review of the cognitive and communication benefits of landscape visualizations. In this way, the whole process of information transfer and interaction is reconstructed.

d) Discussion of the results with regard to the hypotheses

Due to the nature of participation, there is no scale to measure the benefits quantitatively, but the literature review on criteria and potential benefits and limitations of landscape visualizations has led to the criteria in table 6.4.

Hypotheses	Pros	Cons
1. Inclusiveness (process)	• New stakeholder groups are recruited • Diverse stakeholder groups reach a common level of information • Diverse stakeholder groups are addressed	• Additional technical or psychological barriers are imposed
2. Enrichment of Information (process)	• A two-way information process is facilitated • Local and external information is exchanged • Information on landscape dynamics and change is enriched • Factual information is enriched through an emotional component	• A cognitive overload is imposed • People are confused or upset by an emotional component
3. Dialogue (process)	• The tools are flexible enough to respond to the dialogue • Open-end solutions are possible	• The tools are not flexible enough to support dialogue
4. Credibility and Transparency (process)	• The transparency of the visualization process is increased • Diverse perspectives are possible	• Lack of credibility • Additional technical barriers reduce transparency
5. Consensus (outcome)	• Consensus is supported	• Consensus is not reached
6. Learning (outcome)	• Interactive "double loop" learning is supported • A learning outcome is achieved	• Additional technical barriers to learning are imposed • No learning outcome

Table 6.4: User needs in collaborative planning, linked to the potential benefits and limitations of interactive landscape visualizations.

6.3.4 Cross-case analysis

In the cross-case analysis, the three cases are compared with respect to the first research question and the corresponding hypotheses from chapter 4. While the single case analyses focus on the specific results from the various cases, the cross-case analysis focusses on the comparison of similarities and differences across the cases. According to Yin (2003), the application of a cross-case analyses in addition to the single case analysis makes the overall research design more robust because results can be compared across the cases. It should be remembered that a cross-case analysis follows an experimental logic, not the sampling logic commonly used in surveys.

Analytical steps

a) Comparison of context factors across cases

A cross-case analysis is conducted in chapter 8. A major challenge in the assessment of interactivity is to distinguish its impact from the various context variables. For this purpose, a network analysis was applied with the help of the qualitative data analysis software AtlasTi. In the network analysis, codes are displayed as a network to reveal links between codes and co-occuring codes. Co-occuring codes are those that are used for the same, overlapping or neighbouring data segments of the discussion. Especially in the tourism and agriculture cases, the context was very similar, so that similar results could be predicted.

First, from all three cases, all codes that refer to the context *and* co-occur with any interactivity codes (see appendix 4 for a list of codes), were queried. The corresponding quotes that belonged to both codes context and interactivity, were summarised and clustered into six categories (individual user, planning topic, participation process, virtuality, visual variables, presentation techniques). In contrast to the theory-guided analyses of the key moments, the categories were derived from the data itself. After the co-occuring codes had been identified by a query of the transcripts in the research database, the clustering and categorization was done manually, according to Siegel and Dray (2003).

b) Comparison of interaction frequencies for different workshop phases

Second, the diagrams of interaction frequencies are compared for the different phases across the three cases. Here, it is predicted that the frequency of interactions changes with regard to the workshop phase and the participants.

c) Assessment of the reliability of the case study results

Third, the effects of different types of interactions are compared across the three cases. If similar results can be documented for similar context conditions, then the evidence is stronger. Therefore, the cross-case analysis allows an assessment of the reliability of the results from the case study.

6.4 Research methods: Quantitative survey on user preferences

A quantitative survey on self-reported user assessments of 3D visualizations was conducted to answer the second research question on user preferences with regard to interactivity. The questionnaire (appendix 5) included a question where people were asked to rank visualization features related to different types and levels of interactivity. In addition to the questionnaire, the reactions to the visualization stimuli were recorded on video and qualitative feedback to open questions was gathered. Overall, the subjects provided rich qualitative evidence in addition to the quantitative survey.

6.4.1 Survey setup

The "end-users" from the VisuLands end-user workshop suggested that users may have preferences for different types of visualizations with regard to their gender, age, stakeholder group, map-reading skills and local knowledge (see chapter 4). In response to these open questions, the following quantitative survey presents a hypothetical collaborative planning situation to local participants (target population n=53). In the questionnaire, they are asked to rank 2D maps, 3D landscape visualizations, and 3D landscape visualizations with different levels of interactivity on their benefits as tools in participation. For this thesis, only the data of question eight of part B(ii) of the questionnaire and from the open-ended questions are used because they are the only questions related to interactivity. Furthermore, these different types of interactive visualizations are only ranked relative to each other, not in comparison to the maps. For that reason, an order bias resulting from the previous questions on 2D maps can be eliminated.

The comparison of rankings of 2D maps in comparison to 3D landscape visualizations is analysed by Hislop (2005). Finally, socio-demographic information is conducted and allows an analysis of whether map-reading skills have any significant impact on user preferences. The questionnaire was proposed as part of the related research by Hislop (2005), who set up the questionnaire and conducted a partner survey in Scotland. In contrast to the previous qualitative study on the benefits of interactive tools, the questionnaire results reflect a direct self-assessment of the interactive tools by the users.

6.4.2 Target population

The questionnaire was aimed at the local general public with a special focus on age differences. For that reason, a school class (n=18) and the visitors of the local Biosphere market (n=35) were chosen as sample groups (total n=53). The respondents are not the same individuals who participated in the case study workshops. Seven questionnaires were returned without information, these are not included in the target population. In the socio-demographic part of the questionnaire, gender, age, education, place of residence, profession and affiliations to local stakeholder groups were recorded. On basis of these data, respondents were classified with regard to gender, age groups, map-reading competence (self-assessment) and stakeholder interests; there were not enough non-local participants to form two groups for local knowledge or profession. Nevertheless, the setup allowed the hypotheses on gender, age and map-reading skills from chapter 4 to be tested.

Group	Population		Missing	n
Gender	27 female	20 male	6	53
Age	19 younger than 20 years	27 older than 20	6	53
Map-reading skills	27 inexperienced	25 experienced	1	53
Stakeholders	38 non-stakeholders	8 stakeholders	7	53

Table 6.5: Respondents with regard to their group.

6.4.3 Venue

The questionnaire was conducted on two occasions, first with local inhabitants and stakeholders at the Biosphere market Entlebuch in Heiligkreuz (LU) and two weeks later, with fifteen to sixteen-year-old pupils of a biology/chemistry class at the cantonal school Schüpfheim (LU). The venue for the Biosphere market is located in the centre of the case study area and well-visited by locals as well as a few tourists. The questionnaire itself was conducted on a separate balcony in the venue hall, where the participants could follow the input visualizations and conduct the questionnaire undisturbed.

Figure 6.6: Questionnaire setting at local exhibition.

6.4.4 Survey sequence

The survey started with an introduction on the hypothetical planning case and different visualization types. Then 2D maps were presented as a "stimuli". Afterwards, the presentation was interrupted so the first part of the questionnaire, the ranking of 2D maps, could be filled in.

The second stimulus, a presentation of real-time 3D visualization types and interactive features, followed. The interactions were controlled by the research team, so that everybody saw the same set of interactions. In parallel, the reactions to the presentation were documented on video. After the second part of the presentation, the participants had to rank the 3D visualizations and the overall VisuLands project. In a third part of the questionnaire, socio-demographic data was collected. In addition to closed multiple choice questions and rankings, the questionnaire contained six open-ended questions for additional qualitative feedback. Overall, the questionnaire took about 30 to 45 minutes to complete (see appendix 5 for the complete German version of the questionnaire).

Sequence of the survey session
1. Introduction on the planning task: Future management strategies in local agriculture
2. Introduction to different types of landscape visualizations
3. Visual "stimuli" in the form of 2D maps
4. Questionnaire: Ranking of the 2D maps
5. Visual "stimuli" in the form of interactive real-time landscape visualizations
6. Questionnaire: Ranking of different types of landscape visualizations related to interactivity
7. Questionnaire: Socio-demographic data

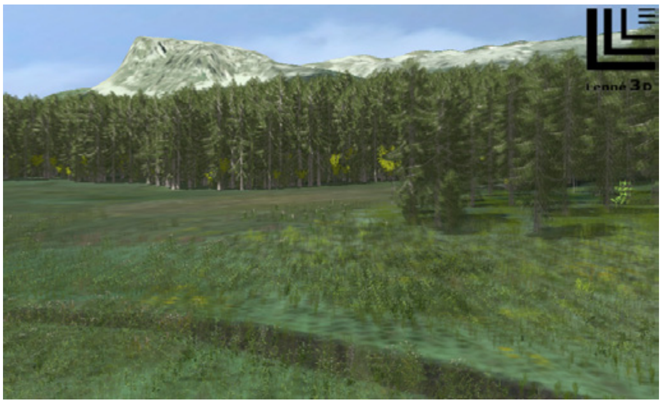
Table 6.6: Sequence of the survey session

6.4.5 Visualization content

The issue of land abandonment and the succession of forest, already presented in the agriculture workshops, was selected as the planning topic for the Swiss questionnaire. The images were produced in Visual Nature Studio with high levels of realism for prototypes of temporal and scenario navigation and contextualization. In addition to the existing material, a real-time pedestrian navigation with a very high level of realism was prepared in Lenné3D (see chapter 3.3.2 for a technical description). A demo of the Lenné3D environment is included on the enclosed CD-ROM. The order of the items was chosen by the Forest Research partner after a test run of the questionnaire.

Figure 6.7 shows the imagery that was used for the ranking of different types of interactive landscape visualizations. In the survey, the real-time walkthrough, the animations and the still images were shown during step 5 as visual stimuli and input to the ranking in step 6 (see table 6.6).

1. Walk-through movement

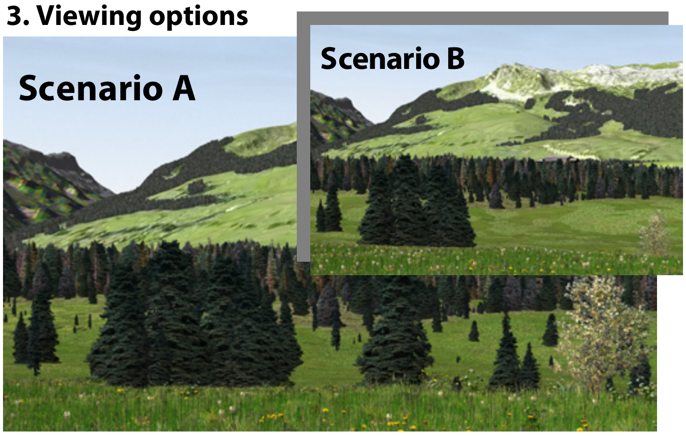


Spatial real-time navigation
(pedestrian metaphor;
software: Lenné3D)
The figure shows a screenshot from the real-time landscape in motion blur. This is the only real-time walk-through visualization in the survey.

2. Time travel

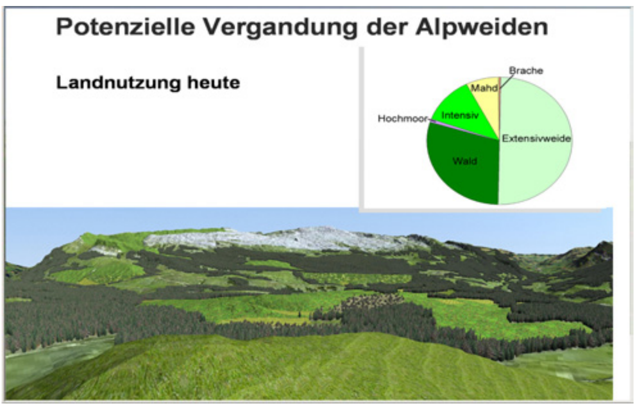
Temporal navigation
(time slider; Adobe Flash animation)
With the time bar, a sequence of three pre-rendered images is shown for the time steps 1972, 1985 and 1997.

3. Viewing options



Scenario navigation
(static VNS images)
Three different scenarios are shown by switching between static images.

4. Inclusion of non-visual information



Contextualization;
(static VNS images)
The land-use numbers are linked to the photorealistic view of the landscape.

Figure 6.7: Screenshots from the interactive features that were used as stimuli to the quantitative questionnaire.

6.4.6 Questionnaire

The analysis of user preferences for different types of interactions refers to the images in figure 6.7 and to question eight in part B of the questionnaire. The various types of interactive visualizations from figure 6.7 are only ranked relative to each other, they are not compared to any of the previous 2D material, so that an order bias from the 2D maps is eliminated. The term "if you were involved in making a comment on landscape proposals" refers to the previous assumption that the respondents should assess the presented tools with regard to their benefit in a hypothetical collaborative workshop on agricultural management strategies. The ranking question for different types of interaction is documented in figure 6.8, the full questionnaire is included in appendix 5.

Zuvor wurden Ihnen verschiedene Möglichkeiten von Computervisualisierungen gezeigt. Bitte stufen Sie diese nach ihrer Bedeutung ein, wenn Sie an der Beurteilung landschaftlicher Planungsalternativen beteiligt wären.

1. Bewegung durch das Modell	__
2. Ansicht verschiedener Standpunkte	__
3. Zeitreise	__
4. Photorealistische Bilder	__
5. Einbindung nicht-visueller Informationen	__

Tragen Sie 1 für die wichtigste Eigenschaft, 2 für die nächst wichtigste usw. für alle 5 Eigenschaften ein

Earlier you were shown various features of computer visualizations. Please rank the features in order of importance to you if you were involved in commenting on landscape proposals.

1. Walk-through movement	__
2. Viewing different options	__
3. Time travel	__
4. Photo-realistic images	__
5. Inclusion of non-visual information	__

Enter 1 for the most important feature; 2 for the next most important feature and so on for all five features.

Figure 6.8: German and English versions of the instructions for the ranking of interactive features, question 8B of the VisuLands questionnaire (Hislop 2005).

The question is formulated as a ranking, which means the respondents have to decide on the order of importance of the various interactive features. In comparison to rating scales, items usually receive a lower assessment in rankings, because the respondents cannot assign high ratings to all items. The questionnaire was formulated by the Scottish VisuLands partner (Hislop 2005) and translated into German at ETH Zurich. Please note that "1" is the highest rank and "5" the lowest one.

6.4.7 Open-ended question format

The survey contained five open questions for qualitative feedback, which returned a rich body of qualitative responses in addition to the rankings. All respondents who completed their forms also answered at least some of the open-ended questions, adding up to a total of 300 comments by 35 of 35 exhibition visitors and 18 of 18 pupils. The major results from the qualitative part are analysed in addition to the quantitative analysis.

The questionnaire contained nine open questions in which the respondents were asked to specify their ranking of the previous quantitative question, i.e., "Please give a brief explanation for your answer to question x" (x: number of the previous question). Five of the open questions referred to the assessment of landscape visualizations:

- B(i)1. If you were asked for your opinion about decisions to do with landscape change at (your study site), would the visualizations you have seen help you?
- B(i)6. Compared to the maps you saw earlier, would the visualizations be more or less helpful to you to comment on decisions to do with landscape change at (your study site)?
- B(ii)1. Do you think there is a role for computer visualization to involve people in decisions about landscape proposals?
- B(ii)3. Do you consider the time and money spent on the development of the computer visualizations to be worthwhile?
- B(ii)5. How prepared are you to trust the visualizations as a reliable representation of the landscape?

7. Single case results: Tourism, agriculture, forest management plan

7.1 Case one: Tourism

Long-term prospects of winter versus summer tourism

7.1.1 Case study context and participants

The Tourism Forum is one of the forums which the Entlebuch UNESCO Biosphere Reserve management coordinates. The forum held workshops to consider the long-term vision for winter tourism, to support strategic planning for the future, and to collect stakeholder views on threats and opportunities to the industry. Currently, most visitors to Sörenberg (1165–2350 m above sea level) take part in winter sports, so safe snow conditions are of great importance, as is the infrastructure required to match demand.

The workshop was held on 13 May 2004 to discuss the current assets, identify the potential, and generate future opportunities for local tourism. One of the Biosphere managers took part as facilitator, along with three VisuLands team members (visualization navigator, co-navigator, observer), and eleven stakeholders. The stakeholders belonged to the Tourism Board (8x), Tourism UBE (3x), local gastronomy association, ski school Sörenberg/Marbach, and Cable Cars Marbach, Cable Cars Sörenberg (1 each). The stakeholders comprised one woman and ten men. All stakeholders were regular participants of the UBE Tourism Forum whom the UBE management had invited to the workshop. As the UBE is an intermediate organisation, the facilitator was independent from other institutions but still responsible to the sustainability objectives of the Biosphere (chapter 5).

7.1.2 Workshop preparations

a) Database

The visualizations were based on the landscape base model of the Entlebuch and complemented in LandXplorer. Specifically for the tourism workshop, the following data layers were included after consultation with the facilitator:

Accommodation vector data	Winter tourism vector data	Summer tourism vector data	Statistical data diagrams and tables
Hotels	Snow cannons	Hiking trails in general	Overnight stays
Camping site	Ski lifts and cable cars	Nature and education trails	
Restaurants	Ski slopes	Bike trails	
Farm houses with accommodation	Sledge slopes	Climbing	
	Winter hiking paths	High ropes course	
	Ice skating rink	Golf course	

Table 7.1: Thematic data layers on tourism.

b) Scenario: Adaptation of national climate change models

For the future scenarios, the focus was put on the impact of climate change on skiing. Three scenarios were formulated for the time span from 2030 to 2050 with snow lines at 1200 m (best case), 1500 m (most likely), and 1800 m (worst case). The applied scenarios refer to climate change scenarios that are described by Föhn (1990), Bürki (2000) and Elsasser and Bürki (2003). Because no local models existed for the area of Sörenberg, the models were transferred from the national scale to local scenarios. As a consequence, the localized scenarios are associated with a rather high uncertainty. However, Sheppard (2005a) showed that the localization of scenarios is very important in addressing local stakeholders, so that this drawback was accepted. However, current research supported the assumption that the Entlebuch site will suffer from rising snow lines (Bürki, personal communication). Recent research reports, e.g., Adger and Fischlin (2007) in the reports of the Intergovernmental Panel on Climate Change IPCC (2007) and the OECD report on climate change in the Alps (Agrawala 2007), provide additional evidence for the assumption of rising snow lines in the Alps.

c) Visualization: Interactive real-time model

After the preparation of the 3D landscape model, but before the workshop, a meeting with the facilitator took place, where he was informed about the available data and interactive functions. In return, the facilitator suggested the key issues for the forthcoming workshop (infrastructure; winter tourism and climate change), so that bookmarks and layers could be arranged for faster navigation. With regard to the level of detail, the facilitator asked for both realistic and abstract visualizations. It was decided that the orthophoto would be turned on for more realistic visualizations, e.g., to help in orientation, and turned off for more abstract visualizations. The vector data and city model remained abstract. A challenge was the construction of a winter orthophoto, because orthophotos are usually taken in summer only. Therefore, the summer orthophoto was covered by a semi-transparent snow layer. The location of snow had been calculated on the basis of a slope analysis in ArcGIS, which defined all areas with a slope higher than 45% as snow-free areas. The vector data was colored according to the previously defined color scheme (see chapter 6.1.3), and the statistical data was prepared in the form of diagrams. The city model of Sörenberg was colored grey, with the hotels in red (figure 7.5).

The final interactive presentation was not rendered beforehand but took place during the workshop. Spatial and thematic navigation (especially zoom and layer navigation), overlays, and links to the statistic diagrams were applied to produce the landscape visualizations on demand. The interactively applied elevation analysis, which showed the position of the future snow line (figure 7.8), was of particular interest.

7.1.3 Workshop setting and choreography

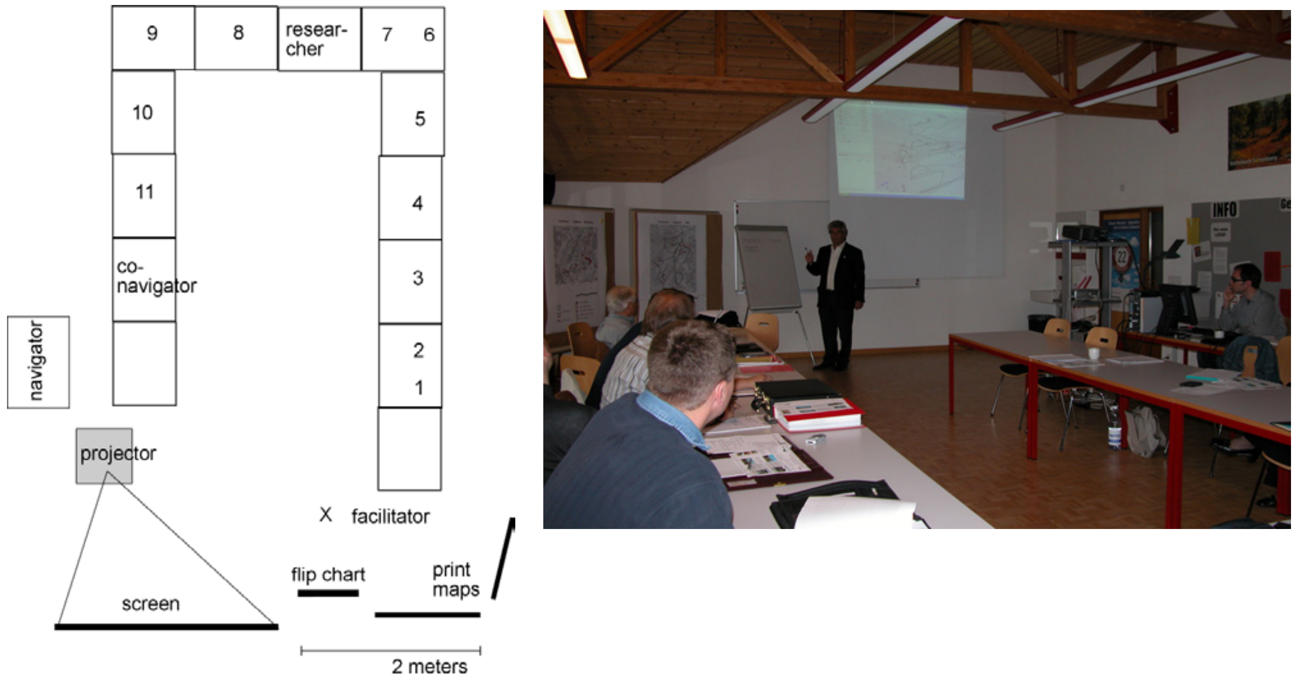


Figure 7.1: Setup of the tourism workshop, the numbers represent the participants (13 May 2004).

a) Workshop setting

The participants were seated around an U-shaped table, so that everyone could address everybody else. The landscape visualizations were projected onto a screen in front of the participant group. From their seats, each participant could watch the visualizations within a degree of a maximum 30° and not further away than about five meters (see figure 7.1). In addition to the landscape visualizations, the facilitator used 2D maps and a flip chart to document suggestions and outcomes of the discussion.

b) Workshop choreography

The workshop was facilitated by a Biosphere manager and supported by the VisuLands team with an interactive 3D landscape model in LandXplorer. The facilitator lead the workshop and he was in charge of the choreography between dialogue and visualizations. It was obvious that the interactions needed time for explanation and interpretation, but time was the most valuable resource in this stakeholder workshop, so, the facilitator allocated how much time the interaction with the visualizations received.

During this workshop, the landscape visualizations were mainly a tool of the facilitator. He used them to open up new topics, support his arguments, discuss spatial issues, and document ideas visually.

7.1.4 Summary of the workshop on tourism

7.1.4.1 Workshop sequence

a) Input/analysis

The workshop on tourism started with the visual analysis of the existing tourism infrastructure in the area. Through the visualization, it became obvious that winter tourism takes place in a concentrated area whereas the infrastructure for summer tourism is dispersed. Then, the representative of the local cable car company, who is the most influential stakeholder, described the situation of winter tourism in the area. He agreed with the other stakeholders that a general decline in skiing and hard international competition are major problems. He suggested additional investments and referred to the landscape visualizations to assess potential locations for investment.

b) Brainstorming

The tourism stakeholders wanted to counter the decline with additional investments and discussed replacing the existing t-bar lifts with chair lifts, attracting snowboarders with a halfpipe, providing a skating rink, and expanding the use of snow cannons. Criteria for the assessment of these options are the capital investment, target groups and added value.

c) Discussion part one

At this point, the facilitator tried to draw the attention of the stakeholders to the issue of climate change. Global warming is likely to affect Sörenberg soon because the village is located lower than most other skiing destinations in Switzerland. For that reason, the facilitator asked the visualization team to show a scenario of declining average snow coverage at a snow line of 1500 m for the time span from 2030 to 2050. Although the stakeholders knew the numbers before, the very intense reactions ranged from astonishment, interest and discomposure to disbelief. A few more issues were briefly addressed afterwards, including shortcomings in the available hotel space, après ski and the transport infrastructure. For transport, one stakeholder asked the visualization team for additional statistical data, but such data is not available at that time.

d) Discussion part two

After a ten minute break, summer tourism became the focus of the discussion. The high change of visitor numbers over seasons, the low added-value of the existing accommodation types (mainly private chalets), and the lack of a visitor centre were identified as major problems. The suggested tourist offers addressed both target groups, day tourists as well as long-term vacationers. With regard to the day tourists, the size of the catchment area was discussed but none asked for visualization support.

e) Second brainstorming

Ideas for additional offers and investments were collected in another brainstorming phase, e.g., an upgrade of existing walking paths, wellness, seminar tourism with Biosphere excursions, religious tourism to the church in Sörenberg, and "mental wellness". Only one stakeholder from agritourism participated and at first, agritourism was not much of a topic. Then the facilitator asked to show farms suitable for agritourism and after they were shown as points in the 3D model, agritourism became a discussion topic as well.

f) Closing

At the end, the facilitator summarised all suggestions on flipcharts and the visualization navigator documented them with annotations in the 3D model. The list of potential investments in winter- and summer tourism closed the discussion. Afterwards, the research team had ten minutes to query the participant's view of the visualizations in a group discussion and with a questionnaire before the workshop ended.

7.1.4.2 Selection of key moments

Overall, the visualizations were less used during the second half of the workshop than they were in the first half. At some points in the workshop, issues were discussed spatially but neither the facilitator nor the participants asked for visualization support. The participants were satisfied with the setting of mediated interactivity and only one participant was interested in using the software on his own. In conclusion, key moments with visualization support were the initiation of the workshop through visual input on the existing infrastructure, and the impact that climate change may have on local tourism. According to the observation protocols, these key moments have a strong impact on the course of the discussion. Table 7.2 shows the workshop sequence and the choreography with interactive visualization support in an overview.

a) input/analysis ->	b) brainstorming ->	**c) discussion ->**	break ->	d) discussion ->	e) brainstorming ->	f) closing
+ visual		**+ visual**			+ visual	+ visual

Figure 7.2: Process of the tourism workshop with the key moments highlighted.

7.1.5 Results from the tourism workshop

7.1.5.1 Input moment : Showing the infrastructure in its spatial context

input/analysis ->	brainstorming ->	discussion ->	break ->	discussion ->	brainstorming ->	closing
+ visual		+ visual			+ visual	+ visual

Figure 7.3: Position of the input moment (bold) in the overall workshop process.

At the beginning of the workshop, the facilitator wanted the visualizations as input to motivate people and to bring the topics from the previous workshop back to mind. First, the visualization navigator turned on the orthophoto with the mountains (landmarks) for orientation. Then, he showed the distribution of winter tourism facilities compared to the hiking and biking routes for summer tourism by turning on the relevant data layers. Then he disabled the orthophoto. As a result, the visualization got more abstract, but the vector data on infrastructure is easier to read (contextualizing interaction, realtime navigation). Overall, the facilitator and the representative of the cable car company Sörenberg, the major stakeholder of winter tourism, had the greatest share of the discussion. About 4-5 other stakeholders contributed sporadically and another 3-4 persons were rather passive.

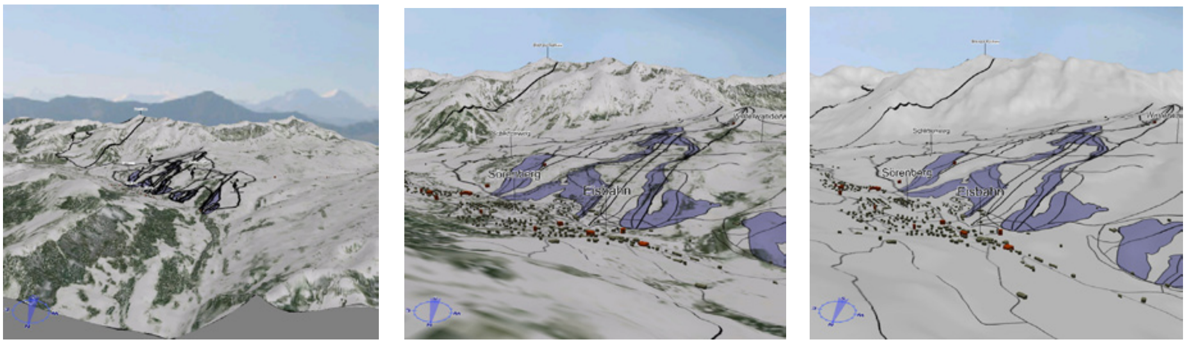


Figure 7.4: Interactive input on the existing infrastructure.

In figure 7.4, the navigator first zooms into the area (*spatial navigation*), provides orientation through compass and landmarks (*orientation*), shows the winter tourism infrastructure (black lines: ski slopes, blue areas: artificial snow, red volumes: hotels), and turns off the orthophoto for higher contrast.
Applied interactions: spatial and thematic navigation, overlays, workshop tools.

The model in figure 7.5 is linked to statistical data on the relationship of day guests to long-term stays (left diagram) and to overnight stays over the seasons (right diagram). The orthophoto is turned off for higher contrast, hotels are colored red.
Applied interactions: Thematic navigation, overlays, contextualization by hyperlinks.

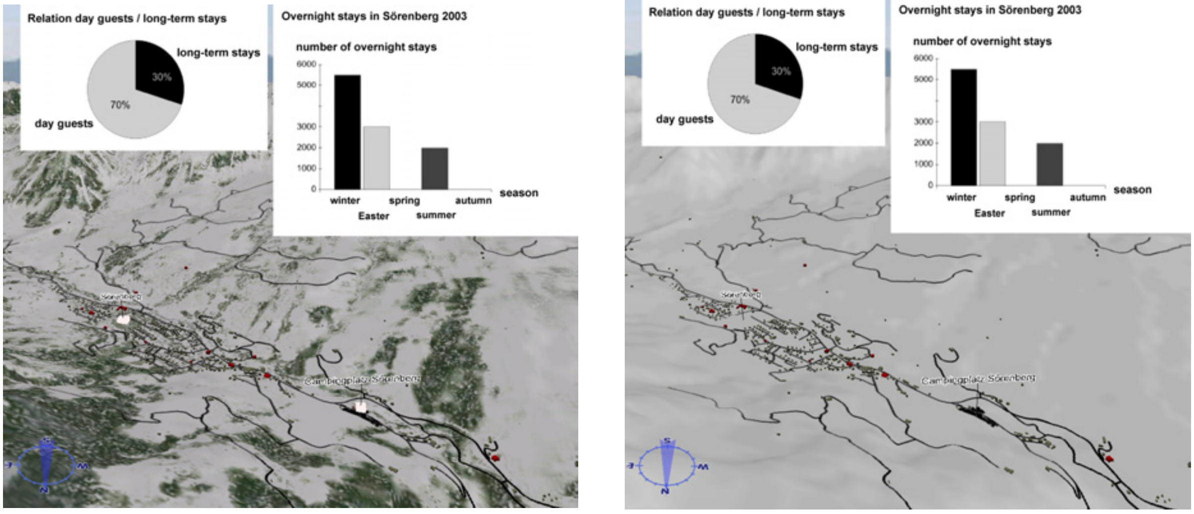


Figure 7.5: Interactive input on guest numbers in comparison to hotel location.

The representation of topography in the landscape visualization supports the spatial assessment of the ski slopes in relation to the structure of the village. According to the research methods in chapter 6.3, the impact of the visualizations is described from various perspectives (data triangulation; second column of table 7.2). In addition, inferences on the impact of interactivity in this context are given (third column of table 7.2). In the following text, these inferences are formulated as chains of evidence.

Impact > **Data sources**	**Visualization effects (data from the research database)**	**Role of interactivity (inferences)**
Researchers (observations)	"Wow-effect" (gestures, whisper, concentrated watching) (P73; 91:91).	Real-time navigation is likely to increase the "wow-effect".
	People need some time to orient themselves (first concentrated viewing, relaxing tension after a moment). After about 5 minutes, people start to get actively involved through questions, comments and requests (P72; 14:14).	Orientation needs time, but orientation aids (compass, landmarks) help familiarization with the model; the users know the places and they regularly work with images.
	The presentation of statistical data in linked windows receives attention and responses (P35; 43:47).	Contextualizing interactions help combine the visual representation with non-visual statistical data.
User group (audio transcript and protocols from the group discussion, and questionnaire)	In the questionnaire, six users declare they always "knew their position in the model", three "knew it most of the time", and three "more or less", nobody felt lost (questionnaire results).	Knowledge of the area, an appropriate presentation and orientation aids help in orientation.
	In the group discussion, one participant says that alternative options are helpful to imagine the landscape. He adds that such visual scenarios are even more helpful in a specific project (P75; 44:45).	It is important to have the real-time tool so that alternative views and layers can be shown.

Impact > Data sources	Visualization effects (data from the research database)	Role of interactivity (inferences)
Facilitator (protocol of the expert interview)	The facilitator has the impression that people need to orientate first (P74; 48:48).	Supports the previous findings on orientation.
	To the facilitator's impression, the statistics on visitor numbers were highlighted through the visualization. The numbers were known before but not acknowledged through the group (P74; 35:35).	The literature (chapter 3) on cartography supports the argument that interactivity can be used to highlight specific pieces of data.
	The visualization helps explore the spatial dimensions of the infrastructure, i.e., that winter tourism is concentrated in Sörenberg whereas summer tourism is dispersed across the valley (P74; 39:39).	It is the combination of real-time navigation, zoom and switching between different layers of winter and summer infrastructure that lead to the group findings.

Table 7.2: Matrix of observed effects and interpretations during input presentation.

a) Initial "wow" effect draws attention

One of the researchers describes a "wow-effect", which means that all participants pay close attention to the visualizations, look at them and whisper about them. At this moment, no real dialogue emerges as long as the visualizations keep changing. One reason might be that the viewers have to get oriented first. Data from all three sources, researchers, facilitator and users, indicate that the users need about five minutes to orient themselves (the first questions and comments come after about five minutes).

> *"Sobald sich etwas auf der Leinwand bewegte, gingen die Augen aufs Bild. Die Leute konzentrieren sich nicht auf die Diskussion, wenn sich was bewegt."*
> *"As soon as something on the screen moved, the eyes moved towards the screen. The people are not concentrating on the discussion, if something is moving."* (P74; 21:21, facilitator).

While keeping a static image in the background poses no problems, any interaction or movement distracts attention from the dialogue. According to the quote, the facilitator's concern is that the visualizations not only support the dialogue but also compete with it. For that reason, the facilitator uses the tool not in parallel but alternating with the discussion.

b) Exploration reveals spatial patterns

As the facilitator states, a key finding from the initial visualization is that the skiing facilities are very much concentrated in the area close to Sörenberg, whereas summer facilities are dispersed across the valley. The group concludes that summer and winter tourism have a different impact on the transport infrastructure. There is some evidence that this exploration of spatial patterns leads to a learning outcome, because participants refer to the distribution of the infrastructure and to the shape of the village later in the workshop. During the presentation, the zooming and rotation of the target area played a key role and offered various perspectives on the infrastructure net.

c) Contextualizing 3D visualization and indicator data

The participants interpret figure 7.6 as showing that there is a gap between the visualized hotel locations and the number of overnight stays. In the following discussion, stakeholders explain that some of the mapped hotels were converted to other uses, so that the numbers are lower than the image would imply.

> *"Das müssen wir analysieren. Die Hotels sind in der Karte drin vorgekommen, da sieht es noch schön aus. Das ist haargenau abzusehen"* (participant, P35; 190:190).
> "We have to analyse this" (the lack of hotel accommodation). "The hotels are shown on the map," (he refers to the 3D visualization) "there it looks still beautiful."

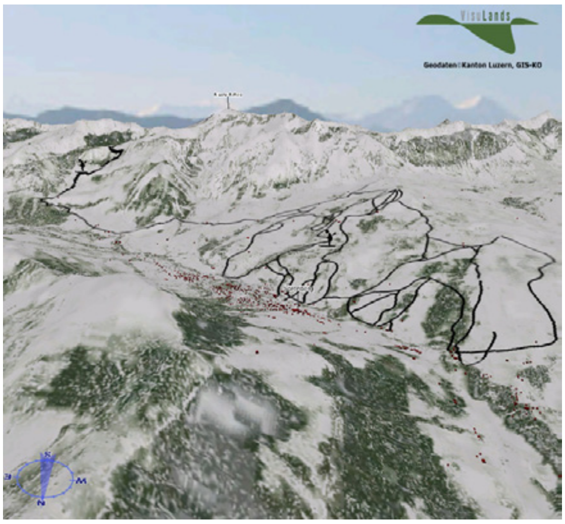
7.1.5.2 Moment of change: Visualizing the snow line

input/analysis ->	brainstorming ->	**discussion ->**	break ->	discussion ->	brainstorming ->	closing
+ visual		**+ visual**			+ visual	+ visual

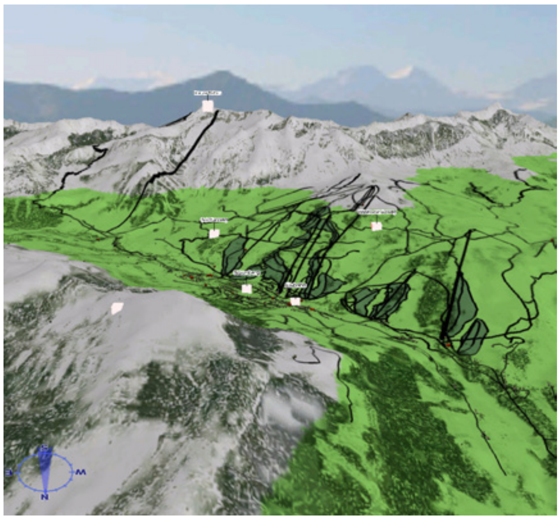
Figure 7.6: Position of the key moment in the overall workshop process.

Figure 7.7: Facilitator referring to the climate change scenario.

After the first brainstorming, the facilitator addressed the issue of climate change. Together with the facilitator, and based on studies by Föhn (1990), Bürki (2000) and Elsasser and Bürki (2003), one of the three scenarios, a future level of probable safe snow conditions of 1500 m for 2030-2050, was interactively constructed as an example to stimulate discussion. The visualization navigator showed a view of the skiing area and then applied a hypsometry analysis. He assigned the color green to the outcome, coloring all areas below an elevation of 1500 m (figure 7.8). In the beginning, the orthophoto was in the background, later, the visualization navigator turned the orthophoto off to give the skiing facilities a higher contrast. Although participants had an impression of the estimates of temperature, precipitation and snow line from previous discussions on climate change, the effects of the visualization tools were discomfort and astonishment. After this demonstration and the following break, the focus of the discussion shifted from the enhancement of winter sports to all-season alternatives of hiking, and educational and agricultural tourism.



Full Snow Cover



Most Likely Scenario: snow line at 1500 m

Figure 7.8: Visualization of snow line at 1500 m by hypsometry analysis.

In figure 7.8, full snow cover and an average snow line of 1500 m are seen in comparison to the existing infrastructure: There is no skiing predicted for the bright green areas below the average level, black lines represent the ski lifts. The dark blue/grey areas can be covered with artificial snow, but the effectiveness of the snow cannons decreases with increasing temperatures (the left image is a reproduction, the right one is an original screenshot from the workshop).
Applied interactions: elevation analysis

Impact > **Data sources**	**Impact of the visualizations (data from the research database)**	**Impact of the interactivity (inferences)**
Researchers (observation protocols)	The facilitator asks for an image to support his argument for diversified tourism through all seasons (P71; 74:74, P72; 33:33).	The elevation analysis in LandXplorer makes it possible to respond to the facilitator's request on demand.
	The participants suddenly realize the threat that climate change imposes on local tourism and economy (P71; 76:76, P72; 33:33).	The sudden change from white to green has a strong effect.
User group (audio transcripts of group discussion and visualization feedback, questionnaire)	One participant is sceptical, suggesting the image was biased. He argues that the snow level is determined by local conditions, so that this representation was too simplified (P72; 45:45).	The climate change scenario could have been presented more credibly if there had been time to show all the scenario alternatives and if local climate change models had been available.
	In the questionnaire, the users assess the correctness of the visualizations overall as “mostly correct” (9), only one each rates them as “completely correct” (1) and “more or less correct” (1).	Nevertheless, the majority rates the visualizations as “mostly correct”.

Impact > Data sources	Impact of the visualizations (data from the research database)	Impact of the interactivity (inferences)
Facilitator (protocol of the expert interview)	The facilitator assesses the visualization of the snow level to "have a very lasting effect" (P74; 40:40).	Supports the assumption that the sudden change from white to green has a strong effect.
	The facilitator guesses that recent investments in chair lifts on a higher level were influenced by the visualizations in the workshop (facilitator, personal communication).	

Table 7.3: Matrix of empirical data and interpretations of the interaction impact during the snow line visualization.

a) Spatial analysis changes the course of the dialogue and the outcome

The impact of the elevation analysis at this point in the process, i.e., the enrichment of the process by additional information, has to be rated as very high. The surprised statement, "*The green will then be without snow!*" (P71; 76:76) by one of the stakeholders demonstrates it vividly. Especially because most of the attending stakeholders generate their income with facilities below the represented future snow line. It's not only the facilitator and the observers who rate the visualization as very influential but the meeting minutes show that the dialogue shifts from skiing to diverse alternatives in winter and summer tourism. In an analysis of tourism stakeholder responses to climate change, Bürki et al. (2003) observed that tourism stakeholders were worried about snow-reliability on the one hand, but generally questioned the relevance of climate change on the other. Considering the observations by Bürki et al., the change of the discussion towards summer tourism becomes even more important, because the discussion of adaptation strategies rarely took place in the stakeholder groups that Bürki observed.

In this case, the visualizations might even have impacted the outcome of the workshop, i.e., investment decisions. A few months later, the cable car owner, who attended the workshop, decided to replace the former t-lifts with chair lifts. On this occasion, he also moved some of the ski slopes to higher altitudes. The facilitator suggested that this decision might have been influenced by the workshop and the visualizations. In 2007, a telephone interview with the responsible stakeholder was conducted to clarify the assumption. In this interview, the stakeholder confirmed that his company is trying to adapt to climate change and that the visualizations from the workshop were one input on climate change that he referred to (P198; 16:20). As a positive side-effect, the new facilities have a lower impact on the environment than the old t-lifts which cut through sensitive moorland. However, this kind of technical adaptation to climate change is not necessarily sustainable in the long-term if it is an isolated measure (Frey and Neuhäuser 2006). Frey and Neuhäuser suggest diversifying the tourism into summer and winter tourism instead, as the facilitator suggested during the discussion.

b) Limited credibility of GIS analysis application

According to one critical user comment, it may be suggested that the visualization does not take full advantage of its interactive possibilities. Originally, it was intended to show more than one scenario, but the first analysis starts the discussion so the facilitator did not request other possible scenarios. Furthermore, the elevation analysis is rather simple and does not incorporate any local models. One participant had strong doubts that the siting of the ski slopes on the northern side of the Brienzer Rothorn was not sufficiently acknowledged, because this side of the mountain will keep snow longer than other locations. However, the lack of localized models is a general problem in climate change as Nicholson-Cole (2005) showed in his critique of climate change visualizations. Despite these limitations, the participants assessed the overall visualizations as mostly correct in the questionnaire. Overall, the majority of participants judged the influence of the visualizations as strong (6) or middle (4), while only one assessed it as low (1) (results from the questionnaire conducted afterwards).

7.1.5.3 Key moments without visualization support

> "*Wenn ich muss anschauen, wie gross in Sörenberg die Distanzen sind, das sind vielleicht 500m, im Vergleich zu grösseren Destinationen die sich selbst behindern. Du kannst dahin,* [zählt verschiedene Orte auf, die zu Fuss erreichbar sind]. *Wenn das Dorf ein kleines Dorf ist, hast du jenste Möglichkeiten.*"(P35; 194:194)
>
> (*If I see how far the distances inside Sörenberg are, that are about 500m, in comparison to bigger destinations which constrain themselves. You can go there,* [listing some places in walking distance].") In response, another participant suggests that it would be even better if Sörenberg had the form of a spiral instead of being a drawn-out street village.

In this example, no visualization support is requested, although the issue addressed the topography and the spatial structure of the village. It might be suspected that the stakeholders did not see a benefit in the visualization, because they know the area very well. It seems that the participants waited for the facilitator to request visualization support and made suggestions only if they were asked.

7.1.6 Discussion of the tourism case results

The results from the tourism case contribute to all six hypotheses on inclusiveness, enrichment of information, dialogue, credibility and transparency, consensus and learning.

a) Inclusiveness: Support of minority opinions

Static visualizations have always been used to emphasize arguments or individual statements, but which difference does interactivity make? Spatial navigation allows the facilitator to focus on minority opinions on request. In this case, the facilitator highlighted agri-tourism by zooming in on the farms with accommodation. It may be objected that the selective support of a single stakeholder group or an expert input is close to manipulation, but collaborative planning will privilege the dominant social groups otherwise (see chapter 2.2.2). Therefore, it is part of the facilitator's role to equalize structural inequalities by supporting minority opinions.

b) Enrichment of information: Exploring spatial patterns

For the discussion of spatial issues in rural areas, real-time movement proves helpful for exploring spatial patterns. In the tourism workshop, the differences between the concentrated winter infrastructure and the dispersed summer infrastructure were highlighted through spatial exploration.

c) Dialogue: A tool for the facilitator

The analysis of the interactions between the facilitator, participants and visualizations helps clarify the role of the facilitator. In this setting, the visualizations are mainly a tool for the facilitator. He utilized the visualizations to support his arguments as well as the discussion, whereas the participants referred less often to the visualizations, although they did watch and discuss them.

d) Credibility and transparency: Manipulation?

Although discussion was encouraged through the input on climate change, one participant felt uncomfortable working with the 3D images, which he considered to be "manipulative". Such concerns are frequently raised when computer-generated visualizations are used in planning and they should be taken seriously. Further research should focus on both more transparent technical solutions and inclusive participation processes. In the case of climate research, localized models on climate change are needed.

e) Consensus: Interactive analysis enriches the group consensus

The tourism stakeholder group is very homogeneous and consensus-building is not a big issue, but the consensus from previous workshops lacked major innovations. For that reason, the facilitator used the visualizations to enrich the dialogue for external input on the impact of climate change on local winter tourism. Evidence is strong that this external input does enrich the outcome of the final consensus, which pays more attention to summer tourism and to the adaptation of winter tourism to climate change.

f) Learning: Adaptation to climate change

A broad study by Elsasser and Bürki (2003) has shown that Swiss tourism stakeholders tend to ignore the negative impact of climate change. In the UBE case study area, stakeholder attitudes were no different now, though the comments by the major stakeholders suggest that the visualization of the snow line had a learning impact. The visualizations raised awareness on the issue of climate change and started a discussion. As a result, the stakeholders discussed whether they should adapt to climate change through technical measures (moving ski lifts upwards; snow cannons) or by changes in behaviour (shift from winter to summer tourism).

7.1.6.1 The tourism case in brief: Snow line analysis facilitates the workshop

Due to time constraints, the interactive possibilities were not fully utilized when showing scenarios of rising snow levels. Although the transparency of the visualization could have been improved, it provided the most important result from the tourism case: the interactive analysis facilitated the dialogue on climate change and had an effect on the workshop outcome.

7.2 Case two: Agriculture Discussing future management strategies

7.2.1 Case context and participants

The characteristic landscape of the Entlebuch region has been shaped by agriculture, cattle breeding and, in particular dairy farming. The future development of this area depends on political and economic driving forces. The main drivers are the liberalisation of the agricultural market and declining subsidies, which will increase the pressure on existing farm management practices. A decline in grazing will cause major changes in the landscape with a negative impact on local socio-economic and ecological conditions. Facing the future challenges of European trends in agriculture that come along with market liberalization and declining subsidies, local farmers of the UBE, administrative representatives, experts, and scientists are working together to develop a concept for future management systems for the alpine farms within the structure of the EU project Lacope, Landscape Development, Biodiversity and Co-operative Livestock System. From the beginning, a strong collaboration between the agricultural forum of the UBE and the research teams of the Lacope and VisuLands projects has been established. The visualization tools were used in two sequenced workshops of the agricultural forum and both workshops have been treated as embedded units of the agriculture case.

The first workshop took place on 22 November 2004 at the LBBZ Schüpfheim and addressed the consequences of current political and economic conditions for the management of farmland if business is kept as usual. Overall, 24 people attended the first workshop, eighteen of them were stakeholders, including fourteen farmers, three Cantonal representatives for forestry, environmental protection and hunting, and a teacher from the local agricultural school (LBBZ). Out of the eleven stakeholders in the first workshop, four were female. The UBE facilitator and five external experts contributed to the organisation of the workshop: Among the external experts were three researchers from the Lacope project (experts on agricultural economy) and two VisuLands researchers.

The second workshop took place on 20 June 2005 and addressed the optimization of alpine farming through sustainable management. Eight farmers, who all had attended the first workshop, and the same facilitator and researchers participated. Out of the eight stakeholders in the second workshop, one was female. This time, no official representatives of local or regional administration took up the invitation, which meant that no political action could be taken (compare chapter 2.2.2 on the limitations of participation).

7.2.2 Workshop preparations

The current trends of decreasing subsidies, increasing competition and migration from rural spaces will lead to farmland abandonment in the mountain areas. As a consequence of farmland abandonment, the landscape will change vastly as much of the open areas will be subject to succession from meadow to forest.

a) Database: Quantification of criteria for abandonment

The Lacope project team had already collected detailed economic and ecological indicator data for the farms that participated in the agriculture workshops. In addition, the Lacope team consulted the farmers as to how they will restructure their farmland under the current circumstances. The main problem was to integrate the qualitative scenario input, described by the farmers, with the quantitative data and transfer it into the GIS database. For this reason, quantifiable criteria for pastures with high potential for land-use change to extensive grazing or abandonment were derived from literature (Pezzatti 2001; Gotsch et al. 2004). These criteria are: the distance between farm buildings and pasture, height above sea level, slope, soil moisture expressed by vegetation types, and current type of management (Wissen et al., in print).

b) Scenarios: Trend scenario and large grazing scenario

In order to prepare the scenarios, the criteria for abandonment were calculated through spatial analyses in ArcView 3.3 and saved as map layers to the geodatabase. The "trend scenario" (status quo scenario) was visualized in the first workshop to provide an impetus for discussions on alternative development concepts (figures 7.23 and 7.24). The images were based on a spatial analysis of potential land-use change for the farmland of the participating farmers. The time frame was defined at 30 years with time steps every five years in the short term and every 15 years in the long term. Based on vegetation ecology, the VisuLands research team built causal chains to allocate the changes in land cover according to the agricultural trend scenario, as explained in detail by Wissen (2007). The vegetation types were mapped with regard to a simple mapping key and a selection of indicator species. These species indicate fens, changes in the grazing intensity, and land abandonment (*ranunculus aconitifolius, veratrum album* as rush species). The development of the future scenarios refers to the Primalp project (Gotsch et al. 2004) and to Lederbogen et al. (2004); the description through indicator species is described in further detail in Wissen et al. (in print) and in Wissen (2007).

After consultation with the Lacope researchers, the VisuLands team prepared the "large grazing scenario" as a sustainable alternative scenario for the second workshop. The idea of the scenario is that larger pasture units will decrease the labour costs for fencing and also increase the ecological value of the farmland. Therefore, the scenario was thought to be both economically and ecologically more sustainable. The "Änzihüttena" farm was selected for the sample demonstration of this scenario and geodata layers were built with the proposed new, larger pastures.

c) Visualization methods: Real-time analysis of change drivers and animated future scenarios

After the scenarios were prepared, two types of visualization were implemented for both the trend scenario (first and second workshop) and the large grazing scenario (second workshop). During the workshops, the driving factors were illustrated on demand in the interactive real-time software LandXplorer, so that single farms could be zoomed in and analyses applied on demand (figure 7.19). To enable the visual assessment of the landscape, the intactness of the vegetation types and their fodder quality, rather realistic representations of the landscape changes were rendered beforehand with the software Visual Nature Studio (VNS). The static images, produced in VNS, were then animated as time series (figures 7.23 and 7.24). A flight through the landscape was prepared in a middle level of realism with the open source software Virtual Terrain Project (VTP) to give an impression of the landscape (figure 7.14). In comparison, the pre-rendered VNS sequences of landscape change had a high level of realism but only a limited level of interactivity. The LandXplorer model of the underlying driving forces was highly interactive but had a low level of detail. Because the landscape visualizations were used in the first as well as second workshop, it was possible to enhance the design iteratively.

	LandXplorer	**VNS**	**VTP**
Level of interactivity	high	low	middle
Types of interactivity	Real-time navigation (spatial, temporal, thematic, scenario), contextualization, landscape editing, analysis, documentation	Temporal navigation (time series)	Real-time model
Level of detail	low	high	middle

Table 7.4: Comparison of different visualization software applied in the agriculture case study.

7.2.3 Workshop setting and choreography

Both workshops were announced as part of the agricultural forum, which meets about twice a year. They were organized by the Lacope research team and the second workshops continued earlier participatory meetings between the farmers and the Lacope research team.

a) Workshop settings

Technically, the setup of the first agriculture workshop was similar to the tourism workshop, described in the previous chapter (figure 7.1). In the second workshop, a panoramic screen (840 x 210 cm) was used for the first time in this multiple-case study (see figure 7.9). Such a panoramic screen provides a higher level of immersion because the viewer gets the illusion of standing inside the landscape when he moves his eyes left and right. In response to suggestions from the first workshop, the stakeholders got a list of the available data sets and two maps with viewpoints as printed handouts for the second workshop.

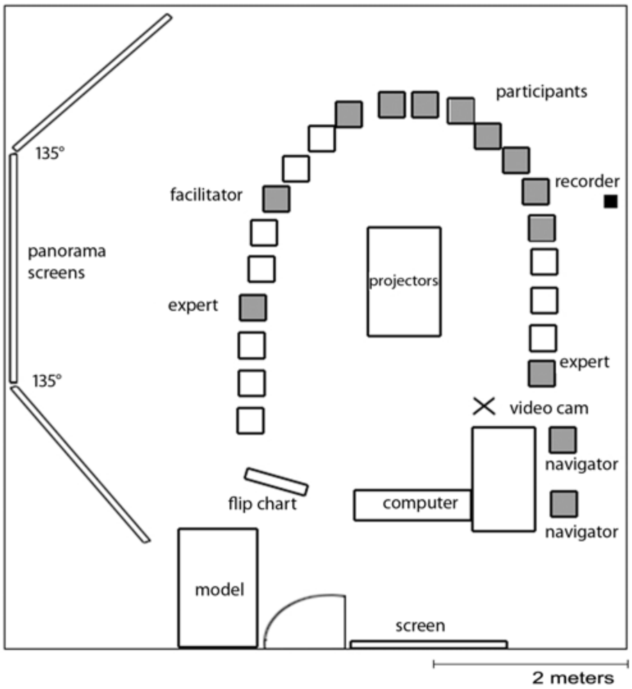


Figure 7.9: Setup of the second agricultural workshop (20.06.2005). Grey boxes mark where the participants sat in the beginning.

The situation, illustrated in figure 7.9, was not static, as people changed seats to get a better view of the panorama screen. Lighting was another issue because the visualizations required reduced lighting, whereas the facilitator preferred daylight for the discussion.

b) Workshop choreography

Both workshops followed similar procedures: they started with input presentations, followed by a brainstorming phase and after a break, the results from the brainstorming were discussed (see figure 7.10). Landscape visualizations were used as part of the input presentations and for analyses and exploration during brainstorming and discussion. The facilitator scripts of the workshop sequences are provided in appendix 2.

The facilitator suggested using realistic images (static or interactive) as support for the imagination of the landscape in the beginning. More abstract but interactive visualizations were suitable for the actual planning of the future landscape. For the decision-making phase, he preferred realistic static visualizations of the discussion results.

Scale was an important factor. In this planning context, the facilitator identified the regional scale as well as the scale of the individual farm as the two key levels of scale. Therefore, zoom navigation was crucial for changing between these two scales.

7.2.4 Summary of the first workshop on agriculture Management responses under changing political and economic conditions

In the first workshop on 22 November 2004, how to respond to changing political and economic conditions was discussed. The result was that the farmers preferred the status quo and the preservation of today's landscape.

a) Input A

After a short introduction, a member of the Lacope project presented diagrams on the results of a survey on the economic characteristics of 130 farms in the Canton, including the farms of the participating stakeholders. The Lacope team used a traditional PowerPoint presentation without landscape visualizations.

b) Input B

The Lacope numbers point to an increasing abandonment of land, which was illustrated in a second presentation by the VisuLands team. This presentation used realistic but static landscape visualizations, which evoked some emotional response. However, the main feedback was related to the first presentation of the Lacope survey.

c) Brainstorming

In a next step, the facilitator started a brainstorming phase in which the farmers were asked to develop visions of future farmland management (30 minutes).

d) Visioning

The following visioning discussion addressed issues such as acreage under-use, organic farming, and the economic structure of the family farms, but in summary, the farmers wanted to preserve the status quo.

e) Clustering

After a short break, the results of the brainstorming were clustered (30 minutes). The highest rankings were assigned to the “customization of land management” (12 votes), “cooperation with tourism” (9), “enhanced marketing of agricultural products” (6), and “more co-operation among farmers” (6).

f) Impact

At the end of the workshop, a second landscape visualization input was given. This time, the more interactive LandXplorer tool was used to demonstrate the ecological impact of economic changes on the visual landscape. During this half-hour session, the farms of the participants were the focus and simple spatial analyses (elevation, slope) were applied. Additionally, a real-time flight through the landscape model was shown.

g) Feedback

A group discussion followed on the benefits of the visualizations (15 minutes). Generally, the feedback was sceptical and although the stakeholders saw some benefits, they doubted whether these benefits justify the effort. The facilitator finally closed the workshop with the main outcome, which was a vote to preserve the current status.

7.2.4.1 Selection of key moments

The input presentation was not chosen as a key moment for analysis because it took place as a non-interactive slide show and had only a small impact on the discussion. Although the visualization of the spontaneous reafforestation did not have a major impact on the workshop outcome, it contributed to the subsequent discussion on the benefits of the visualizations, in particular, the reasons why the stakeholders were sceptical about the visualization benefits in this case and is analysed as first key moment.

-> input A	-> input B	-> brainstorming	-> visioning	-> break	-> clustering	-> **impact**	-> feedback
	+ visual					**+ visual**	

Figure 7.10: Process of the first workshop with the key moment highlighted.

7.2.5 Results from the first workshop on agriculture

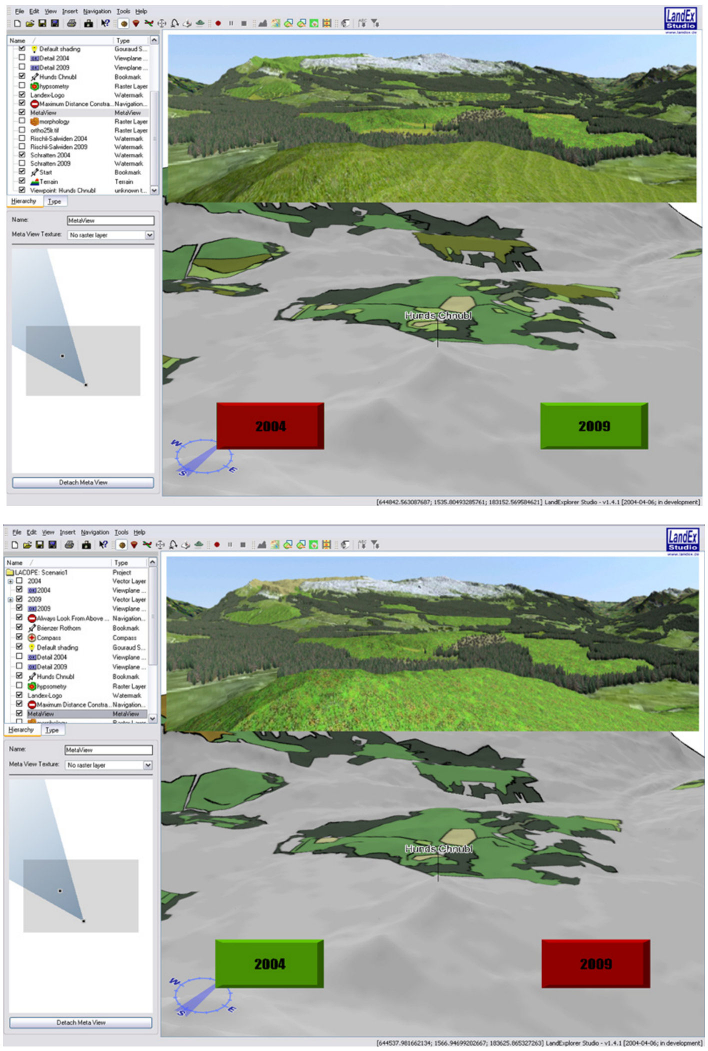
During the first agriculture workshop, most human-computer interactions were non-verbal, i.e., all participants looked at the visualizations and six watched them intensely, three with gesturing and two pointing at them. In contrast, few participants referred to the visualizations verbally. Only the representative of nature protection and the facilitator addressed the visualization navigator.

7.2.5.1 Impact assessment: Spontaneous reafforestation

Intro -> input A -> input B -> brainstorming -> visioning -> break -> clustering -> **impact** -> feedback

Figure 7.11: Position of the impact assessment in the overall workshop process.

In the second half of the first agriculture workshop (see figure 7.11), interactive landscape visualizations were used to illustrate the impact of spontaneous reafforestation as a result of decreasing agricultural activity. The objective was to raise the farmers' awareness for more effective management strategies.

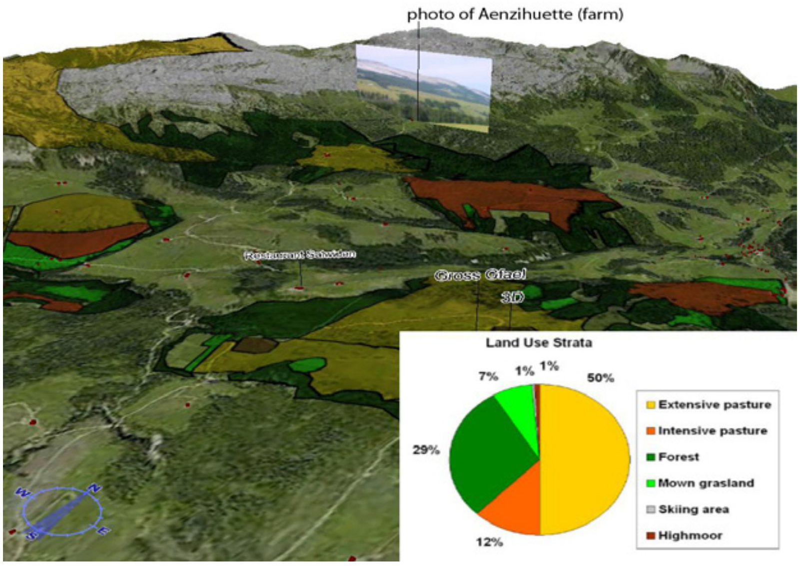


Applied interactions:

- Spatial navigation (flying, click-&-fly, landmark, trackball, zoom, focus navigation)
- Temporal (2004 and 2009) and thematic (different land-use data layers) navigation
- Contextualization (link between the abstract interactive model and the photorealistic static images)
- Workshop tools (buttons, points of interest, overview map)

Figure 7.12: Scenario of land abandonment, visualized by linking realistic static images to an abstract real-time landscape visualization.

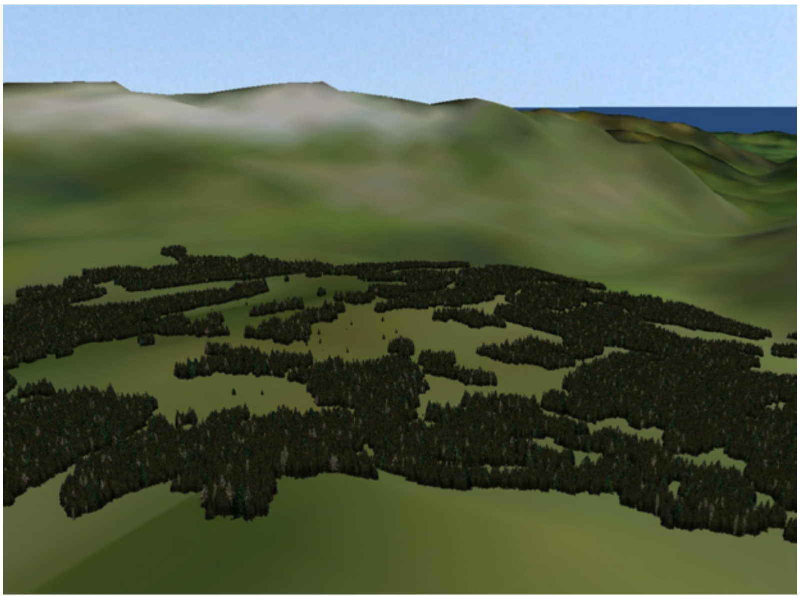
The abstract landscape visualizations in figure 7.12 show the land use strata and their change due to abandonment from 2004 (top) to 2009 (bottom). The realistic images in the top show that the pastures (foreground texture) will change first from mown pastures to scrubland. The visual differences between these realistic images are small and the farmers responded that the change would be more visible. Closer consideration is needed to decide whether the data is not accurate enough or whether the farmers overestimate the visual impact of land abandonment in this location.



Applied interactions:

- Spatial navigation (flying, click-&-fly, landmark, trackball, zoom, focus navigation)
- Thematic navigation (land-use data layers)
- Contextualization (links to land use strata diagrams; overlay of vector data and orthophoto)
- Workshop tools (landmarks, farms of the participants, marked by photos and captions)

Figure 7.13: Visualization of land use strata today. The colors in the linked diagram correspond to the farmland shown in the interactive landscape visualization.



Applied interactions:

- Spatial navigation (flight)
- Limited design interactions (plant trees)

Figure 7.14: Real-time flight navigation in Virtual Terrain Project (VTP). This open source software cannot represent high information intensity as Lenné3D, but it allows showing large numbers of trees in real-time, planting trees, and placing fences.

Impact > Data sources	Impact of the visualizations (data from the research database)	Impact of the interactivity (inferences)
Researchers (observations)	The stakeholders watch the visualizations intensely and discuss the issues demonstrated. However, the observer is sceptical whether the farmers learnt from the visualizations (P89; 144:145).	With regard to the cognitive benefits of interactivity (see chapter 3.4.3), it is likely that the interactions intensify the experience and raise the stakeholders' awareness.
	One observer notes that the realistic visualizations in figure 7.13 trigger (negative) emotional responses (P88; 29:29).	It seems that temporal navigation in combination with a high level of realism contributes to the emotional impact.
User Group - Farmers (audio and video transcripts of group discussion and visualization feedback)	For the farmers, orientation during the flight through the VTP landscape (figure 7.14) is more difficult than spatial navigation in LandXplorer (figure 7.13, P153; 78:86).	It seems that in this case, flight navigation is less suitable than other navigation metaphors. An aggravating factor is that the VTP visualization (figure 7.14) is too abstract to provide references for orientation.
	The farmers do not see a major benefit in the flight navigation (P153; 54:118).	
	A major thought-provoking impulse is the view of the future and the visualization of forest growth processes (temporal navigation in figure 7.12, P153; 97:112).	Temporal navigation seems to enhance the learning about historic and future processes of landscape change.
	One farmer suggests visualizing the process of historic landscape change in order to compare today's trends to historical changes (P153; 243:250).	
	The link to economic factors (contextualizing) is seen as beneficial by the farmers (P153; 159:182).	Contextualizing interactions are regarded as helpful.
	The farmers are sceptical about the benefits of the visualizations because "it is the electronic follow-up perception of people's experiences" and not more (P153; 185:185).	Although the farmers are sceptical about the benefits, these quotes show that the visualizations represent a shared mental model with which all farmers agree.
	The farmers suggest that these images are more significant for the communication of ideas to external stakeholders than locals (P153; 275:276).	
User group - Conservation agency (audio transcript of expert interview)	The key problem, the under-use or abandonment of land, is a creeping process. Time regression is needed to make this process visible (P149; 152:152, 160:160).	Temporal navigation seems to enhance the learning about historic and future processes of landscape change.

Impact > **Data sources**	**Impact of the visualizations (data from the research database)**	**Impact of the interactivity (inferences)**
Facilitator (audio transcript of expert interview)	There is a need for analyses of local characteristics and visualization in combination (P87; 25:25).	There is a need for analytical interactions, but these may be more suitable for small groups.
	Analyses are only appropriate for small groups of up to four people (87; 58:58).	
	There is a need to link the analysis to economic factors (P87; 41:41).	There is a need for contextualizing interactions.
	Movement (spatial navigation) is good for showing different perspectives (P87; 113:113).	For this scale and topic, the LandXplorer navigation metaphors (click-&-fly, landmark, trackball, zoom, focus navigation) were more suitable than the flight navigation in VTP.
	The flight navigation in VTP (figure 7.14) is not realistic enough to provide a benefit (P150; 60:60).	
	There is a need to visualize the results of the discussion (P87; 61:61).	There is a need for workshop documentation tools.
	Lay people need guidance, sufficient time, context and landmarks for successful orientation in realtime landscapes (P87; 92:97).	There is a need for workshop tools that guide the user's navigation and orientation.

Table 7.5: Matrix of empirical data and interpretations on the interactions in the visualization of landscape change in the first agriculture workshop.

a) Landscape perception in flight navigation requires a sufficient level of realism

The VTP flight (figure 7.14) through the Entlebuch valley is assessed as not very helpful and the facilitator as well as the users suggest that the flight needs to be combined with a higher level of realism. Then, the flight may serve as more than an eye-catcher by communicating the visual experience of the landscape (table 7.5).

b) Need for analyses and contextualization

In retrospect of the discussion, the facilitator and users see a need in analytical and contextualizing interactions. However, the facilitator assumes that interactive analyses will be more suitable for small groups of experts. His assumption is comparable to the models by DiBiase (1990) and MacEachren and Taylor (1994), who suggest explorative tools with a high level of interactivity for small groups and individuals (chapter 3.4.2). It may be suggested that only simple analyses and overlays can be used with a group of this size.

c) Temporal navigation enriches the perception and cognition of long-term processes of landscape change

Temporal navigation proves to be most helpful in the facilitation of the process. Farmers and public representatives state that the compressed representation of the slow and long-term landscape change supports learning about these processes (table 7.5). The question of long-term landscape changes calls for temporal navigation and the example proves that even a simple temporal navigation between two time steps facilitates the learning about landscape processes. In this case, the time-sequence is linked to the LandXplorer model and its spatial and thematic navigation, so that multi-dimensional scenario navigation is possible. However, the communication of processes of landscape change might already be communicated through an animation with a low level of interactivity. Therefore, a simple animation was tested in the second workshop, but with increased levels of realism and immersion.

> *"This is exactly the problem, we have creeping development [...]. In particular abandonment or under-use are creeping processes. These processes need to be shown in a time-regression, I think, only at that time does it come to mind." (conservation stakeholder, P149; 160:160)*

d) Unclear learning outcome

The outcome of this first workshop is ambiguous. While one of the experts is disappointed about the lack of innovation, the facilitator assumes that "something happened among the farmers". The facilitator is confident that the insistence on the current status is a valuable outcome. The farmers want to keep the landscape in its current state and the visualizations can be a tool to communicate this: If the subsidies are shortened, the visual landscape will change as shown in the visualizations (table 7.5). In this context, the main contribution of interactivity is to reveal the slow, long-term processes of abandonment through temporal navigation and a high virtuality in terms of realism and immersion. However, the farmers are sceptical about how much the visualizations are worth in terms of effort because, in their words, the visualizations are only "the electronic follow-up perception of people's experiences."

7.2.5.2 Key moments without visualization support

Intro -> input A -> input B **-> brainstorming -> visioning** -> break **-> clustering** -> impact **-> feedback**

Figure 7.15: Process of the first workshop highlighting key moments without visualization support.

The input phase B contains visualizations, but on a very low level of interactivity. During this phase, the key points of input phase A are illustrated through still images and maps, which receive rather low feedback.

The brainstorming and visioning phases contain the key moments in which the farmers identify measures to deal with the increasingly difficult economic situation. Some proposed measures, e.g., the adoption of management strategies for the site and the terrain, could be visualized. However, landscape visualizations were not applied during these phases, because the facilitator did not want to distract the farmers from the discussion. Other measures, e.g., direct marketing, are non-spatial and therefore difficult to represent with georeferenced tools.

7.2.6 Summary of the second workshop on agriculture Optimization of alpine farming through sustainable management

The objective of the second workshop (20 June 2005) was to optimize current alpine farming through sustainable management in order to enhance the economic competitiveness while preserving the existing landscape. Here, the farmers rejected a major change of current management systems but wanted to increase their competitiveness by increasing the number of cattle. The second workshop continued the issues of the first workshop by discussing the optimization of local alpine farming through alternative management systems.

a) Input

Similar to the first workshop, the second started with an expert input presentation (20 minutes). This time, the economic and ecological indicators were presented interactively as part of the landscape visualizations and in collaboration between the two research teams. The Lacope researcher explained the indicators while the VisuLands team conducted the corresponding analyses in the landscape model. Stakeholder feedback was positive and they declared that the visualizations supported their understanding.

b) Brainstorming

During the following brainstorming (30 minutes), the visualizations were turned off and as a consequence, references to the images decreased though the intensity of the dialogue increased. In the discussion, the facilitator proposed the "large grazing system" scenario. This scenario is based on the assumption by the Lacope experts that a decrease in fencing will provide economic savings while preserving the ecological and visual qualities of the current management system. When the farmers asked the experts how they calculated the assumptions of the scenario, a member of the VisuLands team suggested turning on the visualizations again and explained the "large grazing systems" scenario visually.

c) Discussion

After a break, the facilitator asked the stakeholders to discuss alternative management scenarios over the next 40 minutes. However, the original scenario was refused by the farmers, who claimed the effort of fencing to be negligible. At this point, the limitation of the tools in their interactivity became obvious. Not only that the interactive landscape visualization suffered from technical problems, but it was not possible to create other scenarios on demand because the necessary data is either not available or needs pre-processing. Nevertheless, the realistic time-series of the visual impact of the “large grazing system” scenario seems to have had an emotional impact on long-term awareness.

d) Feedback

The visualization impact was discussed with the stakeholders in a ten minutes feedback round. In his concluding words, the facilitator made it clear that the stakeholders do not wish to carry out major changes to the current management system, preferring instead to increase the efficiency through an increase of the production units.

7.2.6.1 Selection of key moments

In comparison to the first workshop, the second one provided more key moments in which the stakeholders interact with the landscape visualizations. These are the interactive analyses that are part of the Lacope input presentation, the explorative brainstorming support, and the presentation of the “large grazing system” scenario during the discussion (figure 7.16). The analysis of the three key moments provides hints as to why the visualizations did not challenge the status quo in this case. It also provides hints on how the visualizations contributed to a slow but long-term change in awareness, although there is little obvious innovation in the outcome.

intro	-> **input**	-> **brainstorming**	-> break	-> **discussion**	-> feedback
	+ visual	**+ visual**		**+ visual**	

Figure 7.16: Process of the second workshop with the key moments highlighted.

7.2.7 Results from the second workshop on agriculture

7.2.7.1 Expert input: Presenting landscape processes rationally

intro	-> **input**	-> brainstorming	-> break	-> discussion	-> feedback

Figure 7.17: Process of the second workshop with the key moments highlighted.

The second workshop started with an input presentation in which external agricultural experts explain the results of the Lacope project and their relevance for the region. In contrast to the first workshop, the input phase of the second workshop integrated the expert contributions and the visualizations in one interactive presentation. The realtime landscape model was used to illustrate the key economic and ecological driving forces in local agriculture parallel to the explanation.

Not only was the frequency of interactions higher than in the input phase of the first workshop, but also the intensity. All participants studied the images intensely, one with gestures, others with laughters and whispers. Above all, three out of eight stakeholders gave five verbal contributions to the overall input. The intense feedback indicates a high interest in the input presentation and in the feedback round, the stakeholders confirmed that the input presentation was very helpful for them. Therefore, a learning outcome can be assumed.

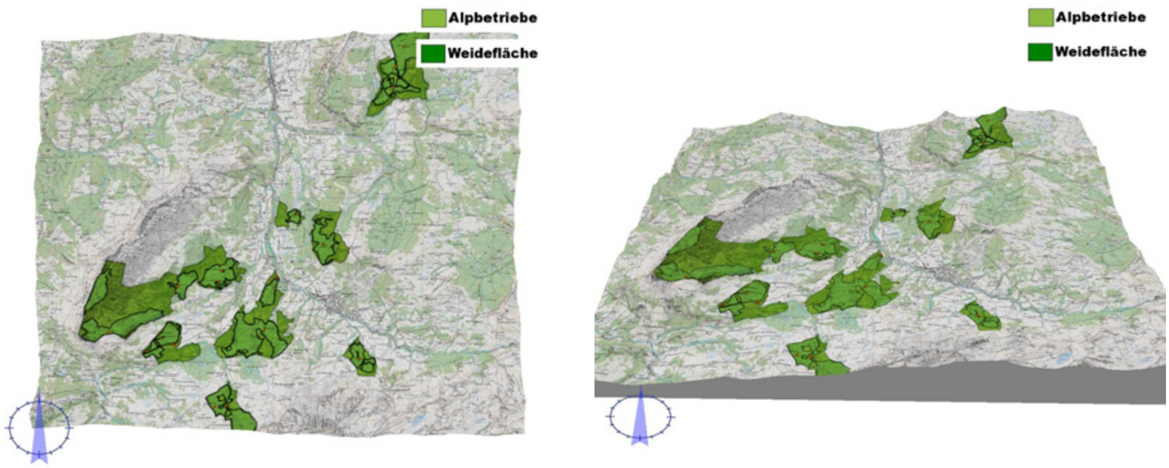


Figure 7.18: The location of the farm land (dark green) of the participating stakeholders. In the beginning, the landscape model is rotated from a plan-view perspective into an oblique perspective 3D view (spatial navigation with the help of the trackball metaphor).

Applied interactions:

- *Spatial navigation (flying, trackball, click-&-fly, zoom, focus navigation) and thematic navigation.*
- *Contextualization*
- *Analyses (elevation, distance)*
- *Workshop tools (compass, legends)*

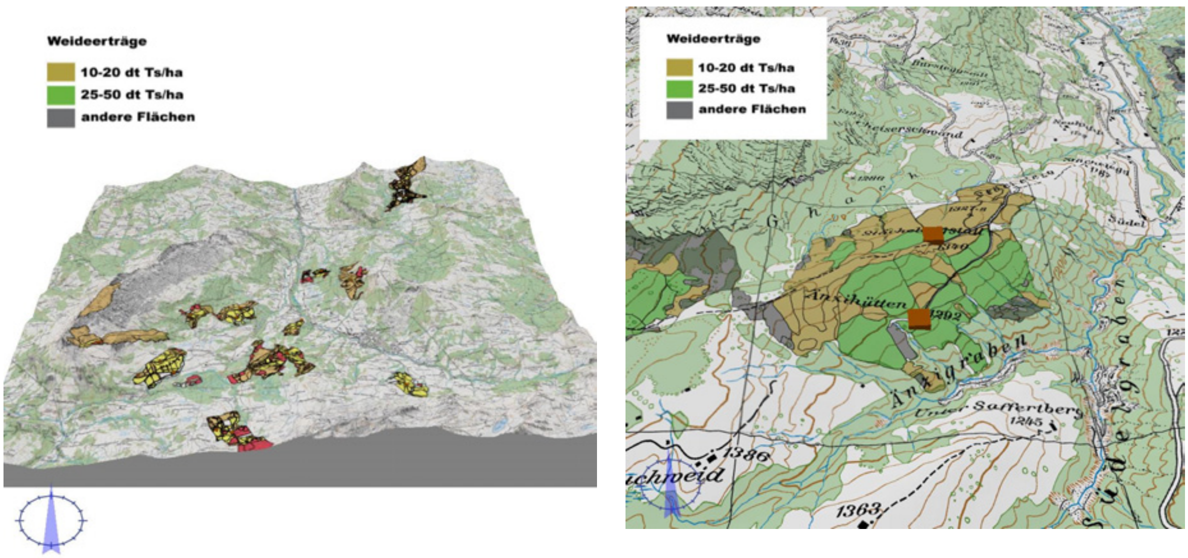


Figure 7.19: Zoom into the alp Änzihütten, showing the crop yield (agricultural output Ts) in Ts/hectare (brown: 10-20 dt Ts/ha, green: 25-50 dt Ts/ha, grey: other uses).
Applied interactions: spatial navigation (zoom).

Impact > Data sources	Impact of the visualizations (data from the research database)	Impact of the interactivity (inferences)
Researchers (observations)	First, stakeholders respond by gestures or other, more emotional (laughter, unease) responses. Then, all stakeholders watch the presentation intensely but without gestures. Later, three of them refer to it in verbal comments (video "lacope_200605").	After an initial “wow effect”, the following intense but calm watching shows that the visualizations are perceived rationally.
User Group - Farmers (video transcripts of group discussion and visualization feedback)	One farmer gives a comment of astonishment (“wow effect”) in response to the rotation from a 2D plan view into a 3D perspective view (figure 7.18; P155, 17:19).	The movement (spatial navigation) and change of perspective raises awareness.
	The farmers assess the change between more abstract and more realistic landscape visualizations as helpful (P156, 38:42).	The interactive visualization seems to enrich the external input.
	In order to improve understanding, the farmers suggest presenting the changes more slowly and reducing the number of parallel windows (P156, 45:49).	The perception of spatial movement and of multiple windows imposes high cognitive costs.
	A farmer requests a location for the rush species (*Juncus sp., Veratrum album*), which are an indicator for under-use (P161, 67:67). A discussion on the increasing growth of rush species starts.	Though the necessary interactivity is available, the request cannot be fulfilled due to a lack of data.
User Group – Lacope experts (protocol of expert interview)	The experts assess the visualizations, especially zooming into detailed views (figure 7.19), as very clear (P8, 18:18).	By zooming instead of jumping, the viewer keeps the spatial context.
	One of the experts is astonished that the farmers remain calm while confronted with the input presentation (P8, 17:17).	It is difficult to say whether the farmers do not feel concerned or whether they repress their feelings.
Facilitator (audio transcript of expert interview)	In the facilitator's view, the abstract visualization of landscape change and processes addresses the rational understanding, the photo-realistic highlights the change (P2, 82:82).	There is a link between the level of realism and interactivity.
	The facilitator assesses the visual support of the expert input as a “big help”. It was much easier to imagine the location of the Änzihütten farm on a bench at the side of a mountain in 3D (P2, 214:215).	As supported by theory (chapter 3.4), the interactive presentation of a place in 3D is particularly helpful, if the topography is of special importance.
	The facilitator suggests that the visualizations initiate new thought-processes and new lines of argument (P2; 66:66).	The interactive presentation of the drivers of change reveals the causal chains behind the process.

Table 7.6: Matrix of observed data and interpretations of the interactions during the input presentation of the second workshop.

a) Raising awareness through spatial navigation

When the plan view rotates into a perspective view (figure 7.18), all stakeholders watch the presentation intensely and one of them expresses his astonishment. After the initial "wow effect" has decreased, all stakeholders follow the presentation attentively but with few gestures or any further astonished comments. The interactive visualizations are closely linked to the verbal explanations of the experts, so that double-encoded learning (see chapter 3.4) is supported. Later, three of them refer to the visualizations, which indicates that the presentation had a strong impact on them. Accordingly, the external experts as well as the facilitator assess the input presentation as very successful (table 7.6).

b) Support of learning about topographic features through spatial navigation

The transcripts show that the stakeholders, experts and facilitator agree that the input visualizations are helpful. According to the facilitator, the location of the Änzihütten farm, which belongs to one of the stakeholders, is illustrated very well. It may be assumed that the position on the bench of a mountain slope could not be communicated without the ability of real-time navigation. Particularly, the focus navigation is assessed as very helpful by the external Lacope experts:

> *"Wir gehen jetzt da mal zur Änzihütte." "Da seht ihr jetzt wie kleinräumig die Vegetationstypen angelegt ist."*
> "*Now, we go to the Änzihütten.*" The viewer flies from the plan view into a detailed view of the Änzihütten (figure 7.19). "*There you can see how fragmented the vegetation types are.*"
> (expert input by the first Lacope researcher, P155; 49:49)

This type of navigation also helps the viewer keep the spatial context, because he is guided from the overview to the detail, i.e., from the overview perspective of the whole valley to a single farm.

> *"Während Sabines Referat hat Andrea die Visualisierungen als sehr klar und sicher präsentiert empfunden. Vor allem beim Anflug auf Detailansichten sei ihr das aufgefallen."*
> "*During Sabine's presentation, Andrea felt that the visualizations were presented very clearly and securely. She noted this especially in the flights approaching detailed views.*"
> (researcher's protocol of the interview with the second Lacope expert, P8; 18:18)

c) Limitations of spatial navigation and contextualization by human cognition

For the stakeholders, orientation was not as easy as it was for the experts. Although the stakeholders favor the visualizations in the input presentation, they suggest improvements. First, the stakeholders have difficulties in orientation because navigation is too fast and the multiple windows (legend and navigation interface) distract them. With regard to the strict limitations of human cognition (see chapter 3.4), it is assumed that a too fast spatial navigation or contextualizing interaction with more than two windows will overextend the user's cognitive load. Particularly with lay people, who are not used to virtual environments, consideration of this issue is suggested.

d) Interrelations between navigation and level of realism

According to the facilitator, the visualization of change enhances the understanding of the processes behind the change. Several comments indicate a dependency between spatial navigation and the level of realism. It seems that the combination of spatial and temporal navigation with abstract representations has a different impact than it has in combination with realistic representations. With regard to the abstract visualizations in the input presentation, the facilitator, observers and external experts describe the stakeholder's response as rather rational (see also table 7.6). For the fourth key moment, visualizations of change were presented in high realism. The comparison of the different combinations of navigation and levels of realism for the presentation of change is given in the final interpretation.

7.2.7.2 Brainstorming: Large grazing scenario

intro -> input -> **brainstorming** -> break -> discussion -> feedback -> closing

Figure 7.20: Position of the key moment in the process.

During the brainstorming, the facilitator put the expert suggestion of reducing the number of fences up for discussion. These fence wires are removed before winter and reinstalled in spring, while the poles stay over the whole year. However, the farmers are very sceptical about the scenario, question the underlying calculations and make alternative propositions. At the end of the brainstorming, a member of the visualization team proposes to explain the scenario calculations with regard to the landscape visualizations. For that purpose, the farm of Änzihütten is zoomed in again and the basic pastures (green), farm houses (red) and fences (black) are shown on top of the grey terrain model (figure 7.21). Next, the number of fences is reduced and the economic and ecological improvements of such a "large grazing system" are explained. Nevertheless, the farmers doubt that the large grazing system will improve the efficiency of their work.

Figure 7.21: Interactive reduction of fences, visualized for the alp Änzihütten as example.
Applied interactions: interactive design.

Impact > Data sources	Impact of the visualizations (data from the research database)	Impact of the interactivity (inferences)
Researchers (observations)	Two farmers, including the owner of the farm shown in the visualizations, have a slightly higher share of the discussion (P4; 53:53).	Single stakeholders can be facilitated to take part in the dialogue by zooming in on their stake.
User Group - Farmers (video transcripts of group discussion)	The farmers ask how the underlying calculations were accomplished. A member of the visualization team explains the calculations with the help of the interactive visualizations (P155; 311:321).	In case of inquiries, the visualizations have to be reconstructible (credibility).
facilitator (audio transcript of expert interviews)	When the farmers reject the prepared "large grazing scenario", facilitation and visualization come to a stand-off (P2; 43:44).	The unforeseen course of the discussion put high demands on both the facilitator and the visualization team.
	If the discussion proceeds in an unexpected way, the benefits of the visualizations are limited (P2; 85:85).	It may be assumed that the tools need to be more flexible.
	The facilitator suggests that participatory visualization and moderation of the discussion is easier for simpler planning questions (P2; 263:263).	Second, the flexibility of the tools is limited by data availability and therefore, by the planning task.

Table 7.7: Empirical data and interpretation of the interactions during the brainstorming phase of the second workshop.

a) Tools and data are limited by their level of interactivity to support an open-end dialogue

Are the tools interactive enough to support changing arguments on demand? In this key moment, it is not possible to adapt to the demands of the farmers and show different scenarios than the prepared grazing scenario. The reasons are multifaceted. First, the facilitator feels surprised by the course of the discussion and losing part of his chairmanship is imminent. Then, he responds to the farmers, who want a "status quo" scenario, i.e., to keep the current situation as far as possible.

In this complicated situation, the landscape visualizations are not flexible enough to provide an alternative scenario. First of all, a sudden computer crash cost valuable time. Second, the necessary data and the time to construct a completely new scenario on demand are not available. Technologically, a wider range of prepared scenarios might be helpful in the first place. In the long term, it would be ideal to have a broad database and fast interactions to construct scenarios on demand.

Third, the farmers address mainly non-spatial economic issues of the "status quo" scenario. With regard to the context factors, landscape visualizations might not be the optimum tool for this type of planning task. The planning objectives are rather broad and difficult to quantify. It may be assumed that a more defined planning task with clear alternative scenarios, e.g., the location analysis for a wind turbine park (Lange and Hehl-Lange 2005), is easier to visualize in a participatory context.

7.2.7.3 Discussion: Scenario visualization

intro	-> input	-> brainstorming	-> break	-> **discussion**	-> feedback	-> closing

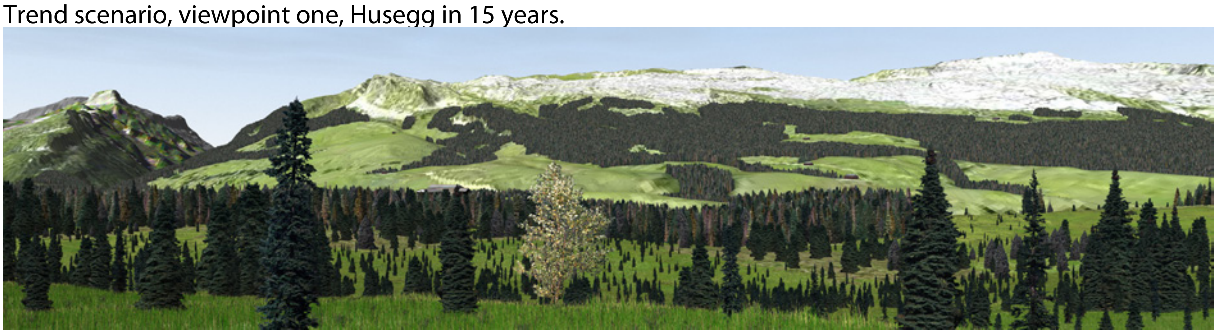
Figure 7.22: Position of the scenario visualization in the course of the second workshop.

After the break, the facilitator asks the visualization team to show the trend scenario for three viewpoints as a time series of realistic images over the next 30 years.

Trend scenario, viewpoint one, Husegg today.

Trend scenario, viewpoint one, Husegg in 5 years.

Trend scenario, viewpoint one, Husegg in 15 years.

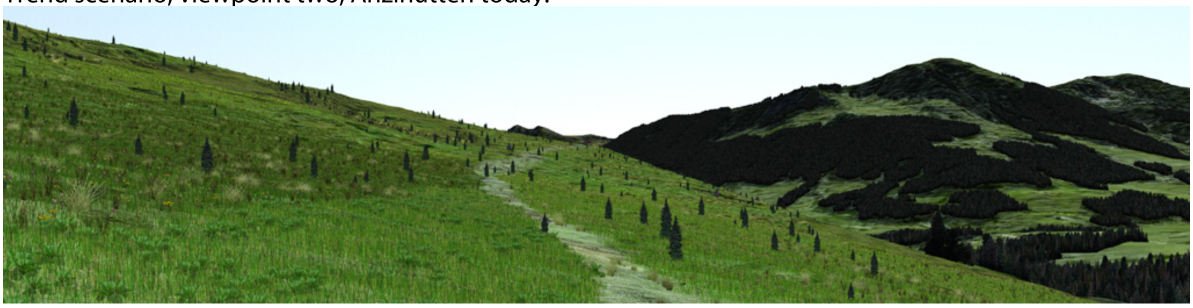


Trend scenario, viewpoint one, Husegg in 30 years.

Figure 7.23: Landscape change over the next 30 years, according to the trend scenario of the abandonment of agriculture.

These images show how forestation as a result of abandonment will change the visual landscape. In contrast to the previous visualizations, these visualizations are shown on an immersive panorama screen (figure 7.9). By requesting the visualizations, the facilitator wants to put the sustainable expert scenario of a large grazing system into the discussion again, but the farmers object. Instead, the farmers propose to increase the number of cattle, which is economically more efficient.

Trend scenario, viewpoint two, Änzihütten today.



Trend scenario, viewpoint two, Änzihütten in 15 years.

Trend scenario, viewpoint two, Änzihütten in 30 years.

Figure 7.24: Landscape change over the next 30 years, according to the trend scenario of the abandonment of agriculture (the time step in 5 years has not been produced for Änzihütten).

Figure 7.25: Current state for viewpoint three, Änzihütten. Future visualizations have not been produced for this viewpoint.

Impact > **Data sources**	**Impact of the visualizations (data from the research database)**	**Impact of the interactivity (inferences)**
Researchers (observations)	The realistic visualization of change allows the farmers to detect discrepancies in the visualization. The farmers describe the pasture in the third viewpoint (figure 7.25) as "picture-book pasture" (P4; 175:175). The farmers use the opportunity to express their anger about the spread of rush species (*juncus*), which are a first sign of land abandonment (P3; 40:47).	The observer assesses the comments as emotional reactions, e.g., anger (rush species) or belittlement ("picture-book pasture"). In this case, it seems that realistic visualizations enrich the perception emotionally. It may be assumed that interactivity and immersion further amplify these emotions by increasing the virtuality (see chapter 3.2).
	The representation of succession to forest over time is rejected as not dense enough. A lively discussion starts on which species (alder or spruce) will come up and how densely they will grow (P4; 175:175).	The communication of landscape change as a simple sequence of three time steps is sufficient to start a discussion about the quality of the underlying landscape processes. The rate of change is not under discussion.
User Group **- Farmers** (video transcripts of group discussion and visualization feedback)	The presentation of future landscape scenarios as a slide show of timesteps (figure 7.23 and 7.24) makes the landscape change clear (P1156; 50:54).	Temporal navigation through realistic images facilitates the understanding of visual landscape change.
	The farmers want to show the visualizations of the "trend scenario" (figure 7.23 and 7.24) to the general public because the public is finally deciding on future subsidies for agriculture (P156; 60:60).	The farmers assess the visualization of landscape change as meaningful.
User Group **– Lacope experts** (protocol of expert interview)	The stakeholder consensus, i.e., an increase in cattle numbers, is in contrast to the expert recommendations (large grazing system) and the visualizations (P8; 17:17).	The visualizations highlight the expert's input but do not change the stakeholder opinion.
Facilitator (transcript of expert interview)	For future research, the facilitator suggests a simulation with intelligent landscape objects that respond to a change of fences. If the number of fences is reduced, the new grazing behaviour of cattle and the resulting change of vegetation should be calculated (P2; 96:96).	Interactivity is still limited and no direct visual feedback is possible. Intelligent landscape models may suit the exploration of scenarios better.
	The facilitator assumes that the realistic visualization of change will address people's subconscious (P2; 78:80).	It may be assumed that landscape visualizations with a higher virtuality (chapter 3.2) are more likely to enrich people's emotions and their subconscious.
	"The awareness of this change, of these processes, has increased a lot" (P2;	Temporal navigation through realistic images facilitates the understanding

Impact > Data sources	Impact of the visualizations (data from the research database)	Impact of the interactivity (inferences)
	143:144). "Reveal cause-effect-chains" (P2; 233:233; 235:235).	of visual landscape change.
	The facilitator is sure that the visualizations initiated a change of thinking and attitudes (German: "Tradierung") towards a change of the current management strategies (P2; 183:183), (P2, 137:137). He thinks that the visualization of change in the trend scenario (figure 7.24) will change the farmer's thinking and attitudes more than the discussion (P2; 73:73; 172:172; 190:190).	According to the facilitator, a long-term learning outcome is facilitated through the realistic visualization of change.

Table 7.8: Empirical data and interpretations of the interaction during the discussion phase of the second workshop.

a) Emotional enrichment through temporal navigation in combination with high virtuality

Observers and the facilitator note rather emotional responses to the presentation of the three series of future landscape change (see table 7.8). The farmers agree with the experts that they have to prevent the forestation process shown and they assume that the change may even take place in less than 30 years. The farmers assess the presentation as very impressive and suggest showing the images to the general public and to policy-makers, who decide on future subsidies. Of course, it has to be noted that the farmers see it as one of their major tasks to prevent any succession to forest on their land.

With regard to the concept of virtuality (chapter 3.2), it is likely that the high immersiveness of the presentation facilitates the emotional impact ("fairy tale landscape") and the intense discussion on the nature of succession. The high level of realism, the interactive change over time, and the immersive panorama screen in combination, create a sense of being in the landscape as it changes within seconds.

> "Eine kleine Leinwand. Wirkt dann natürlich nicht mehr so gut."
> *„A small screen. Of course, it is not as effective."* (Stakeholder, comparing a standard screen to the panoramic screen, P156; 72:72)

Among the "5i" factors, interactivity particularly enhances the compressed perception of change. The farmers have experienced local landscape change over centuries, but now they watch it happen in a few seconds.

> *"Für sie ist es neu, dass sie jetzt das quasi auf der Leinwand sehen innerhalb von ein paar Sekunden, was sie bereits seit ihrer Jugend beobachtet haben."*
> *"For them, it is new that they can see on the screen within a few seconds what they have observed since their youth."* (facilitator, P2; 174:174)
>
> *"Erosionsprozesse zum Beispiel dann, im Zeitraster zu zeigen, oder, wo dann du wirklich in Sekunden siehst, wie sich das entwickelt. Währenddem in der Natur solche Prozesse oft schleichend sind."*
> *"... to show such processes, erosion for example, in a time regression, or, when you can really see in a few seconds how this is developing. Whereas, in nature, such processes are creeping."* (facilitator, P2; 235:235)

In this case, two simple series of overall seven static images in a time regression, showing two different viewpoints, are sufficient to foster the discussion of landscape processes (figure 7.23 and 7.24). It will probably enrich the information, if the temporal navigation is part of a multi-dimensional scenario navigation.

It is arguable whether the continuous animation of change over time will have any further benefits. Bauer and Felber (2006) used series of historic photos to explore the perception of landscape change in the Swiss Alps in detail. They came to the conclusion that lay people become aware of the quality of change but that the rate of change is of minor importance to them.

b) Potential long-term change of attitudes and behaviour through temporal navigation in combination with a high level of virtuality

Because of the emotional impact, the facilitator is sure that the presentation will have a long-term impact on the farmer's behaviour (facilitator: "Tradierung"). However, in the short term, the presentation does not convince them to adopt the sustainable scenario of "large grazing systems". Long-term impact through emotional visualizations are sought in various fields, e.g., climate protection or health care, but the effective benefit is seen to be very controversial (Terry Daniel, personal communication). Long-term studies are recommended to clarify the learning outcome in the long-term.

7.2.7.4 Key moments without visualization support

After the farmers have rejected the "large grazing scenario" in the beginning of the discussion phase, the landscape visualizations are not used any longer. As in the first workshop, the issues under discussion tend to become non-spatial again. One major argument is to improve competitiveness by economics of scale, i.e., through an increase of livestock. If compared to the key moments with visualization support, it is noticeable that the issues under discussion lack any spatial reference.

7.2.8 Discussion of the agriculture case results

The impact of interactivity is now assessed with regard to the hypotheses in chapter 4. Above all, the agriculture case highlights the major role of temporal navigation in the communication of landscape processes. Beside the enrichment, evidence is collected for the hypotheses on dialogue and learning.

a) Enrichment of information:

Spatial navigation and analyses facilitate the presentation of drivers of landscape change

As suggested in the literature (see chapter 3.4), spatial navigation enriches the perception of topographic features. The Änzihütten example (figure 7.19) illustrated how slope and differences in elevation become visible through moving and rotating the three-dimensional visualization. These more abstract landscape visualizations are well combined with fast navigation metaphors, e.g., focus navigation (see chapter 3.5.1).

In this case, slow but natural navigation metaphors (pedestrian navigation, flying) were best suited to support the cognition of the visual qualities of the landscape. Then, the landscape visualization may benefit from a high level of virtuality in general and realism in particular. Here, the comparison of the open landscape in the current state to the future succession to forest started a lively discussion with intense engagement (the dialogue becomes louder and changes more frequently).

If spatial navigation (fast navigation metaphors) through abstract landscape visualizations is combined with analyses and contextualizations, it can enrich the cognition of topographic features and of spatial analyses. After the expert input presentation, there were no comprehension questions, but three contributions referred to the visualized topic and transferred it into the discussion.

b) Enrichment of information:

Temporal navigation facilitates the perception of landscape change

Most important, temporal navigation enriched the perception and cognition of the quality of long-term landscape changes. Up to now, a timeline metaphor that allows forward and backward navigation as well as pause, seems to be sufficient to enhance the exploration and understanding of the underlying long-term processes. However, the farmers addressed only the quality of the change, not the rate of change. With regard to Bauer and Felber (2006), it seems difficult to communicate the rate of change as well.

Temporal navigation through landscape visualizations with a high level of virtuality might also enrich the perception of long-term landscape change in an emotional way. In this case, the whole issue of landscape change was highly emotional, because the farmers are currently paid to prevent landscape change and therefore, react very sensitively to any succession of forest. As a consequence, the visualization of forest succession for their individual farmland is likely to engage them personally. However, the comments during group discussion and interview suggest that the realistic, interactive and highly immersive representation of this controversial issue further amplified an already strong impression.

b) Dialogue: Flexibility is needed

The examples show that spatial real-time navigation is needed to be able to respond to stakeholder objections, questions and requests in a flexible way. Click-&-fly, landmark, trackball, zoom and focus navigation are well-suited navigation metaphors to support the collaborative dialogue because they provide fast and target-oriented navigation. The case also reveals the limitations of current technology and data availability. For the second key moment of the second workshop, it is not possible to construct new scenarios on demand. The facilitator suggests that responding landscape visualizations, as they are enabled through intelligent landscape models (see chapter 3. 2.3), may be more suitable. However, the scope of interactivity also depends on the planning task and, here, the discussion shifted towards non-spatial, economic arguments.

c) Credibility and transparency: Interactive reconstruction of drivers of change

Landscape visualization tools have to be interactive enough to reconstruct the underlying visualization process. In this case, the analyses and assumptions of the drivers of change are reconstructed interactively with the stakeholder group. Although the scenario itself is rejected, the input presentation is assessed as helpful by the farmers. There are no manipulation charges, however, the use of the visualizations to get a particular response should be seen critically.

d) Consensus: Few outcomes

In the first workshop, one of the Cantonal representatives noted that she missed a clear goal. Perhaps the rather broad goal is one reason that the workshops had few “hard” outcomes in terms of political or financial decisions. In both workshops, the stakeholder group is very homogeneous and already in consensus from the beginning. The interactively shown “large grazing scenario” challenged the group consensus, although the farmers did not change their opinion.

e) Learning: Need for long-term studies

It is the task of the external experts to contribute to an informed decision (see chapter 2.1). In the expert input presentation, the interactive landscape visualizations succeed in the presentation of drivers of economic and ecological change as the farmers later refer to the presented content. In particular, the temporal navigation through landscape change, in combination with a high level of realism and immersion is likely to have an impact on stakeholder opinion. The facilitator is convinced that the visualizations will establish a change of behaviour in the long term. There are indications for such a learning outcome, but only a long-term study could validate this.

7.2.8.1 The agriculture case in brief: Communication of landscape change

In summary, the agriculture case provides an example of how rather simple temporal navigation can facilitate the communication of landscape change over long periods of time.

7.3 Case three: Forest management plan
Consensus building in a public involvement process

In autumn and winter 2004/2005, the Biosphere management and the Forest Department (FD) of the Canton of Lucerne organised a series of collaborative workshops on the development of the forest management plan for the Entlebuch region. The Biosphere management was represented by one of its managers, who was not involved in the first two cases on tourism and agriculture. Although the landscape visualizations were rarely used in the beginning, the visualizations facilitated consensus building in the final workshop.

7.3.1 Case study context and participants

In comparison to the forum workshops on tourism and agriculture, the workshops on the regional forest management plan (WEP) led to a binding plan document. The workshops were part of a public involvement process, in accordance with the Bundesgesetz über den Wald 1991 (Federal Forest Act 1991) §20.1, §18.2 to §18.3. Although the UBE supported the process with its infrastructure, the cantonal Forest Department was responsible for the planing and public involvement process. The FD decided that only a high level of participation could obtain the necessary public acceptance and chose a "communicative setting" with public meetings and collaborative workshops in combination (cf. Selle 1994; 2000, see also chapter 2). A FD representative highlighted the importance of a successful participation process, because the agency is evaluated with regard to the successful implementation of the plan. The participation process had the objective to formulate general guidelines for forest management in the so-called "theme sheets" and "object sheets" and to the designate zones for different uses in the priority maps. The final implementation of the guidelines and the zoning took place in individual contracts and on the advice of the forest department. The Canton informed the inhabitants of the Entlebuch area about the participation process and its sequence in a handout, sent by mail:

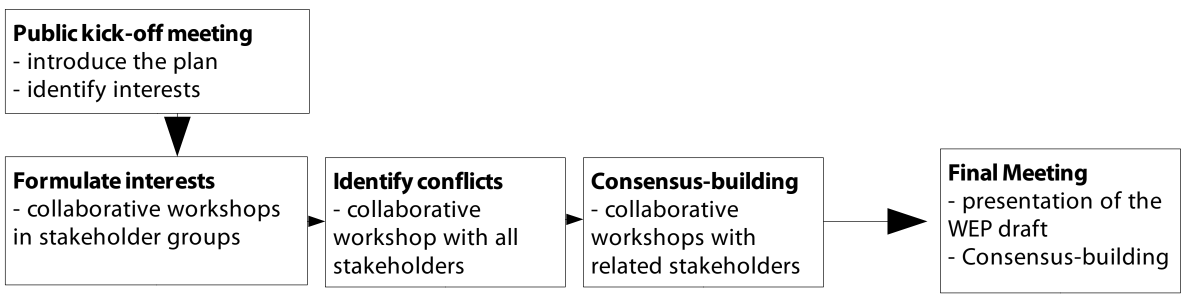


Figure 7.26: Participation process for the forest management plan (translated from Kanton Luzern 2006).

A neutral facilitator with expertise in both forestry and facilitation, was invited to supervise the participation process. Because many workshops ran parallel, he was assisted by additional facilitators from outside the cantonal institutions, including facilitators from other cantons and one of the Biosphere managers. Nevertheless, it was discussed as problematic that the FD organised the involvement process and simultaneously defended its own interests in the issue.

In comparison to neighbouring areas, forest structure and ownership in the Entlebuch area are special in two ways. First, the largest part is in private ownership (80%), whereas forest is mostly public in other cantons (30% private ownership on average). Therefore, private forest owners have a rather strong position in the Entlebuch. Second, large areas are dominated by pine tree monocultures (mainly *Picea abies, Abies alba*). As a result, more than 50% are pine forest, although only 20% pine forest are natural (Kanton Luzern 2006). The participation process was confronted with a highly controversial and emotional public opinion on the current bark-beetle (Ips typographus) epidemic, which had been caused by a drought and forest monocultures. Over the previous months, large pine tree forest stands had died off and the forest owners demanded financial support for the clearance of the infected areas, as is common practice in neighbouring cantons. Instead, the canton did not pay but the forest department recommended leaving the dead timber in place and to plant more diverse timber later. The objective was a more sustainable, i.e., more diverse and species-rich population, adapted to the location (Kantonsforstamt Luzern 2003). Among the local public, this decision was not accepted and forest owners protested that the epidemic spread further, leaving areas unattractive for tourism (Eidg. Forschungsanstalt für Wald, Schnee und Landschaft 2003).

The participation process was announced in local newspapers and personal invitations were sent to all households. The visualization support was not mentioned in the invitations. Although up to 200 participants had been expected, about 50 people attended the opening and the final meeting, while the collaborative workshop sessions were attended by five up to 30 people. Overall, the number of participants was still larger and more diverse than in the UBE forum workshops. While the broader public was not fully activated, all relevant stakeholder groups and key opinion leaders were present (P179; 23:23). The main stakeholder groups were forest owners, the UBE Timber Forum, hunters, farmers, Tourism Forum (who already participated in case one) and two representatives of the ProNatura and the Vogelwarte Sempach nature conservation associations (table 7.9). Interestingly, the stakeholder selection did not change significantly over the course of the participation process (P171; 28).

A conflict was identified between tourist stakeholders and hunters. Both groups felt affected by the other because the growth in summer tourism had led to uncontrolled recreational forest uses such as mountain biking. The hunters warned that endangered species such as grouse are affected by visitors. It was necessary to find a consensus among tourism and hunting stakeholders because the forest management plan designates protection forests, nature reserves, and zones for tourist uses in the priority maps.

Authorities in charge	UNESCO Biosphere Entlebuch (UBE)	Other key stakeholder groups
Forest department (FD) UBE management (host) External facilitator	UBE management Timber Forum Energy Forum Educational Forum Tourism Forum (the same stake-holders as in case one on tourism) UBE research	Forest owners Municipalities Association of forest owners Lucerne (VLW) Forest and timber industry Hunting administration Hunters Agriculture Nature conservation and land-scape protection

Table 7.9: Stakeholder groups involved in the collaborative development of the forest management plan.

7.3.2 Workshop preparations

Information on potential future forest growth and economic, ecological and social parameters were considered in the assessment of the scenarios. The objective was to bring the emotional bark-beetle discussion down to a more rational dialogue and to support the implementation of more sustainable forest management measures (Lange et al. 2003). In consequence, affective visualizations are also less desirable than they were in the second case, but there is a need to make the discussion more rational.

a) Database

The existing infrastructure and forest data were retrieved from the Biosphere GIS, the previous workshop on tourism (case one), and cantonal data. Additional data on the designations of protected forest, educational forest, and hunting grounds was provided by the forest department.

b) Scenario methods: Participatory mapping

Before the participation process started, the VisuLands project had already documented and visualized the progress of the bark-beetle epidemic (Lange et al. 2003). Models for the forecast of the future bark-beetle spread were elicited, but not applied after the forest department decided to keep the bark-beetle issue out of the participation process.

Instead, the conflict between tourism and hunting stakeholders gained in importance during the workshops. In response, the facilitators organised extra meetings, where tourism and hunting stakeholders mapped their interests on printouts of the topographic map (1:25.000). Then, the VisuLands research team digitized the maps in separate layers to prepare the overlay for the final meeting (key moment two; figures 7.24 and 7.34).

c) Visualization: Limitations through time constraints

For the public kick-off meeting, the existing data layers were presented interactively to illustrate the assumptions that the forest department wanted to discuss. Similar to the previous cases, vector data layers on forest and infrastructure were combined with DTM, orthophoto or the topographic map. Here, the orthophoto mainly served orientation purposes and was turned off if its detail confused the information of the vector layers. Unfortunately, the previously developed color scheme could not be applied in the kick-off meeting, due to technical problems and time constraints. As a result, colors did not match the suggestions by Spiess et al. (2002). Different recreational uses were symbolized by photos in the landscape model (figure 7.31).

The process of bark-beetle infection was also shown during the kick-off meeting. For that purpose, a series of realistic images of the local visual impact of bark-beetle damage was produced. The production took place in Erdas Imagine and presented different time steps as a slide show. However, the bark-beetle visualizations got few responses during the workshops (P58; 139:153) because the historic process was already known from photos and future scenarios were not available. The realistic static images, which had already been used in case two on agriculture, demonstrated possible future landscape changes as a result of land abandonment and succession of forest.

During the workshop meetings, there was not enough time nor the technical hardware available to prepare further scenarios in the interactive LandXplorer software. For that reason, only an interactive ArcView 3.3 GIS was available during the second to the fourth workshops. These visualizations used the prepared ESRI color schemes and mainly overlay and analysis interactions. Later, it will be discussed in detail why they failed to have an impact on the discussion.

Before the final meeting took place, the areas of stakeholder interests were digitized as vector datasets in ArcGIS 9 and ArcView 3.3 (figure 7.27) and exported to LandXplorer for an interactive three-dimensional visualization. In LandXplorer, different stakeholder interests in forest designation (recreation vs. protection) were assigned to different layers and presented as overlays to the topographic map (figure 7.34). Spatial and thematic navigation can be used to zoom into points of interest, but the use of overlays was the most important form of interaction.

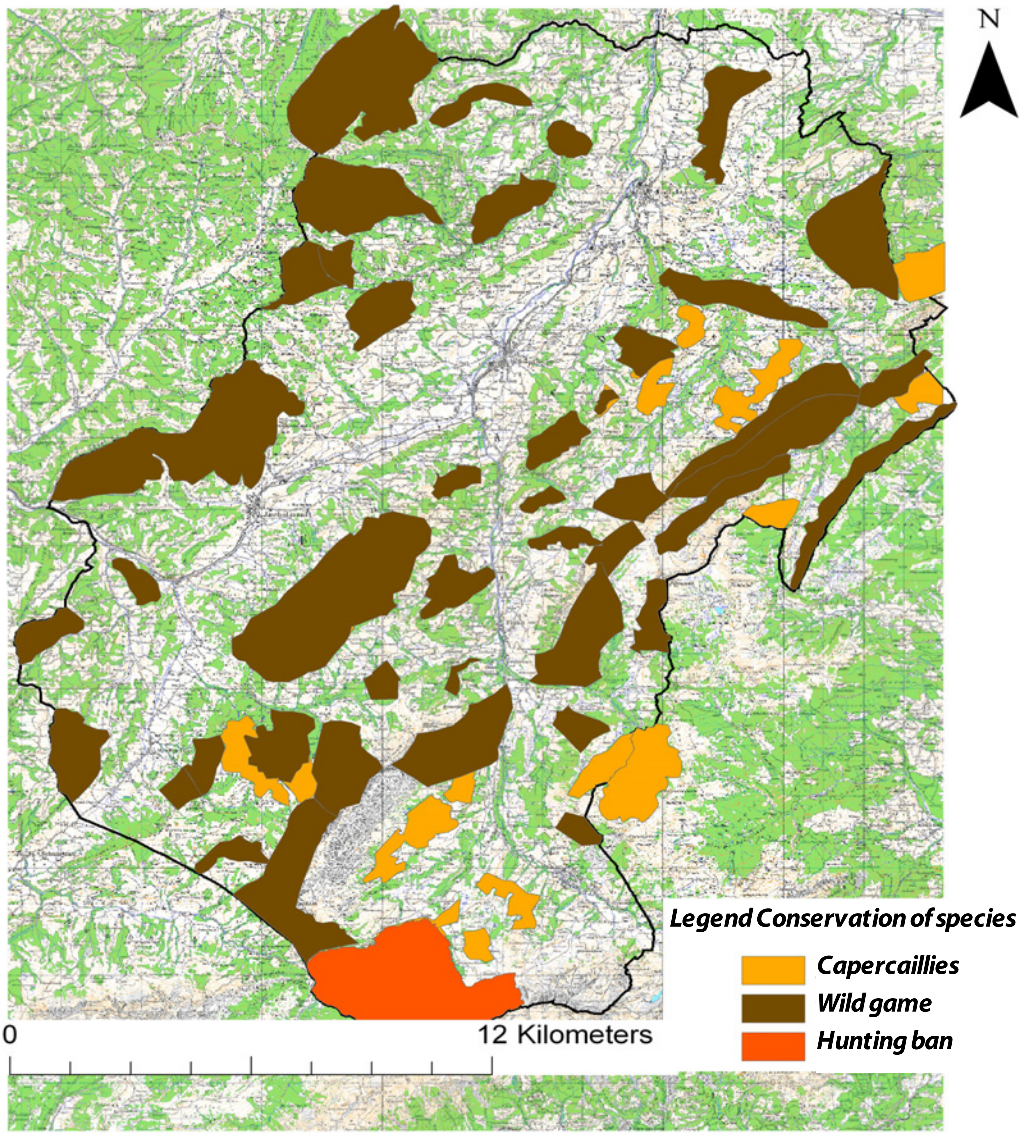


Figure 7.27: Result of the participatory mapping of protection zones: conservation of species for capercaillies (orange), wild game (brown), and hunting ban (red).

7.3.3 Workshop setting and choreography

a) Workshop setting

Technically, the setting had to adapt to changing group sizes. For the large general meetings, a hall in the LBBZ was used, where people sat further away from the screens. The viewing angle was good, but the screen was too far away so that people could not see the details anymore (figure 7.28). The workshop with tourism stakeholders was an exception because it took place with only five people in a small room.

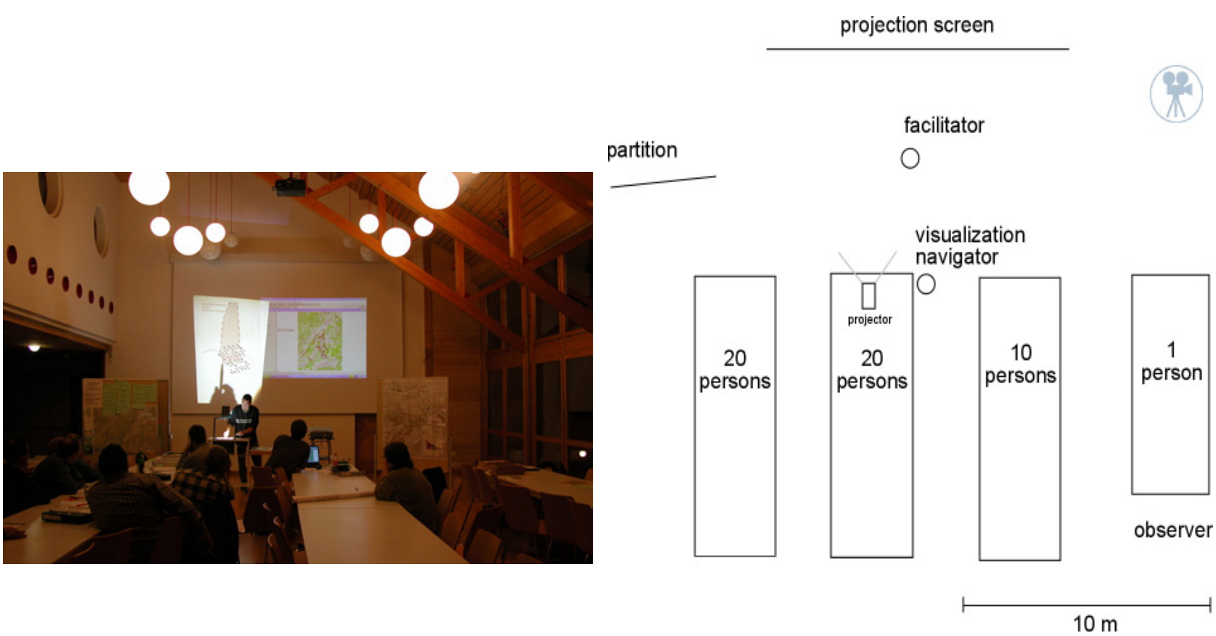


Figure 7.28: Setting of the fifth and final meeting. Combination of various media, i.e., maps, sketching on overhead projector, interactive GIS, during the WEP participation process.

b) Workshop choreography

In terms of visual support, the facilitators preferred a media mix of traditional 2D maps, landscape visualization printouts, interactive GIS, flip charts and hand-drawn sketches in addition to the landscape visualizations. As shown in figure 7.28, the variety of visualization tools provided a lot of flexibility for the facilitator, but the split-screen might have been confusing. All observation protocols and interview transcripts strongly indicate the key role of the facilitator; overall 45 codes in this case study refer to the role of the facilitator. In comparison to the first and second case, this participation process was guided by external facilitators with rich experience in facilitation but no previous experience with landscape visualizations. The comparison of expert interviews over the series of workshops suggests that the facilitators had to become familiar with the possibilities and difficulties of participatory visualization use. The attention of the participants was divided between the prioritized discussion on the one hand and the flip charts and landscape visualizations on the other, which competed with each other (P177; 61:61). As highlighted in the previous paragraph, the landscape visualizations did not receive major responses during the first workshops. After the first workshop, the facilitator of the tourism group said that she would have needed more preparation to integrate the visualizations effectively. In the following key moment analyses, the reasons for the lack of visualization use are discussed in detail.

In the final meeting, the integration of the interactive landscape visualizations worked better. A major outcome of the final meeting was a consensus among tourism and hunting stakeholders that was adopted and mapped in the final plan document.

7.3.4 Summary of the public kick-off meeting on the forest management plan

Objectives of the kick-off meeting were to inform the general public on the forest management plan and to inquire which issues are most important for the stakeholder groups. In parallel workshops, the forest department wanted to identify the different interests among stakeholder groups. The detailed meeting sequence is provided in appendix 2.

a) Introduction

The first part of the meeting started with an introduction to the objectives of the forest management plan in general and of this event in particular. Representatives of the FD and UBE explain the situation of the Entlebuch forest and the participation process in input presentations. Their presentations mainly referred to the corresponding documents by Arnet et al. (2004) and the Kanton Luzern (2004).

b) Parallel workshops

Then, the second part of the meeting with four parallel workshops took place. As key issues, nature protection, forest use, natural hazards and tourism were identified and addressed in four parallel collaborative workshops. As visual input, the existing tourism infrastructure was presented in interactive landscape visualizations to highlight the need for visitor management. The issues of nature protection were visualized in static landscape visualizations; natural hazards and forest use were not supported by landscape visualizations.

c) Summary and closing

In the end, the workshop groups presented their results to the general public again and the meeting closed with an aperitif.

7.3.4.1 Selection of key moments

It was suggested to include the use of visualizations in the tourism workshop during the kick-off meeting, because the discussion showed parallels to previous input presentations in case 2.

introduction ->	**parallel workshops ->**	summary

Figure 7.29: Sequence of the public kick-off meeting with key moment highlighted.

7.3.5 Results from the public kick-off meeting on the forest management plan

7.3.5.1 First key moment: Public kick-off meeting – introduce the plan

introduction ->	**parallel workshops (tourism) ->**	summary

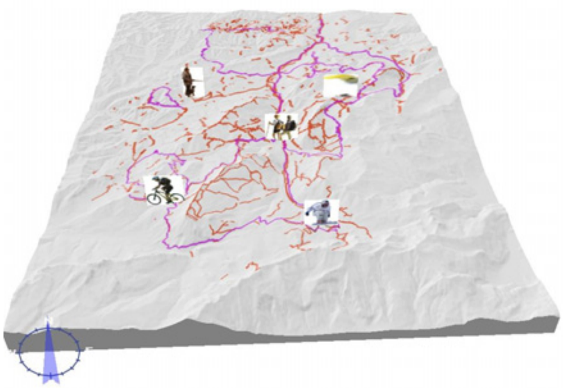
Figure 7.30: Visual and verbal input in parallel workshops during the public kick-off meeting.

Four parallel workshops followed the general introduction of the forest management plan. These four workshops addressed the issues of tourism, forestry, nature and natural hazards; tourism and nature were supported through landscape visualizations. In the rather small tourism workshop, four tourism stakeholders, two who had participated in case one, discussed a set of four assumptions on the conflict between tourism and forestry. The four tourism assumptions were all illustrated by printed posters and interactive landscape visualizations. The assumptions translate as follows; with comments in brackets:

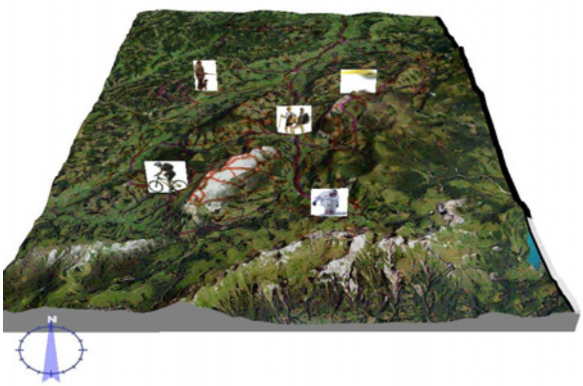
1. Bark-beetle damage is harming tourism.
2. The increasing recreational pressure needs to be directed [to zones, specifically designated for recreation].
3. The Entlebuch forest is an excellent educational resource.
4. Without investment, there is no tourism – neither in the forest [nor in the skiing resort].

The second assumption, i.e., that tourism puts increasing pressure on forest wildlife, is illustrated by the iterative construction of a landscape visualization with all hiking and biking routes, icons of major tourism activities, and the orthophoto with the actual forest. The key visualization steps are shown in figure 7.31. They emphasize the high density of the tourism infrastructure.

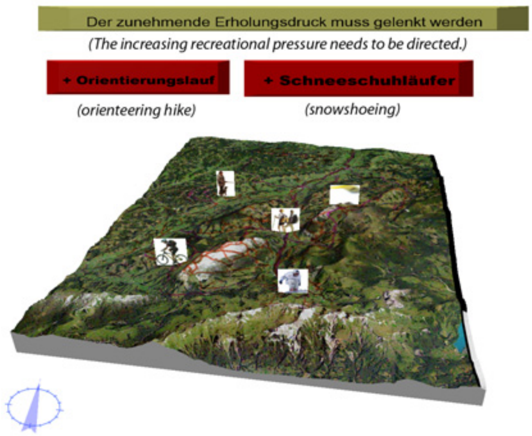
Interactions



Spatial navigation: overview perspective
Overlay: vector data (lines) of tourism routes
Icons for diverse tourism uses



Overlay: orthophoto



Workshop tools: comments

Figure 7.31: Visualization of the high density of the current tourism infrastructure and the pressure that diverse tourism uses impose on the forest.

Impact > Data sources	Impact of the visualizations (observations)	Impact of the interactivity (interpretation)
Researchers (observations)	In the tourism group, the participants watch the visualizations and one comment directly refers to a visualization (figure 7.31, P157; 65:65). Nevertheless, most arguments refer to the written assumptions. The participants of the nature group have different visualizations than the tourism group. They do not refer to their visualization input but to the text input (P24; 17:21).	It seems that the tourism stakeholders are more open to using the landscape visualizations because they are more used to it than the participants of the nature group. Furthermore, a deprecative attitude of the nature group towards the visualization content might impact their use of visualization.
User Group - tourism stakeholders (feedback protocols)	One participant suggests a more iterative construction of the visualizations (1. landmark layer, 2. infrastructure layer) could help in orientation (P178; 27:30).	Overlay interactions support the understanding.
	All participants of the tourism group are interested in interacting with the visualizations (P178; 37:37).	Interactivity motivates working with landscape visualizations.
Facilitator (protocols from expert interviews)	Two of the tourism stakeholders are familiar with landscape visualizations because they took part in case 1. The tourism group is very dynamic already and the facilitator thinks that they do not need additional motivation (P157; 18:18). If the discussion had fallen silent or biased, the facilitator would have referred to the visualizations for motivation (P157; 100:103). From the facilitator's point of view, the visualizations help the tourism stakeholders (P179; 32:33).	The group dialogue is very constructive already so that there is little need for additional visualization support. If the group work had been less vibrant, the facilitator would have used the visualizations for motivation.

Table 7.10: Empirical data and interpretations of interactions in the tourism group during the first workshop.

a) Inclusiveness and individual skills

An interviewed participant said he could orient himself successfully in the realtime landscape visualizations because he knows the area very well and recognizes the mountains (P22; 25:25). Landmarks with a high recognizability, such as mountains (here: Schrattenflue), streets and villages are reference points for users who are familiar with the location. During the group discussion of the first workshop, users confirmed that they were able to orientate quickly in the realtime landscape model because they know the area very well (P178; 25:25). Others had problems, because they did not know the area (P178; 26:26). It seems that users who are used to working with images and who are familiar with the place, were also able to orient themselves more successfully in the realtime landscape visualizations (tourism stakeholders, P178; 25:25). In an interview, two other users who are familiar with the location, also orientate successfully in the realtime landscape visualization, although they were not used to 3D landscape visualizations (P56; 33:33). In contrast, an orienteering sportsman with high map-reading skills preferred the map because he could orient himself quicker with it (P178; 23:24).

These quotes from participant and expert interviews suggest that two factors may play a role: knowledge of the place and map-reading skills. First, a good knowledge of the place seems to help users in the orientation in real-time landscapes. Second, users with high map-reading skills may tend to prefer maps to landscape visualizations because they are more used to the map representation. These two assumptions are taken up in the quantitative survey in chapter 9. There, the user preferences for different types of interaction are tested with regard to individual place knowledge and map-reading skills.

b) Thematic navigation and iterative construction of overlays support the understanding
Apparently, the iterative construction of the images is an appropriate approach because the participants confirmed that it helped to understand the visualizations.

> *"Ich war überrascht, wie viele Wege und Pfade jetzt schon vorhanden sind" (P177; 51:51).*
> *I was surprised, by how many trails and paths are already available.*

The visualization could be improved by showing landmarks as a layer on its own (table 7.10). The workshop tools were used for documentation (figure 7.31, third image), but there is no evidence directly connected to these interactions. It should be noted that the collaborative dialogue in this group was already very dynamic and constructive. The good atmosphere was fostered by positive external factors such as the small and homogeneous group formation, so that landscape visualizations as instruments for dialogue were not essential at this time. In the result, the tourism stakeholders agreed to concentrate the number of hiking routes and to give visitors more direction, e.g., through a new visitor centre. In order to achieve a consensus with the other stakeholder groups, they agreed to map their needs and to put these up for discussion in the forthcoming workshops.

7.3.5.2 Key moments without visualization support

According to participant feedback, the visualizations were helpful but not of major importance for the discussion. The facilitator agreed that the use of the visualizations during the discussion was not optimal. In the interview (P157), she lists the following hindering factors:

- insufficient co-ordination with the visualization team beforehand,
- insufficient co-ordination with the visualization team during the workshop,
- the very short time frame of the workshop,
- the discussion took a different course than expected, and
- it is difficult for the facilitator to watch both participants and visualizations.

7.3.6 Summary of the final public meeting on the forest management plan

The main objective of the final meeting was to find a consensus on the designation of different priority zones. The priority zones are documented in the theme and object sheets and the corresponding priority maps. A solution of the bark-beetle problem was not a goal because it is beyond the scope of the forest management plan.

a) Overview theme sheets

The theme sheets are a central element of the final forest management plan because binding measures are laid down in them. For the final workshop, the FD prepared proposals for the theme sheets of the forest management plan and sent copies to all registered participants.

b) Group work on theme sheets

In the group work, the stakeholder groups discussed the theme sheets that are relevant to them. As a result, they gave suggestions on how to improve the theme sheets. Overall, most stakeholder groups were satisfied with the theme sheet proposals.

c) Collective discussion of theme sheets

Finally, the facilitator presents the group suggestions to all participants. In this session, the facilitator asks for visualization support in order to overlay the interest maps of the tourism and the hunting stakeholders.

7.3.6.1 Selection of key moments

The use of model functions and spatial navigation to support consensus-building in the final meeting was definitely a key moment that initiated the turnaround in the negotiation of tourism and hunters interests. Landscape visualizations were rarely used and the reasons are discussed in chapter 7.3.5.2.

Overview theme sheets ->	Group work on theme sheets ->	**Collective discussion of theme sheets ->**	Closing

Figure 7.32: Sequence of the final public meeting with key moment highlighted.

After the diverse interests of the stakeholders and the conflicts were identified in the first four meetings, the final meeting was planned for consensus-building. At this point, the landscape visualizations actually do facilitate and accelerate the consensus-building process, with interactive overlays playing a key role. By showing the areas of interest for hunters and tourism stakeholders in combination and in addition, focussing and zooming into points of interest, the conflict is made visible and solutions become apparent.

7.3.7 Results from the final public meeting on the forest management plan

7.3.7.1 Consensus-building: visualization-supported consensus-building

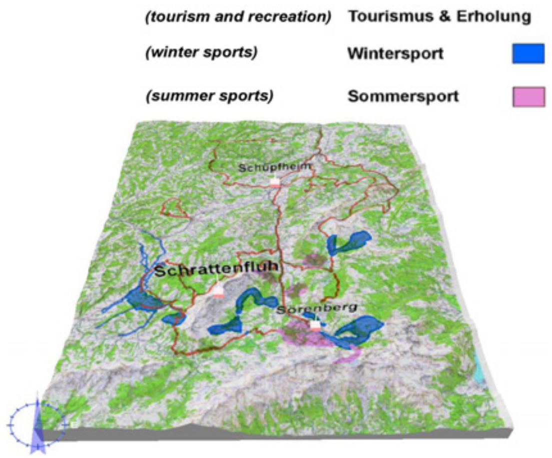
Overview theme sheets ->	Group work on theme sheets ->	**Collective discussion of theme sheets ->**	Closing

Figure 7.33: Second key moment: consensus-building in the final meeting.

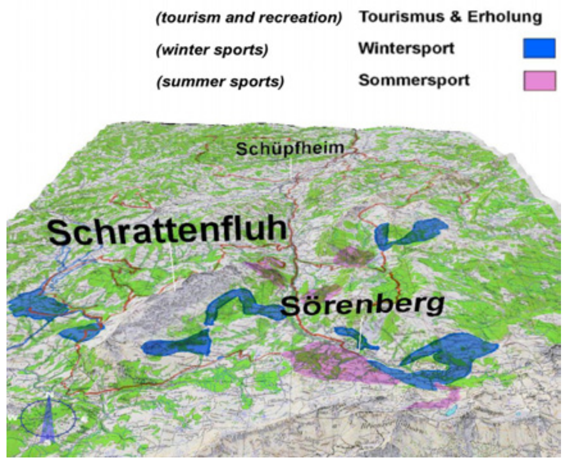
The observer noted that the facilitator is more oriented towards the visualizations (P176). Apparently, the facilitator takes advantage of the tool as the debriefing with the forest department shows:

> *"Aber in dieser grossen Gruppe, an der letzten Veranstaltung, im Plenumssaal, wo es um konkrete Gebiete ging, war die Rückmeldung auch von B.S. [facilitator] so, dass es phantastisch war, mit euch so zu arbeiten. (P55; 41:41)"*
> *Even in this big group, at the last event, in the plenum hall, where it was on specific areas, the feedback by B.S. [the facilitator] was so that it was fantastic to work with you.*

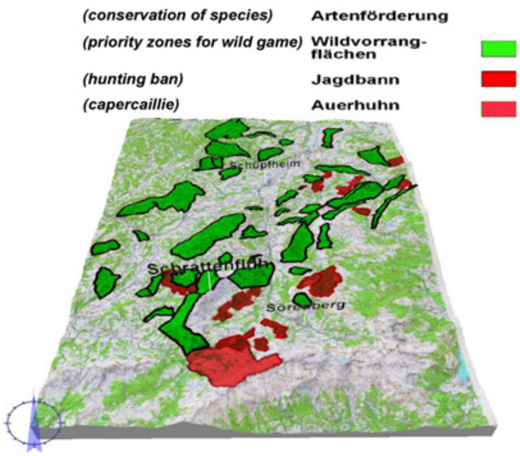
It was in the final meeting that consensus-building among different groups of stakeholders finally became spatial. Before, the interests of the tourism stakeholders, on the one side, and nature protection and hunting on the other side were mapped in a participatory way and digitized. Now, each group's interests are available as vector data layers and the layers are overlayed. In response to people's comments, the visualization navigator zooms into the areas of interest, so that spatial conflicts become visible (figure 7.34).



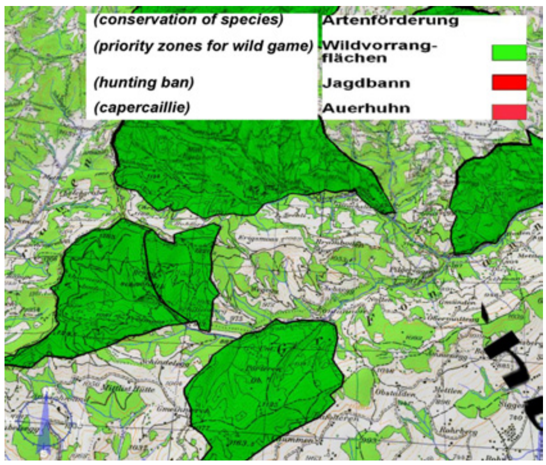
1. Tourism infrastructure
Facilitator instructions: *"Enlarge the map"*(P176).



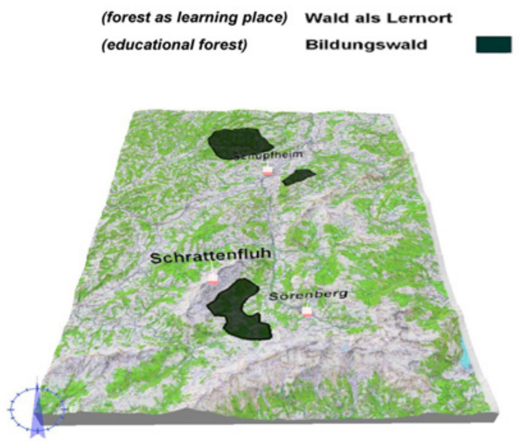
2. Forest as educational resource
Facilitator : "*Map of capercaillie please*" (P176).



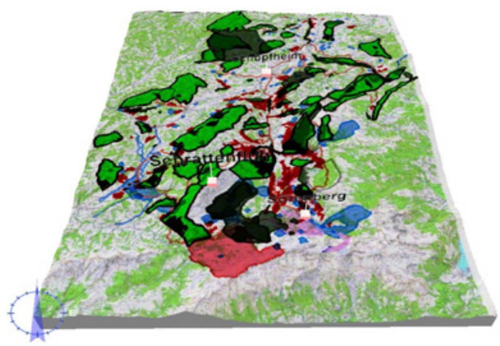
3. Wildlife habitats



4. Overlay
Facilitator: *"Add the educational forest please"* (P176).



5. Educational forest



6. Overlay

Facilitator: *"Zoom in, more south. This is the result of the workshop. We now have to find a solution, how to cope with the overlay. My suggestion, decrease the hunting areas first."* Response by stakeholders follows (P176).

Figure 7.34: Overlay of the areas of tourism and wildlife interests, based on previous participatory mapping.

Impact > **Data sources**	**Impact of the visualizations - empirical data**	**Impact of the interactivity - interpretation**
Researchers (observations)	The observer notes that soon after the interactive visualization (figure 7.34), tourism and hunting stakeholders reach a consensus rather fast (P176).	The observation affirms that the visualizations contribute to the consensus outcome. The requests for zooms and the responses to the overlay of the two interest layers indicate a key role of the interactions.
User Group - tourism stakeholders (feedback protocols)	Two interviewed stakeholders confirm that the visualizations have motivated their participation (P22; 98:98, P56; 11:15).	The visualizations in general motivate the stakeholders.
	The interviewed hunting stakeholder says that he is mainly interested in his land and that he would like to use the zoom function to magnify it (P22; 84-90).	Spatial navigation facilitates the dialogue through addressing individual interests.
	Both interviewed stakeholders are interested in additional design function that allow editing the surface (P56; 127:137, P22; 92:92).	The stakeholders demand interactive landscape editing functions.
	In a participant interview, one of the hunters points out that the iterative construction of the overlay is easier to understand than an immediate overlay (P22; 35:37; P22; 33:33).	The iterative construction of overlays, layer by layer, is easier to understand than the presentation of a static map.
Forest Department Coordinator/ Facilitator (protocols from expert interviews)	The forest department points out that the zooming function causes all people in the room to focus on the same location. As a result, everybody is talking about the shared issue (P55; 44:45, 49:49).	Spatial navigation, especially zoom, allows the shared experience of a landscape among a group of people. This shared experience may also facilitate the construction of a shared mental model. In facilitation, a shared mental model does not necessarily provide consensus, but it is a pre-stage to consensus.
	According to the forest department, the possibility to see the topography not only in 3D but also to zoom into it, creates a constructive atmosphere (P55; 57:57).	
	The forest department assesses it as positive to respond interactively to the people (P55; 61:65).	It seems that interactive design functions will further facilitate the dialogue.
	The forest department assumes that more interactive tools are needed if the discussion becomes spatially more specific. Then, people ask to show specific areas and to complement data (P55; 173:181).	
	In conclusion, the forest department assesses the overlay of diverse maps as most effective. The effective application required a tempo that keeps pace with the dialogue (P55; 165:165).	The forest department says that the interactive overlay had a major positive impact on the consensus among tourism and hunting stakeholders.
	The facilitator of the workshop points out that the interactive overlay has accelerated the consensus-building process a lot (P20; 24:24).	The facilitator confirms the observation that the interactive overlay benefits the consensus-building .

Table 7.11: Empirical data and interpretations of the interactions in the final workshop, when the divergent stakeholder groups negotiate a consensus.

a) Spatial navigation can motivate participants

Attentive response to the landscape visualizations is observed during the fifth workshop and two of the stakeholders confirm in interviews that the visualizations have motivated them to participate (P22; 98:98, P56; 11:15). Stakeholder comments and facilitator observations indicate that spatial navigation has a positive impact on the motivation and dialogue.

b) Spatial navigation assists the construction of shared mental models

A hunter describes the benefit that he can now view the land that he is responsible for by zooming in :

> *"Mich interessiert ja mis Gebiet, nit das Nachbarrevier. I wüt ja wissen, was in mins Gebiet is" .*
> *"I'm interested in the area that is my land. I want to know what is in my area" (participant, speaking local dialect, P22; 84-90).*

The coordinating representative of the forest department summarised the major benefit in comparison to static images as follows:

> *"Alle Leute im Saal waren immer am gleichen Ort mit den Gedanken. Weil ihr sie mit dem Hineinzoomen in dieses Gebiet gebracht habt. [...] Und dann haben immer alle vom Gleichen gesprochen".*
> *"All the people in the hall were always in the same location in their minds because you brought them into this area through zooming. [...] And then, everybody was talking about the same thing" (forest department co-ordinator, P55; 44:45).*

The co-ordinator describes a process that is known as the construction of a shared mental model in the theory (see chapter 3.4). Usually, the construction of a shared mental model is an important step towards consensus-building and can be facilitated through various techniques. The observations indicate that spatial navigation, especially the zoom function, supports this process.

c) Interactive design functions may enhance the dialogue

The interviewed stakeholders suggest that interactive landscape editing functions, e.g., a surface editor, could have fostered the dialogue if it had been available (P56; 127:137, P22; 90:90). The forest department adds that landscape editing could become even more important if the discussion is spatially more specific (P55; 173:181). In this case, the zoning was done collaboratively on paper maps in a previous workshop. When landscape editing functions become available in the near future, it will be possible to map the stakeholder interests directly in the landscape visualization.

d) Overlays accelerate the consensus-building process

The third and most effective interaction, which was applied at this time, was the overlay of various interest maps (figure 7.34). It was observed that shortly after this overlay was shown, the tourism and hunting stakeholders reduced their claims and agreed on a shared zoning proposal. The most controversial area was zoomed in and with regard to the visualization, the key stakeholders for this area were identified. All attendees agreed that these stakeholders should formulate the details of a consensus for the forest management plan (P176). In interviews a few weeks later, the facilitator, as well as a representative of the forest department, confirmed that this consensus had been the turnaround in the discussion and both say that the visualization overlay accelerated the process. The final plan document contains the consensus solution in an extra theme sheet, shown in extracts in figure 7.35 (Kanton Luzern 2006).

Forests with priority functions		
Priority function protection forest	8444 ha	53%
Priority function natural protection	8403 ha	53%
Priority function groundwater protection	285 ha	2%
Priority function education and recreation	2535 ha	16%
Forest without priority function	2535 ha	16%
Total (because of overlaps > 100% of the forest area)	30'616 ha	193%

Priority function natural protection	**Priority function education and recreation**
- Spatial or temporal limitation of public access	- Permanent access is granted
- Restrictive event management	- Maintenance of roads and streets
- No new infrastructure	- Concentration of appropriate recreational and educational uses
...	

Figure 7.35: Area numbers and regulations on priority functions according to the final version of the WEP. Translated from the German original (Kanton Luzern 2006: 20).

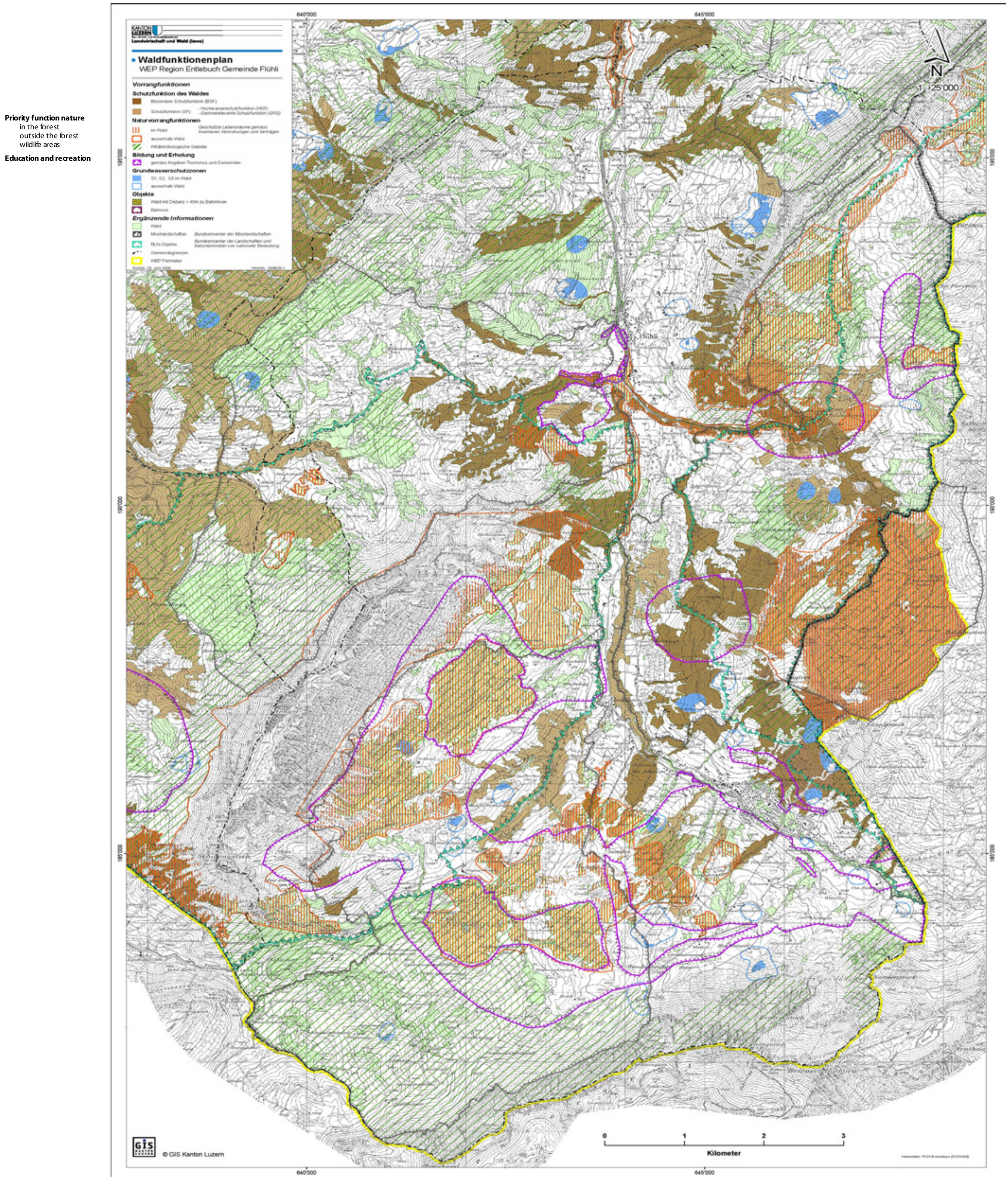


Figure 7.36: Forest Function Plan with the priority functions for the Entlebuch region. The areas marked by magenta lines (educational and recreational functions) and green lines (ecological function) are the outcome of the consensus between tourism and hunting stakeholders.

7.3.7.2 Key moments without visualization impact

After the public kick-off meeting, three meetings with up to two parallel workshops followed over the next two months. In general, these started with a discussion on the shared objectives, a brainstorming session, group work on the relevant theme and object sheets, and a final discussion of the results. Although a broad mix of visualization tools, i.e., maps, sketching paper, interactive GIS and landscape visualizations, had been prepared for the workshops, spatial issues and landscape visualizations were not requested in these workshops, neither by the facilitator nor by any of the participants.

Why did the stakeholders not use the visualizations during large parts of the participation process? According to the observation protocols, interviews and briefing protocols with the facilitators, three reasons stood out. First, the stakeholders discussed non-spatial issues first. Although the facilitators wanted to become spatially explicit from the second workshop on, the discussion issues of the second to the fourth workshops were too general to be visualized.

Nevertheless, the facilitators could have asked for sample visualizations and, according to one of the facilitators, the people are interested in “what happens on my piece of land” (P179; 97). However, another facilitator answered that they did not have the time to work with the visualizations because they had to work as efficiently as possible (P179; 44:46). In summary, time is a major constraining factor and only in the final meeting, did the facilitator assign more time for interactive visualization. The observation protocols indicate that the attitude and experience of the facilitator towards visualizations are crucial at this point. The facilitators of the workshops two to four had not used landscape visualizations before and were sceptical about their usefulness. In contrast, the facilitator of the final meeting had learnt about landscape visualizations before and had made a script on how to use them in his argument. The case shows that the participants rarely start to work with the landscape visualizations on their own because the role of the facilitator is so strong in collaborative planning that people wait for the facilitator.

Third, it needs to be recognized that less advanced computer hardware (laptops instead of a desktop PC) and visualization software (interactive GIS instead of LandXplorer) were used during the second to the fourth workshops, than was used in the start and the final meeting. The reason is related to the previous discussion; because of the strict time frame and the uncertainty of whether landscape visualizations would be applied at all, these workshops did not receive as many resources as the other workshops.

7.3.8 Discussion of the forest management plan case results

In contrast to cases one and two, this case was part of an official participation process (see chapter 2.3.2) on a legally binding map document and different stakeholder groups with conflicting interests were involved. As a result, it not only provides a good overview of the external factors in an official participation process (role of facilitator, user experience), it also has a “real planning outcome”. The interactive overlay in combination with spatial navigation (zoom, focus) facilitated or rather accelerated the consensus-building that usually goes into the plan outcome and helped solve the interest conflict between tourism and hunting stakeholders.

a) Inclusiveness

The visualizations in general were assessed as an additional motivation and spatial navigation contributing to this effect, because stakeholders can view individual areas of interest. If the shared visual working on a planning topic encourages people to go on, it is also the first step towards a consensus. As the supervising facilitator says:

> *“Die Einstiegshürde könnte damit abgebaut werden, sich mit der Materie auseinander zusetzen. Sie können die Leute ermutigen mitzumachen, „die Leute abholen“.*
> *"The visualizations may remove initial barriers and encourage people to deal with a planning topic. They can encourage people to participate" (facilitator, P173; 65:72).*

b) Enrichment of information

In this case, the stakeholders enriched the forest management plan through local knowledge. Their interests and knowledge were mapped collaboratively and then visualized through an interactive layer model. The previous cases (chapter 7.1 and 7.2) were different, because there, the homogeneous stakeholder discussions were enriched through input from external experts.

c) Dialogue

The main benefit of the tools for the dialogue is their contribution to shared model-building. The fact that all people have a shared image to refer to facilitates the building of mental models enormously. Although shared model-building may be facilitated through static images as well, interactive landscape visualizations allow the construction of a supporting image on demand:

> *“Die Möglichkeit, jede beliebige Perspektive zu generieren, unterstützt sachorientierte Diskus sionen: alle haben das gleiche Bild vor sich und denken darüber nach.“*
> *"The opportunity to generate any perspective supports factual discussions: all have the same im age in front of them and think about it" (facilitator, P173;65:72).*

d) Credibility and transparency

There were no charges of manipulating the visualizations in this case. It may be suggested that the collaborative stakeholder mapping increased the credibility and transparency of the final overlay of interests a lot. If possible, this technique, which is well established in participation already, should be applied to the use of landscape visualizations as well. If landscape visualizations develop more interactive design functions, it may be effective to conduct the whole process in the virtual landscape. However, the combination of analog mapping and digital overlay in this case proved practical and has been applied successfully before by Al-Kodmany (1999).

e) Consensus

By identifying the areas of interests together, the involved stakeholders share the same perception. According to the theory on knowledge building, perception is the first step towards knowledge-building and shared perception in the first step in building a shared mental model (Klimoski and Mohammed 1994). Therefore, a powerful shared experience might lead to a better consensus or compromise.

As pointed out before, the shared mental model is an important step to consensus-building. The facilitator emphasizes that the visualizations were of great benefit for the discussion and that they helped to set up a task force with the relevant stakeholders. It can be concluded that the interactive overlay of areas of conflict supports the discussion in the final meeting and helps the participants to reach a consensus. The guidelines that have evolved from this consensus are included in the WEP theme sheets (Kanton Luzern 2006) and in the related priority map (see figure 7.36).

f) Learning

In both key moments, the iterative construction of the landscape visualizations layer by layer was easier to understand than static images with various themes. For overlays of various themes, interactivity supports understanding and learning.

> *"Mhm, ja. Das ist gut gsi, schrittwis, da hät man's gseh, aber miteinand, hätts mich schwierig dunkt".*
> "Well, yes. That went well, step by step, so that you saw it, but all in all, that was difficult" (P22; 35:37; P22; 33:33).

7.3.8.1 The forestry case in brief

In the forestry case, the overlay interaction seemed to accelerate the consensus-building process between tourism and hunting stakeholders. With regard to the literature review on knowledge-building (chapter 3.4), it may be suggested that the visualizations supported the construction of a shared mental model.

8. Cross-case analysis and results: The three cases in comparison

The cross-case-analysis starts with a comparison of context variables across the three cases. Secondly, the frequencies of interactions are compared for different workshop phases. Context variables and workshop phases contribute to the recommendations for planning. In a third step, the observed impact of interactive visualizations are replicated across the three cases. The replication allows an assessment of the reliability of the results from the single cases.

8.1 Results of the context factors clustering

8.1.1 Research database query

As far as the three cases took place under similar conditions, similar context factors can be predicted. In order to identify the context factors that determine the impact of interactive landscape visualizations, the transcripts in the research database were queried for all context codes that co-occur with quotes on interactivity.

8.1.2 Clustering of context factor codes

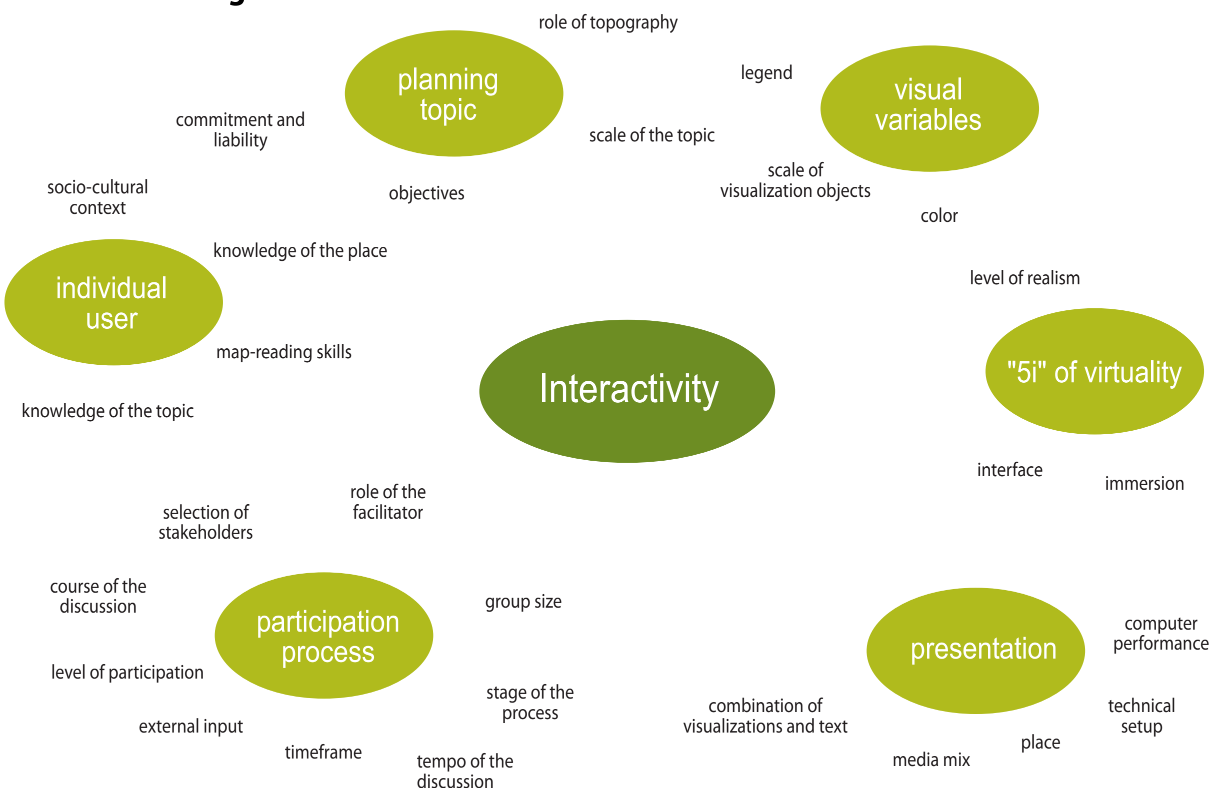


Figure 8.1: Clustering of context variables that affect the application of interactive landscape visualizations in the three cases.

Figure 8.1 presents the results of clustering all documented quotes on context variables that co-occur with any quotes on interactivity. The categories are marked by green circles and the related codes are placed around them. Codes that are in-between two categories relate to both, e.g., level of realism is related to virtuality and visual variables.

The importance of the human factor has already been highlighted by Hislop (2004). Figure 8.1 supports the assumption that human factors (individual user, participation process, planning topic) are at least as important as technical factors (interactivity, virtuality, visualization design). The following summaries present the results of coding and clustering, starting with the human factors:

a) Individual user

The transcripts indicate that map-reading skills and the knowledge of the area are important skills that help users get oriented in real-time landscapes. The impact of these skills and other individual user characteristics, described by gender, age, and stakeholder group are tested in the quantitative survey in chapter 9.

b) Participation process and the role of the facilitator

The comparison of the three cases with regard to changing group sizes suggests that the larger the group size is, the more difficult collaborative visualization gets. Similarly, collaborative planning requires manageable groups sizes as well. If the group gets too large, other forms of participation are preferable.

All three cases show that the role of the facilitator is crucial. First, the cooperative preparation of the workshop by both, the facilitator and the visualization navigator is important. The facilitator has to know the interactive possibilities beforehand. The way that the facilitator refers to the visualizations determines their benefit. During the workshop, the facilitator has to position himself in a way that he can address the workshop participants as well as the visualization navigator and still see the visualizations. The facilitator may limit the use of the visualizations by giving priority to the discussion instead or he may facilitate the interaction with visualizations through references to them. The facilitator has a similar opinion about the visualizations as the stakeholders, i.e., that it is a helpful tool. However, the facilitator of the first and second cases is clearer about their benefits and uses them more target-oriented than the facilitators in the third case or the stakeholders. In consequence, the visualizations have a stronger role in the first two cases. Von Haaren et al. (2005) and Warren-Kretzschmar (2007) support the observation that the role of the facilitator and his coordination with the visualizations is crucial for a successful application.

c) Planning topic

If the key moments without visualization support are compared across cases, it is noticeable that the issues discussed lack spatiality, i.e., they are difficult to localize. The farmers in the agriculture case, for example, refer to the general economic situation of livestock farming in Switzerland. Such a topic can hardly be illustrated through landscape visualizations. Again, the observations are confirmed by Warren-Kretzschmar (2007), who made similar observations for the Königslutter case study. Second, the scale of the topic is crucial for the selection of interactions. The use of different scales requires interactive zoom functions.

d) Presentation

The computer projections require a darkened room, whereas people prefer to hold discussions in a brightly room. Therefore, the visualization team has to consider the lighting setup beforehand and to change the lighting during the workshop if required. Due to the nature of collaborative planning, the discussion has priority and some quotes (e.g., P175; 136:137) show that the necessary trade-off is not always ideal for the visualizations.

Another consideration is that the technical equipment requires time to set up and is not very flexible to changes during the workshop. In the case studies, about two hours had to be calculated for two people to prepare the setup. In the workshops, time is very short (see chapter 6.1.3 on visualization methods). The video documentation from the agriculture case shows that viewers need up to five minutes to get oriented in the real-time model.

Navigation in combination with too much detail may cause a cognitive overload. The visualization navigator can support the viewers by limiting the cognitive load of interactions and visualizations. First, the right tempo is crucial – not too fast if people have to orient themselves, not too slow if the discussion suddenly changes. Second, landscape visualizations as well as interactions require verbal explanations. Interactions are more easily understood if they are explained in parallel: "Now, we are going to Änzihütte" (P155; 49:49). Third, the interface and any interactions that do not directly contribute to the discussion, distract the participants. In the workshops, the stand-by function and full-screen options are used to blend these features out as long as participants are talking.

e) Visual variables

According to the literature review, the visual representation can be described by visual variables, e.g., the position, color, or scale of a visualization object (cf. chapter 3.1.3). The role of the visual representation is discussed in more detail in Wissen (2007).

f) Virtuality

A high level of virtuality, particularly through a high level of realism in combination with a high level of immersion, may increase the viewer's emotional engagement with the visualization. Indications for such effects are discussed in case two on agriculture. In consequence, a high virtuality may support the imagination of future landscapes and the discussion of landscape characteristics such as beauty. However, the danger of dramatising phenomena is also higher in visualizations with a high level of virtuality. For example, a landscape visualization on future pastures brought a comment of a "picture-book pasture" because red clover (*Trifolium pratense*) and arnica dominated the visual impression of the image (cf. case two on agriculture). The role of the level of realism is discussed in detail by Lange (2001).

8.1.3 Discussion of context factors

In table 8.1, the context factors are put in relationship to the hypotheses from chapter 4. Particularly important are the spatiality of the topic for factual enrichment, the level of realism for emotional enrichment, data correctness for credibility, participation objectives, selection of stakeholders for consensus-building, and an appropriate presentation, as well as positive user preferences for learning outcomes. These variable pairs occur more often than others. The list is not conclusive, and contains only variables that could be identified in the three cases.

Benefits	Positive context variables	Negative context variables
Process		
Inclusiveness	Positive role of the facilitator, positive user preferences and skills, knowledge of the place, high level of realism	Lack of user skills and preferences, lack of place knowledge, inadequate level of realism
Enrichment	Spatiality of the planning topic, appropriate presentation techniques, positive user preferences, knowledge of the place, tempo, immersion, high level of realism for emotional enrichment – low level of realism for rational enrichment	Non-spatial planning topics, lack of time, conflict-burden issues, inadequate presentation, lack of user skills, lack of place knowledge, tempo of presentation too fast
Dialogue	Positive role of the facilitator, realistic participation objectives, course of the discussion, positive user preferences, user skills, group size of four to about 15, appropriate presentation techniques	Perceived manipulation, missing participation objectives, low level of participation, negative user preferences
Credibility	Data accuracy, correctness, high level of participation, knowledge of the place, external input	Perceived manipulation
Outcome		
Consensus	Low level of conflict, selection of stakeholders, participation objectives, positive role of the facilitator, spatiality of the planning topic, high level of participation, course of the discussion, tempo of the discussion, positive user preferences / social-cultural context, external input	High level of conflict, disadvantageous selection of stakeholders, low level of participation, unexpected course of the discussion
Learning	Adequate presentation techniques, external input, positive user preferences, high level of realism, role of typology, course of the discussion, local knowledge, socio-cultural context	Inadequate tempo of presentation, perceived manipulation, lack of user skills, inadequate level of realism, unexpected course of the discussion, lack of local knowledge or knowledge on the topic

Table 8.1: Matrix of benefits and related variables, based on co-occurrence of codes from transcripts and observation protocols in the qualitative analysis.

8.2 Comparison of interactions with regard to different workshop phases

Based on the literature review, input, brainstorming, discussion and decision-making phases can be distinguished in a typical workshop sequence (Ackermann 1996). For the different phases in figure 8.2, different frequencies and qualities of interactions may be predicted. Therefore, the frequencies of verbal and non-verbal interactions have been counted for the video sequences of three different workshop phases. The results of the counts of human-human and human-computer interactions are shown in the interaction schemes in figure 8.3.

Introduction ->	Input presentation ->	Brainstorming ->	Discussion ->	Decision-making

Figure 8.2: Typical sequence of a workshop according to Ackermann (1996).

8.2.1 Frequencies of interactions

In figure 8.3, the line width of the arrows corresponds to the number of interactions as counted on the basis of video documentation and discussion transcripts. The brainstorming phase is not included because the facilitator did not want to use landscape visualizations during brainstorming.

a) Input presentation by external experts

During the input presentation of the second agriculture workshop, the human-human interactions concentrated on the experts who presented to the stakeholders in an one-way communication. The experts interacted with the landscape visualizations to illustrate their input. Here, the stakeholders watched the visualizations intensely, whispered, and made gestures towards the visualizations.

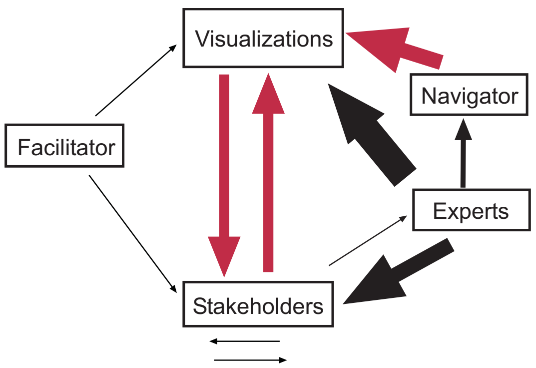
b) Scenario discussion

The stakeholders were more actively involved in the scenario discussions of the second agriculture workshop. The facilitator is the pivotal point of the scenario discussion, he not only encourages the stakeholders, he also establishes the human-computer interactions with the landscape visualizations. In scheme b), it seems that the expert input also started an intense discussion within the stakeholder group. Additionally, the external experts are in discussion with the stakeholders. All three actors, facilitator, experts and stakeholders, use the visualizations in their argumentations by referring to them.

c) Decision-making

Figure 8.3 shows the situation of the final meeting on the forest management plan, where two stakeholder groups are in conflict. Here, the facilitator is leading the discussion and most interactions take part between him and the stakeholders. He uses the visualizations as a tool to facilitate the consensus-building between the two stakeholder groups.

a) Input presentation by external experts

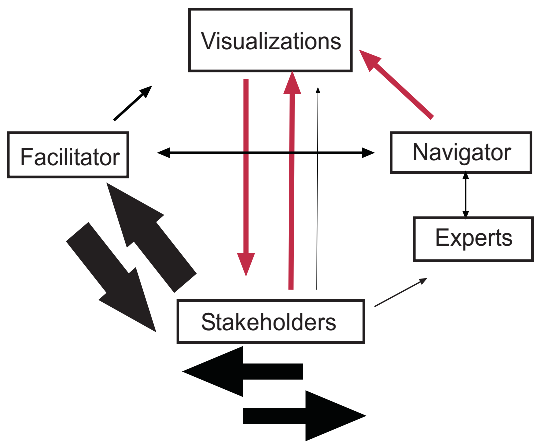


Center of the discussion:
Presentation of the external experts to the stakeholder group

Interaction with visualizations:
The external experts ask for specific visualizations to illustrate their input. The stakeholders watch intensely, indicated through whispering and gestures towards the visualizations.

(Case 2: Agriculture; second workshop).

b) Scenario discussion with stakeholders and external experts

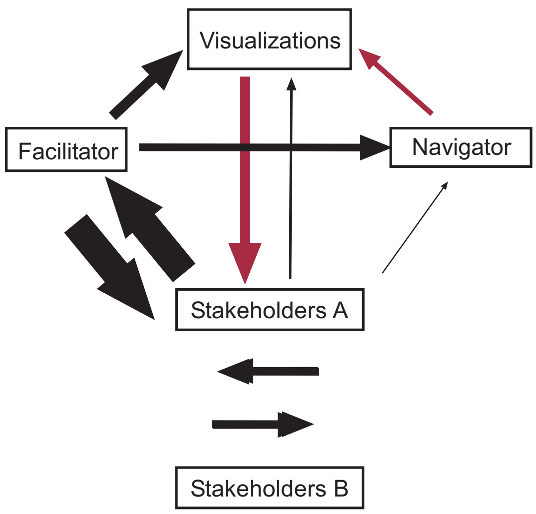


Center of the discussion:
Discussion among the facilitator, stakeholder group and experts

Interaction with visualizations:
Now, the visualizations are not only used by the experts but also by the facilitator. Both ask for specific visualizations. The stakeholders do not request specific interactions in this case, but they refer to the visualizations verbally in their argument.

(Case 2: Agriculture; first workshop)

c) Decision-making with different stakeholder groups



Center of the discussion:
Interactions between the facilitator and stakeholders as well as between the stakeholder groups A and B

Interaction with visualizations:
The facilitator uses the visualizations to accelerate the consensus-building process between the two stakeholder groups. One of the stakeholders also asks to zoom into an area of interest.

(Case 3: Forest management plan; final meeting)

Figure 8.3: Verbal (black) and non-verbal (red) interactions during different workshop phases. The line width represents the frequencies of interactions as counted on the basis of the video and observation documentation. Tabular counts of the interactions are provided in appendix 4.

In comparison to the workshops in cases one and two, the public involvement process for the forest management plan involved different stakeholder groups with conflicting interests. Scheme c) in figure 8.3 illustrates the setup for consensus-building among tourism and hunting stakeholders in the final meeting. This setting is particularly interesting for consensus building, because the negotiation of divergent interests determines the human-human interactions. Furthermore, the observer notes that most participants watch the visualizations intensely (red arrow in figure 8.3) although only three stakeholders directly refer to them.

In collaborative workshops, human-computer interactions are less frequent than human-human interactions. However, the single case analyses showed that the visualizations did have a major impact on the course and outcome of the workshops. Therefore, not the quantity but the quality of the visualization use is crucial. All actors, external experts, facilitator and stakeholders, interact with the visualizations to facilitate the dialogue at specific moments. The quality of the interactions within these moments is analysed in table 8.2 in relation to the different workshop phases.

The analysis of the decision-making phase is rather case-specific because only the forest management plan reached a decision-making phase with consensus-building among different groups. However, the input presentation and scenario discussions are similar for the three cases and can be replicated across them.

8.2.2 Qualities of interactions

In table 8.2, the visualization effects (interpreted on the basis of the qualitative data) are ordered according to their impact on different workshop phases (chapter 2.3.3).

Opening	**>a) Input presentation**	**>Brainstorming**	**> b) Scenario discussion**	**> c) Decision-making**
c1/c3: Raising awareness	**c1/c2/c3**: Enrichment of landscape perception and imagination, e.g., to illustrate causes of change **c2**: Enrichment of the perception of landscape processes and long-term landscape change **c2**: Analyses enrich the input presentation **c2**: Contextualization enriches the input **c2**: Overlays support learning from input	**c1/c2/c3**: Visualizations are not used	**c1/c2**: Spatial navigation facilitates the dialogue and the construction of a shared mental model **c1/c2**: Analyses enrich the dialogue. **c2**: Temporal navigation enriches the dialogue. **c2**: Scenario assessment benefits from multi-dimensional navigation **c1**: Focus navigation encourages minority opinions	**c1**: Analysis enriches the decision-making process (learning outcome on climate change impacts later investments) **c2**: Long-term change of behaviour through emotional perception of landscape change **c3**: Consensus-building among different stakeholders is accelerated through overlays

Table 8.2: The table relates visualization impact to different workshop phases. The cases are abbreviated as c1: tourism, c2: agriculture, c3: forest management plan.

The overview in table 8.2 provides an important input to the final recommendations for the interactive use of landscape visualizations in collaborative workshops. Not all types of interactions are required in every phase of the workshop. A real-time visualization may be sufficient to raise awareness in the beginning. During the following input presentations, interactive zooms into points of interest and interactive analyses support learning and understanding.

The following brainstorming phase is inspired through the visualization input. However, it may be useful to do the brainstorming itself without any visualizations, because participants have to concentrate on the brainstorming and the cognitive load of interactive visualizations may be too much distraction. Any suggestions and ideas for the brainstorming can be presented visually as part of the input presentation. However, other collaborative settings should be tested in future research, perhaps a visual brainstorming method could be developed then.

Mainly, the scenario discussion provides various potential applications for visualizations, from the collaborative construction of scenarios to the assessment of alternative scenarios (cf. examples by von Haaren et al. 2005; Lange and Hehl-Lange 2005; and others in chapter 3). This phase is also the most demanding with regard to the level of interactivity. All types of interactions may be necessary to respond to the discussion in a flexible way. A multi-dimensional scenario navigation that fosters the perception of alternative landscape changes in their temporal dimension is fundamental. During this phase, facilitator and stakeholders interact with the visualizations equally often.

Finally, interactive landscape visualizations may be a catalyst to consensus-building in the decision-making phase. Unfortunately, only the forest management case (case three) lead to an obligatory final decision, but there, the tools did accelerate the consensus-building among the two groups of stakeholders. However, their use as a catalyst is still controversial and Hislop (personal communication), for example, could not confirm such a benefit for the Scottish VisuLands partner study.

8.2.3 Discussion of results on interactions with regard to the workshop phase

The schemes suggest how the center of discussion shifts during different stages. The interaction schemes point up that most interactions are human-human and take place within the stakeholder discussion. However, the analysis of the qualitative contributions by visualizations shows that visualization input generally has a high impact. The position of the facilitator is central and the success of the discussion depends on the facilitation. The visualizations are both a tool and a competitor for the facilitator. Depending on the course of the discussion, the facilitator may refer to them in order to activate the discussion, to highlight specific points, to support minorities or to support a consensus.

8.3 Replication of the case study results

8.3.1 Interaction effects on the process

In this chapter, the interpretations of the effects are assigned to the six hypotheses on inclusiveness, enrichment, dialogue, credibility, consensus and learning.

Type of interaction		Inclusiveness	Enrichment	Dialogue	Credibility
Navigation	Spatial	c1: facilitation of minority opinions c1/c2/c3: raise awareness ("wow effect") c3: motivation through individual response	c1: spatial phenomena c1/c2/c3: information on spatial causes of landscape change c2/c3: visual landscape perception is enriched c1/c2: limitations by cognition	c1/c2: facilitator tool to highlight, focus, etc. c3: facilitates the construction of a shared mental model	
	Temporal		c2: landscape perception and imagination c1/c2: perception of long-term landscape changes c2: emotional or factual enrichment		
	Scenario			c2: facilitates the construction of a shared mental model c2: scenario assessment *(technical / data limitations)*	
Contextualizing functions	Overlay			c3: facilitates the construction of a shared mental model	
	Indicator link		c1/c2: stakeholder requests for indicators c2: limitations by cognition		
GIS Spatial analysis			c1/c2/c3: information on spatial causes of landscape change	c1: causes a major shift in discussion c2: a tool for the facilitator	c1: *manipulation concerns* c2: allows reconstruction the visualizations
Landscape editing			c2/c3: scenario assessment *(limited)*	c3: may enhance the dialogue	c3: participative mapping
Documentation functions				c1/c2: visual documentation	

Table 8.3: Case-ordered interaction-benefits matrix for the process of collaborative planning. Limitations and negative interaction effects are printed in italics.

The matrix in table 8.3 shows the relationships of different types of interactions (in ascending order) and their benefits in the process of collaborative planning. Negative impact is printed in italics. The cases are abbreviated as c1: tourism, c2: agriculture, c3: forest management plan. Major functions of different types of interactions are described with regard to the observations from the three cases. Because similar results can be predicted for similar workshop conditions, the replication of any of these effects increases the reliability of the evidence. If an observation can be replicated for two or even all three cases, the evidence is stronger. As a result, the list is ordered from inferences with a strong reliability (observed in all three cases) to those with moderate (observed in two cases) and weak reliability (observed in one case only). The corresponding context factors and workshop phases are assigned according to the description in 8.1 and 8.2.

a) Inclusiveness: Raising awareness

In all workshops, the interactive landscape visualizations evoked initial behavioural responses in the form of attention, gestures or comments of astonishment. With regard to the literature (chapter 3.4) and in comparison to static images, there is strong evidence that movement (e.g., flight and trackball navigation in figure 7.18) raises attention. The effect is further emphasized through a high degree of virtuality. However, this initial "wow effect" decreased over time. When the tourism and agriculture stakeholders attended the forest management workshop, they already had worked with the landscape visualizations in the previous UBE workshops and the "wow effect" seemed to weaken. Nevertheless, two of the stakeholders stated that the visualizations were still motivating for them. These quotes indicate that interactive landscape visualizations may have a motivating effect, which lasts beyond the initial "wow effect".

Type of interaction:	*spatial navigation*
Workshop phase:	*input, discussion*
Context variables:	*user preferences, role of the facilitator, level of realism*
Effect:	*initial "wow effect", raising attention in the first place (strong evidence), perhaps creating long-term motivation (weak evidence)*
Evidence:	*strong (c1; c2; c3)*

b) Enrichment of information: Illustration of causes of landscape change

In all three cases, the interaction with the landscape facilitates the illustration of causes of landscape change. This function is mainly applied by the external experts or the facilitator in order to contribute additional input to the discussion. In the tourism case, the hypsometry analysis highlights the potential impact of climate change on snow levels; in the agriculture case, the causes of land abandonment are illustrated through slope and distance analyses; and in the forestry case, different forest uses are zoomed in for different land use layers.

Types of interaction:	*spatial navigation, analysis, overlay*
Workshop phase:	*input*
Context variables:	*level of virtuality (especially level of realism), presentation techniques, knowledge of place*
Effects:	*an improved understanding of the causes of landscape change*
Evidence:	*strong (c1; c2; c3)*

c) Enrichment of information: Perception of long-term landscape change

Strong effects in types of response were caused by the temporal navigation (timesteps in figures 7.23, 7.24). The comparison of key moments across cases shows that the effect strongly depends on the virtuality of the landscape visualization, particularly its level of realism. Depending on the level of realism, temporal navigation supports the understanding of landscape processes and enriches the discussion factually (low level of realism) or emotionally (high level of realism). Even simple temporal navigation metaphors such as time lines prove very effective in communicating time progression.

Types of interaction:	*temporal navigation (slide show, time progression, timeline metaphor)*
Workshop phase:	*input, discussion*
Context variables:	*level of virtuality (especially level of realism), presentation techniques, knowledge of the place*
Effects:	*in comparison to single static images, animated time sequences facilitate the understanding of landscape change (in combination with a high level of realism) or facilitate the understanding of landscape processes (in combination with a low level of realism)*
Evidence:	*moderate*

d) Enrichment of information: Addressing emotional responses

Under the previous point c), it is already mentioned that the cases may indicate a relationship between the level of virtuality (i.e., level of realism, immersion, intelligence, interface, interactivity) and the level of emotional response. In this setting, the effect cannot be fully distinguished from other context factors. The level of conflict, for example, is likely to have an impact on the emotional engagement of the participants, too. However, the combination of a high level of realism, simple temporal interactions and an immersive panorama screen in the agriculture case causes more emotional responses than the more abstract and less immersive, but also interactive, visualization of causes of change in the same workshop. Usually, more factual responses seem appropriate for a workshop, but under exceptional circumstances, emotional responses might be desirable, too. In that case, landscape visualization provides a tool for the facilitator to direct the level of emotional response.

Types of interaction:	*multi-dimensional navigation, analysis*
Workshop phase:	*input, discussion*
Context variables:	*level of virtuality (especially level of realism), level of conflict, presentation techniques*
Effects:	*in comparison to single static images, animated time sequences facilitate the understanding of landscape change (in combination with a high level of realism) or facilitate the understanding of landscape processes (in combination with a low level of realism)*
Evidence:	*moderate*

e) Enrichment of information: Landscape perception and imagination

Some evidence from the tourism and forestry cases points to the benefits of realtime navigation in enhancing landscape perception and the exploration of topographic features. A key term, used in several stakeholder comments, is "imagination" and real-time navigation seems to support the imagination of landscapes.

According to the literature, depth cues are crucial for the full perception of a landscape and depth cues require the user to move (chapter 3.4). Particularly, rather "slow" navigation metaphors, e.g., pedestrian navigation, seem to support the spatial perception of realistic landscapes. It is suggested that future research will investigate this additional dimension of landscape perception in more detail.

In the tourism and forestry cases, spatial navigation guided the participant's views and gave new insight into the spatial distribution of infrastructure networks (figure 7.4, 7.31) and farmland characteristics in case two (figures 7.12, 7.13). The topographic features such as slope and elevation especially became clearer. For the exploration of spatial features, "fast" navigation metaphors in comparison, e.g., click-and-fly, focus or landmark navigation, were most suitable.

Types of interaction:	*spatial navigation - "slow" navigation metaphors (pedestrian and flight metaphors) and realistic landscapes or "fast" navigation (trackball, zoom, landmark metaphors) and abstract landscapes*
Workshop phase:	*input, discussion*
Context variables:	*level of virtuality (level of realism), user preferences, spatiality of the topic, presentation techniques*
Effects:	*in comparison to static images, enhanced landscape perception (in combination with a high level of realism) or enhanced spatial exploration (in combination with a low level of realism)*
Evidence:	*moderate*

f) Inclusiveness: Encourage minority opinions through focussing

Another effect was observed in the first workshop (tourism). There, agri-tourism became a topic after farms with hotel beds had been zoomed in, although only one representative of agri-tourism was attending. The example suggests that minority opinions could gain in importance through being focussed on (zoom and focus navigation). The evidence, of how far this benefit is usable as an emancipatory tool is not very strong, but it seems to provide some potential. The literature on participatory GIS supports the assumption because authors like Schlossberg and Shuford (2005) also see the emancipatory benefits of GIS in this point.

Type of interaction:	*spatial navigation - zoom and focus*
Workshop phase:	*discussion*
Context variables:	*role of the facilitator, composition of stakeholders*
Effects:	*enhancement of minority opinions*
Evidence:	*weak*

g) Multi-dimensional navigation benefits scenario assessment

Scenario navigation, i.e., the combination of spatial, temporal and thematic navigation, has a big potential but could not fully be applied throughout the three cases. The navigation across space, time and theme was not appropriately implemented yet. Neither was the database flexible enough to support on-demand scenario-building. However, the concept seems promising and the experiences are taken up in a prototype interface in the conclusions (chapter 10).

Type of interaction:	*scenario navigation (multi-dimensional navigation), landscape editing*
Workshop phase:	*discussion*
Context variables:	*course of the discussion, role of the facilitator, level of virtuality*
Effects:	*seen as potential, though not yet flexible enough to respond to the discussion*
Evidence:	*weak*

h) Contextualization (multiple windows) through human cognition

The inclusion of indicator and other non-visual data is seen as very promising (Wissen et al., in press). Nevertheless, people do not refer to the non-visual data nor does the information go into any of the outcomes. It may be suggested that the technology is still not sufficient. Furthermore, the benefits of integrated visualizations of indicator and visual data strongly depends on the choice of indicators. As documented in the VisuLands project (Miller et al. 2006), the choice of indicators for this case study needs to be revised. However, the participants assessed integrated visualizations as promising and asked for links to transport and economic data.

Types of interaction:	*combination of realistic landscape visualizations and the visualization of indicator data through hyperlinks or juxtaposition of multiple windows*
Workshop phase:	*discussion*
Context variables:	*presentation techniques, visual variables (color, position etc.), selection of indicators, user preferences, map-reading skills*
Effects:	*participants consider it helpful but there is no evidence of a direct outcome*
Evidence:	*weak*

8.3.2 Interaction effects on the outcomes

Comparing the outcomes of the three cases (table 8.4), cases one and two show a "soft" impact on future stakeholder decisions and behaviour, whereas only the third case results in a "hard" plan outcome. The different context situations are crucial – in cases one and two, homogeneous stakeholder groups met in collaborative workshops to decide in voluntary commitment on their future management strategies. In the third case, a public authority conducted a participation process on the regional forest management plan, an official plan document. The goal of the participation process was to include local knowledge in the plan, to increase its acceptance, and finally, to improve its chances for implementation. In the first and second case, the stakeholders were in agreement beforehand to keep the status quo. However, the facilitator tried to challenge their perspective through external input. In the third workshop, stakeholders with conflicting interests met and it was the objective of the facilitator to reach a consensus among these groups.

Type of interaction		Consensus	Learning
Navigation	Temporal navigation	c2: long-term change of behaviour	
	Overlay	c3: consensus-building among different stakeholders	c3: the iterative construction of overlays supports learning
	Spatial analysis	c1/c2: existing consensus is enriched	c1: learning on climate change impacts investment

Table 8.4: Case-ordered interaction-benefits matrix for the outcomes of collaborative planning.

The matrix shows the relationships of different types of interactions (in ascending order) and their benefits with regard to the outcome of collaborative planning. Negative impact is printed in italics. The cases are abbreviated as c1: tourism, c2: agriculture, c3: forest management plan.

a) Analysis enriches the decision-making process

In two cases, tourism and agriculture, spatial analyses (elevation, slope) were applied on demand during the workshops. In both cases, the analyses results helped understanding and received major responses. In the case of tourism, it is even likely that the elevation analysis influenced the key tourism stakeholder's investment decision. The agriculture case had no measurable outcome, but a long-term change of behaviour and attitudes may occur, although that is impossible to prove with current data. In comparison to the analysis functions of a GIS, the LandXplorer analyses are rather simple and have a higher usability. Among the LandXplorer options, hypsometry (elevation analysis), slope and distance tools were most helpful in the three cases.

Types of interaction:	*interactive analysis, i.e., hypsometry (case one: hypsometry, case two: slope and distance tools)*
Workshop phase:	*discussion, decision-making*
Context variables:	*composition of the stakeholder group, goals and objectives of participation, role of the facilitator*
Effects:	*acceleration of consensus-building through an overlay of stakeholder interests*
Evidence:	*moderate*

b) Contextualization (overlay) accelerates consensus-building

In the third case, the use of the interactive overlay is perceived as helpful in the observations. The facilitator and two of the participants also assess it as very helpful and as accelerating the consensus-building. With regard to the previous discussion on shared mental models, it can be argued that the overlay helps the conflicting stakeholders to get to a shared perception of the problem first (shared mental model), which then leads to a consensus. In the context of collaborative planning, the finding is very important. Unfortunately, it cannot be replicated for the tourism or the agriculture case because those workshops did not reach a clear consensus-building phase.

Type of interaction:	*overlay of stakeholder interests*
Workshop phase:	*decision-making*
Context variables:	*selection of stakeholders, goals and objectives of participation, role of the facilitator*
Effects:	*acceleration of consensus-building*
Evidence:	*weak*

8.4 Discussion of the cross-case analysis results: Assessing the reliability of the case study results

The facilitating effects of interactivity are replicated best in the input presentations of causes of landscape change. For that purpose, interactivity is also an easy way of raising people's awareness – as soon as something moves, the eyes are on the screen. The use of interactive visualization as a means of presentation are well established in other disciplines, e.g., in media psychology, and observed for this case study by Wissen (2007) as well.

The first research question focusses on the benefits of different types of interactions for collaborative planning, so that the benefits for the dialogue are even more interesting. With regard to the dialogue, the study has some very promising results, but these cannot be replicated for all cases. At least in two cases, the facilitating effects of interactivity on the perception of long-term landscape changes were observed. Furthermore, the interactions seem to facilitate the shared building of a mental model best for the forest management plan.

Finally, there are indications for some potentially powerful functions of interactivity, although the evidence is only available for one case. In the tourism case, the facilitator supports the minority position of agritourism by prompting the visualization navigator to zoom into farms for agritourism. In the forest management case, the facilitator even uses the interactive overlay of different interest layers as a catalyst for consensus-building, but these effects cannot be replicated for the other cases because other context factors are too influential. In contrast to the forest management plan, the tourism and the agriculture case do not reach the final decision-making phase. In consequence, there is no test for consensus-building. In the agriculture case, the stakeholder group is more homogeneous than in the tourism case, so that there is no need for minority support. It is suggested that the observed effects, which could not be replicated across the three cases, be tested in future research.

In this setting, the researchers, facilitators and stakeholders had agreed before the workshops that the dialogue must have priority over the visualizations. For that reason, the facilitator had a key position as gatekeeper and he coordinated the use of the tool to a large extent. The visualizations did have a major impact in key moments, but they were not consistently present. In comparison, the visualizations were more at the centre of attention in the workshops analysed in Lange and Hehl-Lange (2005) or by Stock and Bishop (2008). In conclusion, the workshop by Lange and Hehl-Lange (2005) could be described as "visualization workshop". In contrast, this multiple-case study refers to "collaborative workshops with visualization support."

9. Quantitative analysis and results: User preferences

The quantitative survey (see appendix 5 for the full questionnaire) refers to research question two on user preferences for different types of interactions. It was conducted according to the methodological description in chapter 6.4 and produced ordinal ranking data. First, the rankings are described by frequency distributions. Second, the preferences of different groups with regard to gender, age, and map-reading skill, are tested for correlations with the types of interactions. The variables "place of residence", "stakeholder group", and "profession" are not tested quantitatively, because the target population does not provide sufficient subsamples.

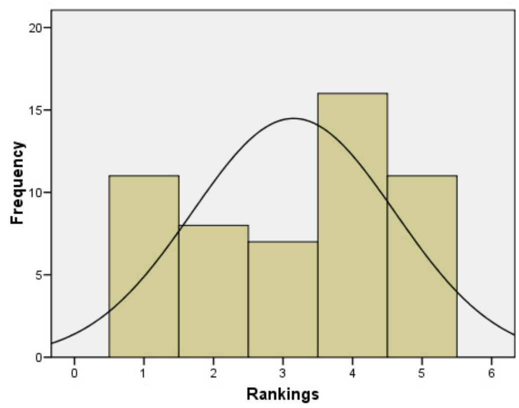
9.1 Quantitative results from the overall ranking

9.1.1 Descriptive statistics

For ordinal ranking data, frequency distributions and histograms are meaningful statistical methods to start with. They provide indications on the ranking order and the distribution. The most positive rank is "1" and the least is "5", i.e., high numbers mean low rankings.

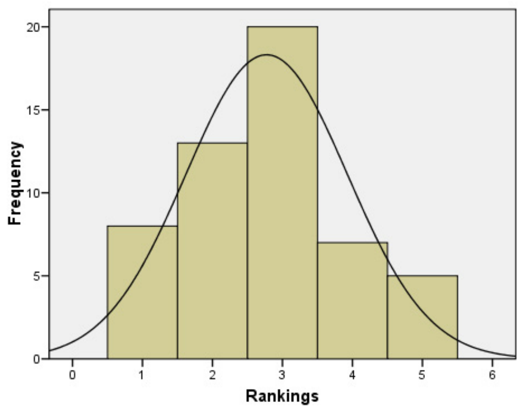
a) Walk-through movement

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	11	20.8	20.8	20.8
	2	8	15.1	15.1	35.8
	3	7	13.2	13.2	49.1
	4	16	30.2	30.2	79.2
	5	11	20.8	20.8	100.0
	Total	53	100.0	100.0	



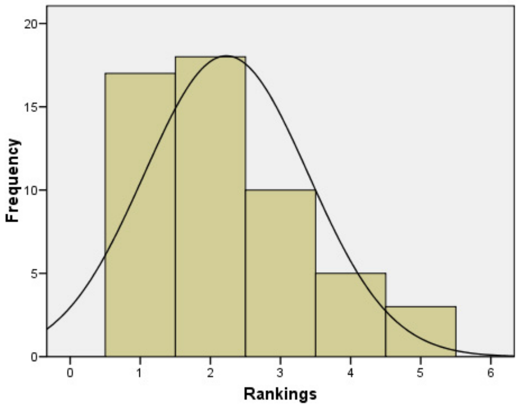
b) Viewing different options

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	8	15.1	15.1	15.1
	2	13	24.5	24.5	39.6
	3	20	37.7	37.7	77.4
	4	7	13.2	13.2	90.6
	5	5	9.4	9.4	100.0
	Total	53	100.0	100.0	



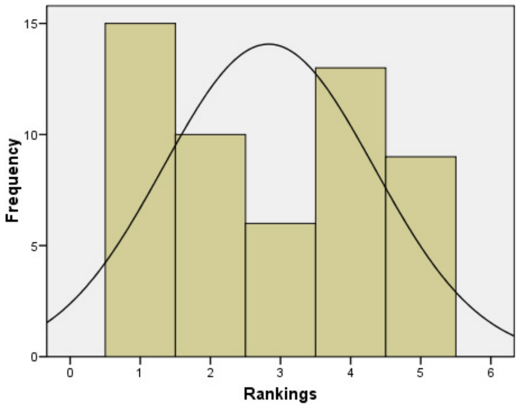
c) Time travel

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	17	32.1	32.1	32.1
	2	18	34.0	34.0	66.0
	3	10	18.9	18.9	84.9
	4	5	9.4	9.4	94.3
	5	3	5.7	5.7	100.0
	Total	53	100.0	100.0	



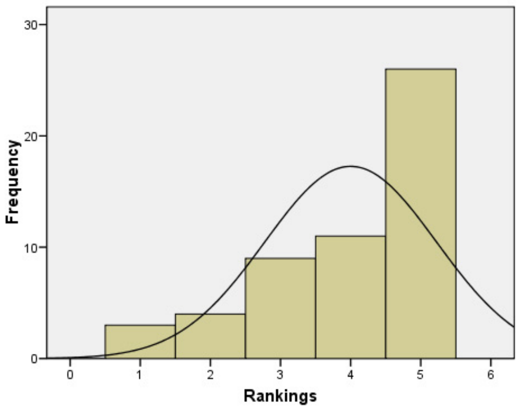
d) Photo-realistic images

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	15	28.3	28.3	28.3
	2	10	18.9	18.9	47.2
	3	6	11.3	11.3	58.5
	4	13	24.5	24.5	83.0
	5	9	17.0	17.0	100.0
	Total	53	100.0	100.0	



e) Inclusion of non-visual information

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	3	5.7	5.7	5.7
	2	4	7.5	7.5	13.2
	3	9	17.0	17.0	30.2
	4	11	20.8	20.8	50.9
	5	26	49.1	49.1	100.0
	Total	53	100.0	100.0	



Tables 9.1a to 9.1e: Frequency distributions of the respondent's preference rankings (rankings on the importance of different visualization features related to interactivity).

Figures 9.1a to 9.1e: Histograms of the ranking frequency distributions.

The overall frequencies are summarised in table 9.2 as percentage values.

Types of interactions	Ranking				
	1	2	3	4	5
Walk-through	20.8%	15.1%	13.2%	**30.2%**	20.8%
Viewing options	15.1%	24.5%	**37.7%**	13.2%	9.4%
Time travel	**32.1%**	**34.0%**	18.9%	9.4%	5.7%
Photo-realistic	**28.3%**	18.9%	11.3%	24.5%	17.0%
Non-visual	5.7%	7.5%	17.0%	20.8%	**49.1%**

Table 9.2: Ordinal ranking order in percentage, n=53. The highest value in each row and each column is printed in bold.

The minimum, maximum, median and mean values are summarised in table 9.3. The median is the ranking number that divides the higher half of the sample from the lower half. For ordinal ranking data, the median is much more reliable than the mean value. Here, the means and their standard deviations are only listed to illustrate the trend.

	n	Min. rank	Max. rank	Median rank	Mean	Std. Deviation
Time travel	53	1	5	**2**	2.23	1.171
Viewing options	53	1	5	**3**	2.77	1.154
Photo-realistic	53	1	5	**3**	2.83	1.503
Walk-through	53	1	5	**4**	3.15	1.460
Non-visual	53	1	5	**4**	4.00	1.225

Table 9.3: Medians of ordinal rankings, n=53.

The medians in table 9.3 show the overall trend, i.e., time travel is the most favoured form of interaction. Both viewing options and photo-realistic (but static) images come second. Walk-through movement is ranked fourth and the inclusion of non-visual information last.

A closer look at the frequency distributions could explain whether the users ranked homogeneously or not. For the frequency distributions of "walk-through movement" and "photo-realistic images", the graphs point to bimodal distributions. That means that the users seem to be polarized in their preferences. Either a user likes this type of interactive visualization a lot or disregards it. In comparison, the other rankings are more balanced.

The graphs of the frequency distributions suggest that "time-travel" and the contextualization of "non-visual" information are not normally distributed; walk-through is barely normally distributed either. This assumption is supported by a Kolmogorov-Smirnov test, which shows significant deviations from normal distribution for time travel and non-visual indicators. Other types of interaction show trends that they are not normally distributed.

One-Sample Kolmogorov-Smirnov Test

		Walk-through	Viewing options	Time-travel	Photo-realistic	Non-visual
N		53	53	53	53	53
Normal Parameters [a,b]	Mean	3,15	2,77	2,23	2,83	4,00
	Std. Deviation	1,460	1,154	1,171	1,503	1,225
Most Extreme Differences	Absolute	,229	,196	,237	,197	,283
	Positive	,143	,196	,237	,181	,207
	Negative	-,229	-,182	-,147	-,197	-,283
Kolmogorov-Smirnov Z		1,667	1,426	1,726	1,433	2,064
Asymp. Sig. (2-tailed)		**,008**	**,034**	**,005***	**,033**	**,000****

[a] Test distribution is normal.
[b] Calculated from data.

Table 9.4: Results from the one-sample Kolmogorov-Smirnov-Test on normal distribution.

9.1.2 Chi-square test

Under these conditions, i.e., ordinal ranking data that is not normally distributed, the non-parametric chi-square (X^2) test and the Mann-Whitney U-test can be applied. These tests have low statistical power, but the conditions for more powerful tests are not fulfilled in this case. The following analysis focuses on the chi-square test. In comparison, the results of the Mann-Whitney U-test are described in Schroth and Schmid (2006) for the same data sample.

The chi-square tests a variable (observed N) for whether its distribution is equal to a user-defined second distribution (expected N). Usually, an uniformly distributed function is used as a second distribution, i.e., the probability of any outcome k_i is *1/n for* $k_1, k_2 ... k_n$. The chi-square value X^2 indicates how far the observed values deviate from the expected values. The higher the chi-square value is, the more the observed N deviate from the expected N. If f_b is the frequency of the observed N, and f_e the frequency of expected N, then the formula for chi-square (X^2) reads as:

$$X^2 = \sum \left(\frac{(f_b - f_e)^2}{f_e} \right)$$

The two-tailed standard derivation (Asymp. Sig. α) indicates whether the difference is significant or not. In this case, the degrees of freedom are equal to the number of ranks minus one. The residuals quantify the deviation of the observed N from the expected N for each rank. According to Bühl and Zöfel (2000: 239), a standardized residual of 2.0 and more (printed in bold in table 9.5) indicates a significant divergence from the expected frequency.

	Walk-through movement		
	Observed N	**Expected N**	**Residual**
1	11	10,6	,4
2	8	10,6	**-2,6**
3	7	10,6	**-3.6**
4	16	10,6	**5,4**
5	11	10,6	,4
Total	53		

	Viewing options		
	Observed N	**Expected N**	**Residual**
1	8	10,6	**-2,6**
2	13	10,6	**2,4**
3	20	10,6	**9,4**
4	7	10,6	**-3,6**
5	5	10,6	**-5,6**
Total	53		

	Time-travel		
	Observed N	**Expected N**	**Residual**
1	17	10,6	**6,4**
2	18	10,6	**7,4**
3	10	10,6	-,6
4	5	10,6	**-5,6**
5	3	10,6	**-7,6**
Total	53		

	Photo-realistic		
	Observed N	**Expected N**	**Residual**
1	15	10,6	**4,4**
2	10	10,6	-,6
3	6	10,6	**-4,6**
4	13	10,6	**2,4**
5	9	10,6	-1,6
Total	53		

	Inclusion of non-visual information		
	Observed N	**Expected N**	**Residual**
1	3	10,6	**-7,6**
2	4	10,6	**-6,6**
3	9	10,6	-1,6
4	11	10,6	,4
5	26	10,6	**15,4**
Total	53		

	Walk-through movement	**Viewing options**	**Time travel**	**Photo-realistic images**	**Inclusion of non-visual info**
Chi-square	4.642	13.698	17.472	4.642	32.189
df	4	4	4	4	4
Asymp. Sig. α	.326	.008	**.002***	.326	**.000****

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Table 9.5: Results of the Chi-square test for the overall sample, n=53. Standardized residual of 2.0 and more are printed in bold. The assumed bimodal distribution of user preferences on photo-realism is highlighted in grey.

The Chi-square test compares the observed ranking data to an uniform distribution. The test results confirm that the rankings of “time travel" are significantly higher than the expected uniformly distributed ranking (α=0.002*). In contrast, the ranking of the "inclusion of non-visual information" receives a significantly lower ranking than the expected uniformly distributed ranking (α=0.000**). The ranking of “viewing different options” is very close to significance (α=0.008) and tends to be higher than the expected uniformly distributed ranking. For “walk-through movement” and "photo-realistic images", sigma is far from significance.

Next, the distributions of "photo-realistic images" and "walk-through movement" are examined in order to say whether they are bimodal. The histogram in figure 9.1 already points to a bimodal distribution. The residuals for “photorealism” (table 9.5) support the assumption of a bimodal distribution, because the residuals are high for both edges of the distribution, for the first and the fourth rank. That means, there are two groups of users, one prefers photorealism a lot whereas the other group rejects photorealism to rank four. Though this finding is not directly related to interactivity, it may help to explain the different impact of spatial and temporal navigation depending on the level of realism (chapters 7.2 and 8).

In contrast, it seems that the user preferences on “walk-through” are not bimodal in this test (table 9.5). The majority of users chose rank four, whereas all other ranking categories received lower results than the expected uniformly distribution. In other words, the function has only one exceptional peak, not two. Overall, preferences for walk-throughs are lower than for “time travel” or “viewing different options” but not as low as they are for the "inclusion of non-visual information".

9.2 Quantitative results on group differences

In order to analyze the correlation between different group variables and the rankings for different types of interactions, Spearman's rank correlation coefficient (Bühl and Zöfel 2000) is calculated for the sample first (calculated in SPSS as "Spearman's rho"). In contrast to other tests of correlation, the Spearman's rank correlation coefficient applies to ordinal rankings. The coefficient assesses how well an arbitrary monotonic function could describe the relationship between a group variable, e.g., age, and a type of interaction, e.g., walk-through movement. The selection of group variables (gender, age, stakeholders/non-stakeholders, map-reading skills) refers to the second research question and the corresponding hypotheses.

In addition to the Spearman's rank correlation coefficient, the overall sample is split according to the hypotheses in chapter 4 and the Chi-square test is applied to the sub-groups. By comparing the sub-groups to each other, the influence of the group characteristic can be estimated. The comparisons are only presented for the impact of the map-reading skills, which show a significant Spearman's correlation coefficient. For all other group variables, neither the Spearman's rank nor the Chi-square tests show any significant results.

9.2.1 Gender

9.2.1.1 Spearman's correlation coefficient

			Walk-through	Viewing options	Time-travel	Photo-realistic	Non-visual info
Spearman's rho	Gender	Correlation Coefficient	-0.090	0.034	0.123	0.017	0.083
		Sig. (2-tailed)	0.000	0.821	0.414	0.911	0.584
		N	46	46	46	46	46

Table 9.6: Spearman's correlation coefficient for the "gender" variable.

26 of the respondents from the overall sample (n=53) are female, 20 are male, and 7 did not answer this question. The Spearman's rank correlation coefficient does not indicate any significant correlation between gender and types of interaction.

9.2.1.2 Chi-square tests of split samples

A split of the sample with regard to gender also does not show any trend or bimodal distribution that differs from the overall results. There is no evidence that gender has an impact on the preference for different interaction types.

9.2.2 Age (or pupils in comparison to market visitors)

9.2.2.1 Spearman's correlation coefficient

In table 9.7, the target group is split into respondents younger than 20 years (n=19) and users, 20 years and older (n=27). This split is almost identical to the distinction between pupils (n=18) and market visitors (n=26), because only one responding market visitor was younger than 20 years.

			Walk-through	Viewing options	Time-travel	Photo-realistic	Non-visual info
Spearman's rho	Age	Correlation Coefficient	-0.125	-0.045	0.224	0.078	0.089
		Sig. (2-tailed)	0.409	0.767	0.134	0.604	0.557
		N	46	46	46	46	46

Table 9.7: Spearman's correlation coefficient for the "age" variable.

The Spearman's rank correlation coefficient does not indicate any significant correlation between age and types of interaction.

9.2.2.2 Chi-square tests of split samples

The sample is tested for users younger than 20 years (n=19) in comparison to users who are 20 years or older (n=27). Similarly, the sample is tested for other age splits, i.e., for groups of respondents younger and older than 30 years and younger and older than 40 years. None of the tests shows a significant correlation different from the overall sample. In other words, both younger and older users rank the importance of walk-throughs equally low. In the qualitative comments, the pupils seem to be even more sceptical about walk-throughs (chapter 9.3). Perhaps the technology lost its “wow effect” for them or they are better prepared to question new technologies. Of course, there might be correlations between age and computer literacy, but none seems relevant for preferences in interaction types.

9.2.3 Stakeholders

Eight of the respondents from the overall sample (n=53) belong to one of the local stakeholder groups relevant for agriculture (landowners, farmers, politicians), 38 do not belong to any stakeholder group (local inhabitants or tourists who are not landowners, farmers or politicians) and seven provided no information on this question. The stakeholder sample is too small to get a significant result and it does not show any noticeable trend. In contrast, the sample of the non-stakeholders reproduces the same results as the overall sample. Therefore, it can be assumed that the overall results represent the preferences of the non-stakeholders.

9.2.4 Place of residence (local knowledge) and profession

The role of local knowledge and profession could not be analyzed because the number of non-local respondents and planning professionals in the target group is too low to fulfill the conditions of the Spearman's rank correlation coefficient.

9.2.5 Map-reading skills

In the first survey question, the respondents were asked to assess their map-reading skills. 28 of the respondents assessed it as very low to little (summarised as “inexperienced map users”), 25 assessed themselves as having some experience up to a lot of experience (“experienced map users”). The two aggregated groups of inexperienced and experienced map users are analysed on significant differences of ranking proportions by Spearman's correlation coefficient and Chi-square tests of the split samples.

9.2.5.1 Spearman's correlation coefficient

			Walk-through	Viewing options	Time-travel	Photo-realistic	Non-visual info
Spearman's rho	Map-reading skills	Correlation Coefficient	0.025	-0.110	-0.094	0.301(*)	-0.278(*)
		Sig. (2-tailed)	0.860	0.436	0.510	**0.030**	**0.046**
		N	52	52	52	52	52

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 9.8 Spearman's correlation coefficient for the "map-reading skill" variable.

For the relationship between map-reading skills and types of interactions, Spearman's correlation coefficient is significant for two features, i.e., "photo-realistic images" and "inclusion of non-visual information".

9.2.5.2 Chi-square tests of split samples

These two features are analyzed in further detail by splitting the sample into a group of experienced map users (self-assessment as very experienced or experienced) and inexperienced map users (self-assessment as no, very low or low experience). For these two subsamples, the frequency distributions are compared to the expected N of a uniformly distributed ranking.

a) Map-reading skills and static photo realistic images

	Photorealism/ Inexperienced map users		
	Observed N	**Expected N**	**Residual**
1	**11**	**5.4**	**5.6**
2	6	5.4	.6
3	3	5.4	-2.4
4	3	5.4	-2.4
5	4	5.4	-1.4
Total	27		

	Photorealism/ Experienced map users		
	Observed N	**Expected N**	**Residual**
1	4	5.0	-1.0
2	4	5.0	-1.0
3	3	5.0	-2.0
4	**9**	**5.0**	**4.0**
5	5	5.0	.0
Total	25		

	Photorealism
Chi-square [a]	8.370
df	4
Asymp. Sig.	.079

	Photorealism
Chi-square [a]	4.400
df	4
Asymp. Sig.	.355

[a] 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 5.6.

Table 9.9: Chi-square test on the ranking of "photorealism" through inexperienced and experienced map users, n=52.

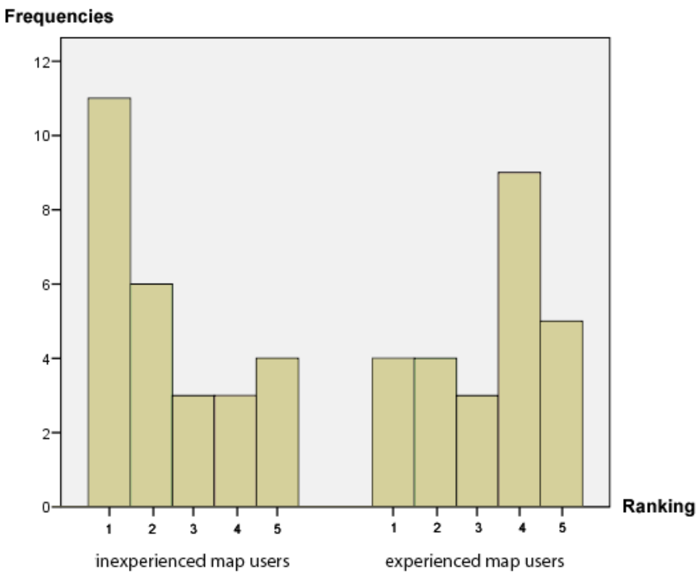


Figure 9.2: Different preferences for static "photo-realistic images" with regard to map-reading skills, n=52.

The inexperienced and experienced map users tend to rank in opposition on photorealistic images. While inexperienced map users rate the photorealistic visualizations very high (11 first ranks, residual = 5.6), the experienced map users rank them rather low (9 fourth ranks, residual = 4.0). The higher the residuals, the stronger the ranking deviates from an uniformly distributed function. The different distributions are illustrated through the comparison of the bar diagrams in figure 9.2. For inexperienced map users, the peak is at the first rank; for experienced map users, it is the fourth.

b) Map-reading skills and the inclusion of non-visual information

The Chi-square test (table 9.10) on the rankings of the "inclusion of non-visual information" as an interactive feature does not become significant for the experienced map users, although it is close (α=0.066). In contrast, the ranking through inexperienced map users is highly significant with α=0.000**. That means that low map-reading skills result in a very low ranking of "non-visual information" and the graph in figure 9.3 illustrating this relationship clearly.

	Non-visual information / Inexperienced map users		
	Observed N	Expected N	Residual
1	2	5.4	-3.4
2	2	5.4	-3.4
3	1	5.4	-4.4
4	5	5.4	-.4
5	**17**	**5.4**	**11.6**
Total	27		

	Non-visual information / Experienced map users		
	Observed N	Expected N	Residual
1	1	5.0	-4.0
2	2	5.0	-3.0
3	8	5.0	3.0
4	6	5.0	1.0
5	8	5.0	3.0
Total	25		

	Inclusion of non-visual information
Chi-square [a]	35.929
df	4
Asymp. Sig.	**.000****

	Inclusion of non-visual information
Chi-square [a]	8.800
df	4
Asymp. Sig.	.066

[a] 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 5.6.

Table 9.10: Chi-square test on the "inclusion of non-visual information" for inexperienced map users (left) and for experienced map users (right).

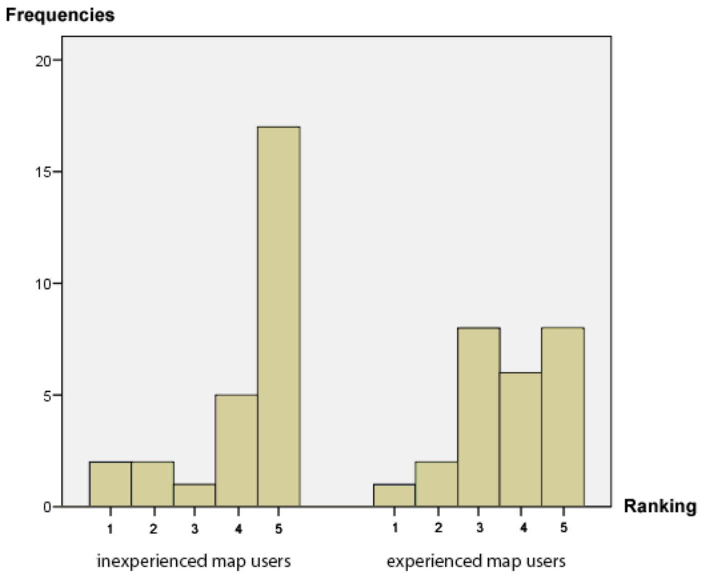


Figure 9.3: Different preferences for the "inclusion of non-visual information" with regard to map-reading skills, n=52.

9.3 Qualitative results from the open-ended questions

From the comments that refer to the landscape visualizations, about 60% are positive, 30% negative and 10% address neutral issues. Either the sample group is more critical than the stakeholders or the anonymous survey environment enabled respondents to express criticism more easily than in the group discussions. The research database contains a complete set of comments from the open-ended questions in German and an English summary.

9.3.1 General comments: Facilitating the imagination and perception of landscape change

The majority of exhibition visitors assess the interactive landscape visualizations as more "catchy" and "entertaining" than maps. Two previously identified benefits of landscape visualizations are highlighted by various comments and both are related to interactive navigation. 21 comments state that the landscape visualizations (a timeline animation was shown to the respondents) help viewers perceive landscape change. 19 comments say that the landscape visualizations (temporal navigation/time progression and spatial navigation/pedestrian navigation, see figure 6.7 in chapter 6.4) facilitate people's imagination.

> *"Durch den Zeitraffer sah man die Veränderung sehr gut."*
> *"Because of the time-progression, the change was easy to see" (pupil, P14; 47:47).*
>
> *"Die Leute können sich besser vorstellen, was passiert, wenn man eine bestimmte Entscheidung trifft und welche Gebiete es betreffen würde" .*
> *"The people can better imagine what will happen if a certain decision is made and which areas would be affected" (pupil, P16; 58:58).*

Although some respondents doubt whether the effort is worth the benefit, most agree that landscape visualizations have an impact on discussions and decision-making. Three respondents refer to the visualization function of providing all participants with a shared image.

> *"Es entstehen gemeinsame Bilder und somit ist die Diskussion auch klar definiert (alle sprechen vom Gleichen)."*
> *"Shared images emerge and, therefore, the discussion is clearly defined (all are talking about the same thing)" (local exhibition visitor P16; 12).*

The quote supports the findings from the qualitative case studies that interactive visualizations help in the construction of a shared mental model. It may be concluded that the contributions to both individual and group knowledge building and consensus-building is recognized as high. Furthermore, a couple of comments highlight that the visualizations help in forming opinions:

"Hilfreich meine eigene Meinung zu bilden, losgelöst von politischer."
"Helpful in forming my own opinion, independent of political stands" (local exhibition visitor, P14; 34:34).

Most respondents agree that any image could be manipulated and, therefore, judge the credibility of the underlying data and the credibility of the visualization authors rather than the image itself.

"Das System ist nur glaubwürdig, wenn die Daten glaubwürdig sind."
"The system is only credible if the data is credibile" (local exhibition visitor, P18; 8:8).

"Kommt drauf an, wer sie macht. Politischer Missbrauch?."
"It depends on who makes them. Political misuse?" (local exhibition visitor, P18; 40:40)

As one respondent points out, it is necessary to reproduce the construction of the visualizations if their credibility should be assessed. For this point, more interactivity might facilitate the credibility of landscape visualizations. One respondent (female, 30 to 39 years, no feedback on the profession) adds that the "inclusion of non-visual information" is likely to improve the explanatory power of the visualizations.

9.3.2 Qualitative comments related to user group characteristics

b) Gender

The questionnaires contain no comments that suggest any gender-specific preferences for any type of interaction.

c) Age

On the two questions, of whether users think that computer visualizations will play an important role in landscape participation (B(ii)2), and whether the visualizations are worth the time and money (B(ii3)), one respondent (age category 50-59 years) answers that the tools are more suitable for young people. There are no other comments that refer to age-specific barriers in the use of landscape visualizations. Instead, it is noticeable that the respondents younger than 20 years see the visualizations with more scepticism than the respondents older than 20 years, e.g., by pointing out the threat of potential manipulation and of "apparent realism" (see chapter 3.2.1 in the literature review).

d) Local knowledge

Although the number of non-local respondents is not high enough for any statements on significance, 13 comments refer to the role of local knowledge. These comments follow the two questions on the helpfulness of the maps shown (A4) and the helpfulness of the used visualizations (B(i)4). Six respondents, who ranked both maps and visualizations as not very helpful, explain their answers by their lack of knowledge on the area. In contrast, seven persons, who ranked the helpfulness higher, add that their good local knowledge helped them get oriented. In summary, local knowledge seems to have a strong impact on the helpfulness of both maps and visualizations.

e) Profession (expert and lay people)

For the question on the helpfulness of the landscape visualizations, nine respondents remark that they think landscape visualizations are particularly helpful for lay people. In contrast, two people comment that the landscape visualizations could be helpful, but the content was interesting for planning experts only. In summary, the answers indicate that landscape visualizations may facilitate lay people. However, it is still required that people are interested in the topic – without any interest in planning participation, lay people may not be motivated by landscape visualizations either.

f) Map-reading skills

The qualitative comments provide explanations, of why respondents with high map-reading skills tend to prefer abstract images, whereas respondents with low map-reading skills tend to prefer photo-realistic images. Thirteen respondents comment that the photo-realistic images facilitate their imagination of the landscape and understanding of the images. In general, these respondents rank their own map-reading skills as rather low.

In contrast, five respondents, who assess their map-reading skills as moderate to high, comment that the maps were clearer to them than the photo-realistic visualizations. Interestingly, four out of these five respondents are pupils. Therefore, the comments are also contrary to the assumption (e.g., in Petschek 2005) that young people generally prefer computer-generated images to maps.

> *"Karten sind übersichtlicher, Visualisierungen 'lebensechter'."*
> *"Maps are clearer, visualizations are more lifelike" (journalist, high map-reading skills, P15; 31:31).*

> *"Ich konnte die Veränderung bei der Visualisierung besser vorstellen, wurde aber auch mehr von Details, die auf der Karte nicht zu sehen sind, abgelenkt."*
> *"For me, it was easier to imagine the change in the visualizations, but I was more distracted by details, which are not in the map" (pupil, moderate map-reading skills, P15; 57:57).*

g) Other factors: Computer literacy

Three respondents point to the role of computer literacy. One of the pupils responds that he won't use the interactive landscape visualizations, because he is not interested in computers. A woman between 20 and 29 years, no feedback on her profession, prefers visualizations to maps, but she doesn't feel computer literate enough to interact with them on her own. A third respondent points out that he only trusts the computer visualizations because he feels computer literate.

9.4 Discussion of the survey results

9.4.1 Limitations of the survey method and setting

The survey is subject to a number of limitations. First, not all group variables are analyzed because there were not enough non-locals or enough professionals to fulfill the statistical requirements of the Chi-square test. Second, the survey was conducted as part of the related VisuLands project, so that there was not full control of the research design, but rather the result of an international workshop with stakeholders from all VisuLands case study sites. The differences between the questionnaire terminology and the general terminology in this thesis are translated in table 9.11:

Questionnaire terms	Case study terms
Walk-through movement	Spatial navigation
Time-travel	Temporal navigation
Viewing different options	Scenario navigation
Inclusion of non-visual information	Contextualization

Table 9.11: Terminology of the questionnaire in comparison to the case study terms.

Third, the questionnaire was part of a simulated participation process. Nevertheless, the respondents were asked to answer as if in a real planning process, but it might be possible that users will act differently under true collaborative conditions. All answers represent self-assessments by the respondents, i.e., how do they assess their map-reading skills or which type of interaction do they prefer. The response was not measured as it would be done in an experimental research setting. Fourth and most important, the results are only valid for the scale and issues of the planning task in this particular questionnaire.

9.4.2 Discussion of the ranking results

The low ranking of the **"inclusion of non-visual information"**, or contextualization as it is called in the case studies, is surprising but well documented through significant and highly significant values. The result is even more surprising because in the case studies, many stakeholders explicitly asked for the inclusion of non-visual information. The analysis of group differences (chapter 9.2) provides a hint, as to why contextualization is ranked so low. The overwhelming majority of respondents, who assess their map-reading skills as low, rank “inclusion of non-visual information” last (α=0.000**), whereas experienced map users rank it slightly higher on average. It has to be concluded that this visualization type is preferred by experienced map users. It has to be pointed out that the absolute user preference for the inclusion of non-visual information could still be positive, although the feature is ranked last. The different types of interactions were only ranked in comparison to each other, not in absolute terms.

"**Walk-through movement**" (real-time navigation in the case studies) is ranked fourth, although it is important in the qualitative study. However, real-time navigation serves different purposes in the workshops than in the questionnaire. While the workshop facilitators use realtime navigation to show specific views in response to the dialogue, the survey focuses on movement as part of landscape perception. The qualitative comments from the survey show that movement facilitates people's imagination. However, the three factors "scale", "planning issue", and "level of realism" need to be considered as important variables, too (Ervin, personal communication). The larger the scale of landscape change, the more suitable the representation through maps may become. The quotes show that the size of the Sörenberg valley (40 km^2) is at the upper limit of landscape visualizations. It is just possible to show the entire Sörenberg valley from a viewpoint on top of the Brienzer Rothorn mountain or to move through the real-time model with the equivalent speed of a car. A real-time flight through the whole valley is eye-catching, but if the whole valley should be covered, it is too fast to identify details (see chapter 7.2). In conclusion, visualizations of small areas in landscape architecture (Kretzler 2005) may benefit more from walk-through movement than the visualization of large areas for regional planning used in this survey.

The ranking of **"photo-realistic images"** shows a clear bimodal distribution. Either a respondent ranks photorealism very high or very low. Again, map-reading skills seem to have a strong influence because inexperienced respondents prefer the realistic images to the abstract ones. As a consequence, it may be suggested to use interactions in combination with a high level of realism if working with lay people (as suggested by Paar 2006). In contrast, experienced map users are more likely to prefer interactive visualizations on an abstract level. In this context, appropriate customization features (see chapter 3.5) could prove valuable.

"Time-travel" (temporal navigation in the case studies) receives the significantly highest ranking. This result matches the comments from the qualitative documentation: “At a glance, I was able to imagine how the change will take place” (questionnaire participant, translated from German). Of course, the high benefit of this type of interaction is related to the use of a planning topic that addresses long-term landscape changes. Nevertheless, the high ranking throughout all groups shows that the form of temporal navigation presented meets the preferences of public users and is appropriate to address issues of long-term landscape change.

9.4.3 Discussion of user group preferences

The hypotheses that user groups vary in their preferences for different types of interaction by **place of residence** could not be tested through this survey because the subsamples were not large enough to be statistically significant. However, the qualitative comments to the open questions indicate that it makes a big difference how well the users know the area in the use of both map and landscape visualization. The hypothesis that user groups vary in their preferences by **profession** (expert and lay people) could not be tested either. The comments indicate that many users think that realistic landscape visualizations were particularly helpful for lay people.

The hypotheses that user groups vary in their preferences for different types of interaction by **gender** or by **age** are tested but they are not verified by this survey. Except for one critical comment in the "open questions" section, there are no indications that either gender or age has an impact on user preferences for different types of interactions. Therefore, the supposition in Schroth and Schmid (2006) that the "Generation Playstation" (Petschek 2005) may rank walk-through movement higher than older users, because young people are more used to virtual reality, could not be validated. However, the comments indicate that the computer literacy of the users might play a role. It is suggested that testing computer literacy as a variable on its own in future surveys would be useful.

The relationship between map-reading skills and user preferences is perhaps the most interesting result. Spearson's correlation coefficient shows a significant relationship between map-reading skills and the "**inclusion of non-visual information**". The Chi-square tests of the split sample show that users who assess their map-reading skills as low also rank the inclusion of non-visual information low. That means that the interactive combination of landscape visualizations and diagrams of non-visual information may require high map-reading skills from the user. Perhaps, the argument (discussed in Wissen et al., in press) that landscape visualizations enable lay people to combine visual and non-visual assessments of landscape change needs to be rethought. It seems that users with good map-reading skills benefit more from this type of interactive landscape visualizations.

Spearson's correlation coefficient also shows a trend to significance for "**photo-realistic images**". Here, the Chi-square tests of the split sample indicate that the users with low map-reading skills tend to rank photo-realistic images higher than might be expected from an uniformly distributed sample. In contrast, the users with high map-readings skills rank the photo-realistic images lower. Such a correlation could explain the bimodal distribution of very high and very low rankings of the photo-realistic images. The finding is supported by the qualitative comments, which are either in favour of photorealism or sceptical. The sceptical comments refer particularly to the advantages of maps, which are said to be clearer and less ambiguous.

10. Conclusions and recommendations

Although interactivity is seen as an important asset of landscape visualizations, the literature provided little scientific evidence on the role that interaction plays in the application of landscape visualizations as a tool for collaborative planning. Even less evidence was documented on the impact that landscape visualizations actually had on the outcomes from participation practice. This thesis has addressed the benefits of interactivity from a planning perspective and from the user perspective. The first question asked: How far do interactions improve the qualities of the collaborative planning process and outcomes? On basis of the results, recommendations are given for the application of the tools in planning and for future research. The second research question asked whether preferences for different types of interactions can be identified among different user groups. The results for the second question provide an alternative perspective on the benefits of interactivity and enhance the user-centred development of tools.

10.1 Benefits of interactivity in collaborative planning

10.1.1 The benefits of interactions for the qualities of collaborative planning

The first research question on the benefits of interactivity refers to the hypotheses in chapter 4.1. In the following, these hypotheses are validated with regard to the multiple-case study results. The resulting propositions contribute to theory-building and show which functions specific types of interactions can fulfill in collaborative workshops.

a) Inclusiveness (process)

Hypothesis: Interactivity facilitates an inclusionary participation process.

- The hypothesis is supported, but the results cannot be replicated for all cases.

Of course, inclusion as a democratic demand in participation (cf. Healey 1997; 2003) cannot be ensured by technical means only. The effectiveness of interactive landscape visualizations as a tool for inclusiveness is affected by the role of the facilitator, the map-reading skills of the target groups, the virtuality of the landscape visualizations and other factors.

It has been argued that new groups of participants, e.g., young people, could eventually be motivated to participate by raising their attention through interactive landscape visualizations. However, the participants in the case studies were all recruited from the previous forum work, by newspaper announcements and personal invitation. The study does not provide any evidence that participants came particularly because of the interactive landscape visualizations. Neither does it provide strong evidence that the interactive tools imposed a barrier to specific participant groups. However, the visualization navigator mediated the human-computer interactions, so that people with low computer literacy had an equal chance to participate. Sporadic quotes from the survey indicate that computer literacy might play a role, if people interact directly with the computer.

During the workshops, interactive landscape visualization can be a tool for the facilitator to raise people's awareness of specific topics as all movement immediately draws attention. In the discussion of the tourism case, the interactive zoom into farm house locations drew the attention to agritourism, which had previously been neglected by the stakeholders from winter tourism. In conclusion, it may be suggested that spatial navigation can support minority opinions in order to compensate information or power disparities.

Propositions 1 and 2

Spatial navigation clearly raises awareness through the creation of movement.

Spatial navigation may enable the facilitator to support minority opinions through focussing on specific areas and themes.

b) Enrichment (process)

Hypotheses: Interactivity enriches two-way information on landscape processes and change. Interactivity enriches the factual dimension of information on landscape change. Interactivity enriches the emotional dimension of information on landscape change.

- The multiple-case study provides strong evidence supporting these hypotheses.

The level of enrichment not only depends on the type of interaction, but also on the level of virtuality, map-reading skills, the participation process, the planning task and the presentation. Especially the level of realism seems to have a strong impact (cf. Wissen, 2007). Depending on the level of realism, **spatial navigation** can either enrich the imagination of the visual landscape emotionally, or the understanding of topographic features in a more rational way. However, it is suggested to use spatial navigation carefully, because it easily distracts people if applied at the wrong moment.

Propositions 3 and 4

Spatial navigation in combination with an abstract representation can illustrate topographical landscape features and facilitate more rational responses.

Spatial navigation in combination with a photo-realistic representation can illustrate topographic landscape features and facilitate more emotional responses.

Similarly, the effect of **temporal navigation** depends on the level of realism so that time sequences can either enrich the perception of a long-term landscape change emotionally, or the understanding of landscape processes in a more rational way. Usually, a more rational perception is regarded as more scientific and less biased than an emotional one. However, there are specific tasks and situations in planning when more emotional responses can be useful, e.g., for motivation.

Interestingly, a low level of interactivity, i.e., the simple animation of a series of images, was already sufficient to communicate landscape change in the agriculture case study. The landscape change can either be historical or in the future.

Propositions 5 and 6

Temporal navigation in combination with an abstract representation can illustrate landscape processes and facilitate more rational responses.

Temporal navigation in combination with a realistic representation can illustrate long-term landscape change and facilitate more emotional responses.

The simple spatial hypsometry, slope and distance analyses proved practicable. In the case studies, the issues of land abandonment and climate change are good examples, in which two causes of landscape change were explained by spatial analyses.

Proposition 7

Simple spatial analysis clearly enriches the discussion of causes of landscape change.

Participants of the case studies requested the inclusion of additional non-visual indicators. In response, landscape visualizations and non-visual indicators were linked through contextualizing interactions, e.g., hyperlinks. However, according to the quantitative survey, the inclusion of non-visual information is less suitable for inexperienced map users than it is for users with good map-reading skills. The low ranking may also suggest that the selection of non-visual indicators or the design of the indicator visualizations may need to be improved (cf. Wissen et al., in print).

c) Dialogue (process)

Hypothesis: Interactivity facilitates engagement and dialogue.

- The multiple-case study provides strong evidence supporting this hypothesis.

The multiple-case study shows that interactive navigation is a necessary requirement for a facilitator to be able to respond to individual stakeholder needs immediately and to enable an open-end collaborative planning process. Inherently, the nature of the planning task and its spatial relevance, the participation process, the role of the facilitator, and the presentation are closely related external variables. The parallel interactive visualizations illustrate the dialogue and locate arguments in space. Thereby, interactivity fulfills the important function of creating a shared perception, which facilitates the construction of a shared mental model. Fast navigation metaphors (zoom, focus, trackball) are best suited to respond to the stakeholder dialogue in time. However, truly interactive scenario-building on demand was not possible because the database was too limited and the landscape editing functions were not flexible enough.

Propositions 8 and 9

Spatial navigation, especially on basis of focus, zoom, and click-and-fly metaphors, can support the use of landscape visualizations as a tool for dialogue.

Collaborative interactive visualization can facilitate the construction of a shared mental model among a stakeholder group through the provision of a shared perception.

d) Credibility (process)

Hypothesis: Interactivity increases the credibility and transparency of landscape visualizations.
- The hypothesis is supported, but the results cannot be replicated for all cases.
Throughout all cases, manipulation has been a common concern in relation to landscape visualizations. However, the majority of stakeholders are aware that any type of visualization may be used in a manipulative way. Therefore, it is not the technical nature of the visualizations, but trust in data and institutions or persons that are crucial criteria for credibility. Within this context, the interactive reconstruction of landscape visualizations and participatory mapping may increase the transparency of the visualization process.

Proposition 10

The interactive reconstruction of landscape visualizations through spatial analyses and participatory mapping can increase the transparency of the visualization process. The credibility of the visualizations is determined more by the context factors.

e) Consensus (outcome)

Hypothesis: Interactivity helps build consensus among stakeholders with different interests and different perceptions.
- The hypothesis is supported, but the results cannot be replicated for all cases.

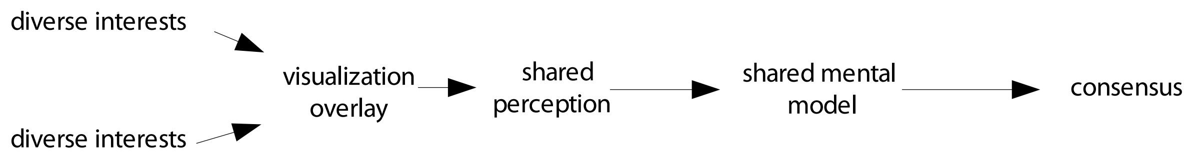


Figure 10.1: The acceleration of consensus-building through the construction of a shared mental model with the help of interactive layers.

Consensus-building strongly depends on external human variables such as the selection of stakeholders, the level of participation, goals and objectives of participation, and the role of the facilitator. Within this context, the conflict can be narrowed down by mapping it in the first place. Then, the interactive overlay of divergent stakeholder interests accelerates the consensus-building process as in the forest management plan. Here, the successful application took place for a spatial conflict of interests on a low intensity level. The landscape visualizations were not applied in the very emotional conflict on barkbeetle damage. Therefore, the multiple-case study cannot give any suggestions as to whether the tools are suitable for the mediation of highly controversial conflicts.

Proposition 11

Consensus-building processes can be accelerated through the interactive overlay of conflicting interests.

f) Learning (outcome)

Hypothesis: Interactivity facilitates collaborative learning from landscape visualizations.

- The hypothesis is supported, but the results cannot be replicated for all cases.

The learning outcome is affected by the presentation, user skills and other context factors. In this context, interactions with the landscape visualization can foster learning effects. Through the interactive elevation analysis of rising snow lines in the tourism case, the stakeholders learnt about the future impact of climate change and rethought their future investments. In the agriculture case, learning was facilitated through temporal navigation and through collaboratively applied analyses. The facilitator even thought that the temporal navigation between realistic scenario visualizations of forestation might have caused a long-term change of behaviour among the farming stakeholders towards more sustainable management practices. Additional research is needed to prove the assumption because it is not supported by other observations or participant interviews.

Proposition 12

Interactive navigation and analyses can facilitate collaborative learning.

10.1.2 User group characteristics and preferences for different types of interactions

Hypothesis: User groups vary in their preferences for different types of interactions by their gender or age.

- The quantitative survey provides no indications to support this hypothesis.

The survey does not show any correlation between the preferences for different types of interactions and age or gender. However, it is possible that a larger sample will reveal correlations, especially because the qualitative comments in the survey indicate a relation between user preferences and their computer literacy, which again is likely to be correlated to age.

Hypothesis: User groups vary in their preferences for different types of interactions through their knowledge of the area or by their profession.

- The hypotheses cannot be tested in the survey because the subsamples of non-locals and of planning professionals are too small.

Although the hypothesis cannot be tested by quantitative measures, the qualitative comments suggest that a good knowledge of the area facilitates the interaction with landscape visualizations.

Hypothesis: User groups vary in their preferences for different types of interactions through their map-reading skills.

- The quantitative survey verifies this hypothesis for two types of interactions.

The quantitative survey shows a correlation between the user's map-reading skills and their ranking of photo-realistic images and the inclusion of non-visual indicators (contextualizing interactions). Inexperienced map users seem to rank photo-realistic images higher than experienced map users do. The inexperienced map users explain that the photo-realistic images help them imagine the landscape. However, some experienced map users rank the photo-realistic images lower because they feel confused by the high amount of detail. The inclusion of non-visual indicators is ranked slightly higher by experienced map users than by inexperienced ones. This may be the case because indicator diagrams require skills that are similar or included in map-reading skills.

Propositions 13 and 14

Users with low map-reading skills tend to prefer photo-realistic landscape visualizations. Users with high map-reading skills tend to prefer more abstract landscape visualizations.

Users with high map-reading skills benefit more from the inclusion of non-visual indicators in landscape visualizations than users with low map-reading skills.

10.2 Recommendations for workshop facilitators and visualization navigators

10.2.1 Workshop preparations

The use of interactive landscape visualizations in workshops still requires considerable preparations and sufficient resources in time, data, know-how, hardware and software. In particular, the objectives of the participation process, the level of participation, the planning topic, and the target user groups need to be considered when preparing the visualizations. The importance of the user's map-reading skills has been highlighted in the previous paragraphs.

Technologically, two factors are crucial. First, a well-prepared geodatabase is essential for the credible conduct of interactive landscape visualizations. Second, interaction design (Buurmann 2005) will certainly gain in importance. As described in the literature review, interaction design means that not only does the representation needs to be designed, but also the interactions, e.g., the interaction metaphors.

10.2.2 Workshop setting

The technical setting of the workshop requires more attention than a traditional workshop because the hardware and display, seating and lighting have to be considered. The technical hardware requires sufficient time for the setup, cables and transport. In collaborative planning, it is preferable to bring the workshops to the people, so the hardware has to be mobile. If a highly emotional involvement of the participants is intended, it might be worth choosing an immersive panorama display to intensify the effect of the visualizations. As the forest management workshops showed, the technical setup also determines the area in which the facilitator moves. In the last forest management workshop, the facilitator worked much more with the visualizations, but he also had a smaller operating radius.

In the subject of seating, there is a conflict between the needs of collaborative planning, which benefits from communicative settings like a U-shaped or round table, and seating that is oriented towards the screen. In these case studies, U-shaped seating has proved the best compromise. Similarly, there is a conflict around lighting because projected landscape visualizations are viewed best in a darker room, whereas bright lightening supports the atmosphere of a transparent and equal dialogue. Here, it is suggested to change the lighting with regard to the workshop choreography as was done in the second agriculture workshop.

10.2.3 Workshop choreography

It has been argued controversially whether the human-computer interactions should be direct or mediated (Lovett, personal communication). In the multiple-case study, which focuses on face-to-face collaborative workshops, mediated interactions proved to be successful. People with diverse levels of computer literacy could participate equally. In the case studies, the workshops were very much guided by the facilitator. With mediated interactivity, the facilitator can easily integrate the visualizations into the workshop sequence. It might be suspected that the workshop is more difficult to facilitate if all participants interact on their own. However, it may be argued that the participants can only interact self-directed if they have direct control of the landscape visualizations. In future research, it will be interesting to compare settings with mediated and direct interactivity each other.

In general, coordination with the facilitator and a careful consideration of how the interactive features are presented are crucial. Above all, it must be considered that interactions take time and in many participation processes, time is a rare commodity (cf. Salter et al., unpublished). In the worst case, the inappropriate use of interactions might even distract the discussion process. In these case studies, the facilitator was responsible for the workshop choreography. Although this hierarchy might have biased the visualization use towards the facilitator, it was ensured that the dialogue had priority over the visualizations.

The visualization navigator not only needs to be an expert in landscape visualization, but the navigator should also know the area and the topic to be able to respond to requests. It might be helpful if the visualization navigator provides suggestions for specific visualizations. However, it has to be clear that it is an external input in order to avoid charges of manipulation. Finally, it has to be considered that interactivity increases the cognitive load of landscape visualizations in comparison to static images. Therefore, it is a key task of the visualization navigator to limit the additional cognitive load as much as possible, while ensuring understanding and orientation. Table 10.1 lists potential means for supporting people in understanding interactive landscape visualizations.

Objective	Means of assisting interaction
Support orientation	• Use of landmarks • Use of overview orientation maps
Avoid cognitive overload	• Avoid details of information that are not necessary for the discussion • Turn-off interface elements, which only the visualization navigator needs • Avoid abrupt cuts • Limit the use of multiple windows
Support understanding	• Construct landscape visualizations iteratively • In temporal navigation, go backwards and forwards • In scenario navigation, toggle between different scenarios • Give verbal explanation and integrate complementary media if possible
Support dialogue	• Adopt the visualization tempo to the discussion tempo • Provide the visual feedback immediately

Table 10.1: Means of assistance available to the visualization navigator.

10.2.4 Functions of different types and levels of interaction in the workshop

For future work, table 10.2 (inlay) provides suggestions on how different types of interactions can be assigned to the various workshop phases. The table is best used in combination with the practical advice by Warren-Kretzschmar (2007), von Haaren (2005) and Wissen (2007). Above all, it is important to consider the workshop context, the level of participation, stakeholder selection, and the planning topic under discussion beforehand. Although the preparation of visualizations is case-specific, in general the "code of ethics" (Sheppard 2001; 2005c, chapter 2.3.4) should be considered in order to ensure the credibility and transparency of the visualizations.

Interestingly, a high level of participation does not necessarily require a high level of interactivity. In the case studies, the rather simple temporal animations already facilitated the discussion of landscape change over a long time period very well. A high level of interactivity is linked to a high level of complexity and could impose additional barriers to the users. Therefore, too complex analyses should be reserved for experts (cf. Schneider 2002). However, the scenario phase (c) does require a high level of interactivity and a range of different types of interaction in order to allow the necessary flexibility to respond to the discussion.

a) Input phase

The input phase of the workshop can be opened by a real-time flight or walk-through of the area of interest to raise people's awareness and to make them familiar with the major spatial characteristics of the area. If the external input refers to specific locations, it is recommended to focus on these in parallel. Additional layers of information should be activated iteratively, e.g., layers on zoning regulations. If the input presentation refers to spatial analyses, the parallel reconstruction of the analyses facilitates the learning impact more than the plain presentation of analysis results. In the multiple-case study, the application of hypsometry analysis (elevation), slope and distance tool proved practical. Historic as well as future processes are represented very well in rather simple time steps. The comparison of different time steps benefits considerably from alternately going back and forth.

b) Brainstorming

During brainstorming, people should not be distracted from the group work. For that reason, the facilitators in the case studies suggested already presenting visual input during the previous input phase. The procedure has proved successful, although it could be interesting to test more visual brainstorming techniques in the future.

c) Scenario discussion

The third phase, the scenario discussion, provides the greatest potential for interaction with landscape visualizations. At the same time, this phase is the least fixed and, therefore, the most challenging for the visualization navigator. It is also the most demanding in terms of the level of interactivity and the level of complexity. The whole diversity of interactions should be used to response flexibly to the course of the discussion. If the stakeholders refer to a specific location, the visualization navigator should focus on this location and zoom it in. The use of the zooming function is good to put detailed measures into their broader context, e.g., by starting in the map view and zooming into the human perspective. If the stakeholders develop scenarios, the visualization navigator may show the visual impact through overlays, spatial analyses and landscape editing. The documentation functions are important to place ideas in the landscape model. If intelligent landscape models become available in the near future, the stakeholders may also test alternative scenarios with different parameters.

d) Decision-making

During the final decision-making phase, the stakeholders may come back to the developed scenarios and its visual documentation. In this case, the scenario navigation should be used to facilitate the assessment of alternative scenarios. The comparison of different scenarios benefits from repetitions and toggling between alternatives and different time steps. Here, overlays can also be a valuable tool to put different layers of information into context to each other. Such layers of information could show the existing zoning and alternative building proposal for example. If available, additional indicator data might be linked through hyperlinks or in an additional window.

Functions in the participation process	Phase	Recommendations for the visualization navigator	Appropriate interactions								
			Scenario navigation			Overlay	Indicator link	Spatial analysis	Land-scape editing	Documentation	Customization
			spatial	temporal	thematic						
Inclusiveness											
Raising awareness	all	• Any movement or dynamics	X	X	X						
Motivation of discussions on local issues	all	• Opportunity to navigate to individual locations on demand	X	X	X	X					
Support of minority opinions	discussion	• Focus on minority interests spatially	X	X	X	X					
Enrichment											
Support the perception of the visual landscape and facilitate more emotional response	all	• Walk or fly through the area in a high level of virtuality • Show spatial context of the location from various perspectives	X								X
Support the perception of topographic landscape features and facilitate more rational response	all	• Explore spatial structures in a more abstract landscape model	X								X
Support the perception of long-term landscape change and facilitate more emotional response	all	• Time progression of long-term landscape changes in combination with a high level of virtuality and realism		X							X
Support the understanding of landscape processes and facilitate more rational response	all	• Time progression of long-term landscape changes in combination with an abstract representation		X							X
Illustrate drivers of change	input	• Hypsometry, slope and distance analyses; overlays	X	X	X	X	X	X			
Comparison of alternative development scenarios	decision	• Toggle between alternative scenarios	X	X	X	X	X	X	X		
Communicate uncertainties	decision	• Distinguish different certainties by different levels of realism				X	X	X			X
Integration of the visual landscape and landscape indicators	all	• Link landscape visualizations to indicator diagrams			X	X	X				
Dialogue											
Collaborative scenario-building	discussion	• Flexible mix of interactions with an open-ended outcome	X	X	X	X	X	X	X	X	X
Facilitate a shared perception and the construction of a shared mental model	all	• It is essential that the tempo of the visualizations fits to the tempo of the discussion and that immediate visual feedback is provided	X	X	X					X	
Localize and document contributions in their spatial context	all	• Zoom and focus in response to the dialogue • The bigger the group is, the more difficult the process gets	X							X	
Credibility and Transparency											
Enhance credibility and transparency	all	• Interactions need verbal explanation • Provide diverse perspectives and time steps • Shared reconstruction of visualizations through analyses • Participatory mapping	X	X	X	X	X	X	X	X	
Consensus											
Facilitate consensus-building among stakeholders with different interests and perceptions	decision	• Provide a shared image • Overlay of different interests	X		X	X					
Learning											
Collaborative learning	all	• Interactive analysis or experimentation					X	X		X	
Long-term change of behaviour	input	• Spatial, temporal and scenario navigation plus a high level of virtuality	X	X	X		X				X

Table 10.2: Functions of interactions with landscape visualization in collaborative planning. The workshop phases are in the following order: input – brainstorming – discussion – decision-making phase.

10.3 Recommendations for software developers

a) Need for multi-dimensional GIS

Current GIS software does not provide sufficient structures to manage multi-dimensional scenario data. Today, the organisation of temporal data in a GIS is just in its beginnings and alternative timelines are even more difficult to manage. Flexible scenario navigation will require a more appropriate geodatabase structure that supports alternative storylines and different time steps for one location, e.g., by indexing data not only spatially but also with time stamps.

b) Need for interactive adjustable levels of realism

In computer visualization, the research in non-photorealistic rendering styles (see chapter 3.3.1) is promising. Different shaders allow the rendering of landscape visualizations in real-time and for different levels of realism, all from the same database. As the multiple-case study showed, spatial and temporal interactions can have very different effects, depending on the level of realism. Furthermore, an interactive adjustable level of realism could be used to distinguish different levels of certainties and different stages in the design process. Finally, the survey showed that users with different map-reading skills prefer different levels of realism. Interactively adjustable levels of realism could make it possible to respond to these diverse needs in landscape planning.

c) Need to integrate spatial and temporal navigation metaphors

The spatial navigation metaphors of the LandXplorer software already work sufficiently. For temporal navigation, the rather simple timeline metaphor, implemented as an interactive prototype, worked very well, too. It is suggested that such a feature will be included in future LandXplorer versions. The focus navigation metaphor was already implemented in the LandXplorer software during the course of this research in response to the iterative exchange between software developers and researchers.

d) Need to improve the interactive links between landscape visualizations and indicator data

In interaction design, further research is needed on appropriate metaphors for the integration of landscape visualizations and indicators (cf. Wissen et al., in print). The main argument is that it allows a more balanced assessment of the landscape. However, the survey showed that users with low map-reading skills rank this type of interaction significantly lower than other types. Therefore, it is suggested that visualization and interaction approaches be developed that are easier to understand without good map-reading skills.

10.4 Recommendations for landscape visualization researchers

a) Continue transdisciplinary case study research on landscape visualization in practice

In the multiple-case study, the use of interactive landscape visualizations as a tool for dialogue was only tested with stakeholder groups. As public participation addresses the general public, the effectiveness should be tested with interested citizens, the passive public, and children or young adults. Other settings, i.e., with and without a facilitator and with direct interactivity in comparison to mediated interactivity should be conducted. Such comparisons may allow more information on the roles of the facilitator and of the visualization navigator to be obtained. It was also argued that the visualizations would gain in importance if the roles of the facilitator and the visualization navigator were cut back. However, the facilitator and the visualization navigator also facilitated the use of the visualizations, so that might constrict the visualization use by stakeholders with low computer literacy. In contrast to the described impact on short-term planning outcomes, the long-term impact of the workshops is not within the scope of this research. If methods could be developed to explore the long-term impact of landscape visualizations on behavioural changes and attitudes, the results will be very interesting beyond the field of planning. Perhaps the combination of a case study with an ex-post-facto design in which the attitudes and behaviour of the participants are revisited at a later time, could provide an approach to the analysis of long-term impact. The research must not be limited to landscape planning, but the use of landscape visualizations should be subject to interdisciplinary research across related fields, such as climate change or spatial planning.

b) Investigate the causes for emotional and rational responses

Based on the concept of virtuality as described by Heim (1998) and MacEachren et al. (1999), the results of this dissertation imply that a high level of virtuality intensifies the emotional engagement of the viewers. However, this assumption is not verified yet and further tests could contribute to a general visualization method.

c) Conduct quantitative surveys and experiments on usability

Now that the basic relationships are better known, the quantitative research can be extended. For quantitative research, it would be particularly interesting whether the strong correlation of map-reading skills is valid for other samples as well. Additional surveys may support the common argument that photo-realistic landscape visualizations are particularly helpful for lay people, if these are defined as people with low map-reading skills. In contrast, the preference of users with high map-reading skills for more abstract landscape visualizations is an argument for further research on non-photorealistic rendering methods.

Finally, the comparison of the Swiss quantitative survey with the other VisuLands case study sites may reveal additional inter-cultural correlations. Hislop (2005) started to analyze the inter-cultural differences and identified a slightly more positive attitude towards landscape visualizations among the respondents from the Swiss sample in comparison to the Scottish ones. Above all, larger target populations may still reveal possible correlations between interactivity and age, gender, place of residence, profession, or other socio-demographic factors. In future questionnaires, "computer-literacy" should be included as a variable.

d) Need for interactions that support multi-dimensional navigation

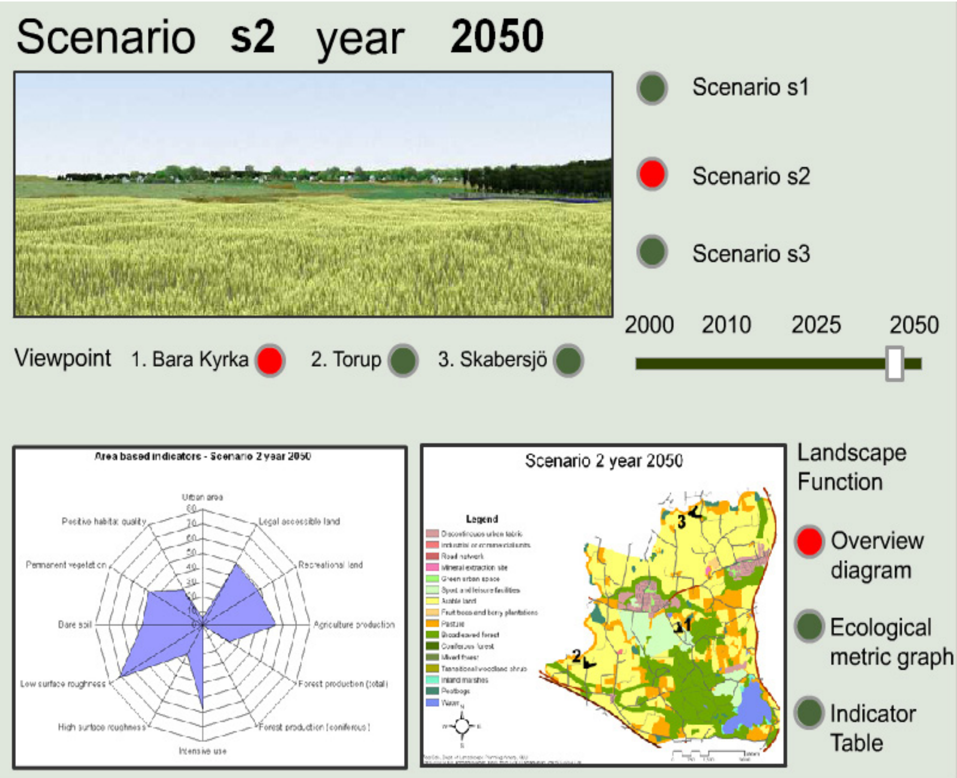


Figure 10.2: Interactive prototype for an expert interface for scenario navigation (image: Schroth and Ode, in Miller et al. 2006). For an interactive version, please see the enclosed CD-ROM.

Dransch (2000) noted that current interaction types are designed to support map-making, not map use. In chapter 3.5, a selection of interaction types for planning was introduced with scenario navigation as a special form of multi-dimensional navigation. A fully functional scenario navigation will require a GIS database that supports multi-dimensional data structures and navigation metaphors that allow changing time and scenario lines. Some of the case study results are implemented in the interactive prototype in figure 10.2. Although the prototype does not provide real-time functionality in the upper landscape window, it contains a multi-dimensional interface to navigate across scenarios in space, time and theme. In addition, the landscape visualizations are linked to maps and indicator diagrams in the bottom part of the interface.

The interactive version of the prototype is included on the attached CD-ROM. With some adjustments, described on the CD, it can be adapted to most image sets. However, the results from the quantitative survey suggest that the complex interrelations between the three windows, the indicator diagram and the land use map are more suitable for experts with high map-reading skills than for lay people.

10.5 Evaluation of the research

10.5.1 Research objectives revisited for the first research question

The benefits of interactions with landscape visualizations (defined in chapter 3) have been critically analyzed and all hypotheses from chapter 4 are answered, providing an important contribution to theory-building in landscape visualization. The benefits for the communication of causes of landscape change and raising awareness are well-documented for all cases. There are also sporadic indications of potential, though not confirmed, benefits such as the facilitation of minorities.

Considering the previous lack of evidence on the actual outcomes of landscape visualization, one very important result is that effects of the landscape visualization can be allocated in the outcome of two cases. The landscape visualizations had an impact on the investments of stakeholders in the tourism case and on the forest management plan.

10.5.2 Research objectives revisited for the second research question

The outcome of the survey is limited insofar as some sub-groups were too small to apply tests for significance. Nevertheless, it is an important outcome that age and gender show no correlations with user preferences for different types of interactions. It is very important that the map-reading skills are correlated to photo-realism and non-visual information. As discussed in the recommendations for landscape visualization research, this result may initiate future research on the role of map-reading skills.

10.5.3 Review of the qualitative case study method

The multiple-case study method proved suitable addressing the group processes in collaborative planning in their context. The central element of the case study analysis was the "key moment analysis", which is derived in chapter 6. For key moments in the course of the discussion, the visualizations and different data sources are analyzed in combination with each other (data triangulation). With regard to both theory and data, the role of interactivity has been derived from these observations in the "chains of evidence". If this method is valid and reliable, it has to fulfill the following four criteria (Yin 2003):

a) Construct validity

The research design has to ensure the objectivity of the research. In this research design, the triangulation of different data sources increases the construct validity during data collection (Yin 2003). The coding of the data and the analysis are guided by theory-based hypotheses.

b) Internal validity

It is a challenge that the impact of interactions cannot be observed directly, but is instead based on inferences from the visualization effects. The formulation as "chains of evidence" ensures the internal validity during this process.

c) External validity (generalizability)

External validity addresses issues of generalizability, which is often misunderstood by the critics of case study research. Yin (2003) points out that case studies do not refer to statistical generalization such as surveys, but to analytical generalization. Analytical generalization is similar to the replication logic of experiments. Similarly, generalizations are allowed if another case under the same conditions comes to the same result. If the conditions of the compared case are altered, altered results can be predicted as well. This form of replication applies to the forest management case, where conditions were different from the first two cases. The cross-case analysis is very important bringing the different cases together and therefore, to increase the external validity of the overall study.

d) Reliability

The case study database and the case study protocols are well-established procedures that increase the reliability of the case study documentation. Key quotes are included in the analysis sections seven to nine. The complete documentation is included in the research database which is included on CD-ROM and available as separate book. The research database allows the reviewer to replicate the original quotes and the coding method.

In summary, the method can be recommended for application in comparable research contexts and some ideas have already been taken up in an ongoing CALP case study (Sheppard, personal communication).

10.5.4 Review of the quantitative survey method

The target population was sufficient for making statements on overall user preferences, and comparing different types of interactions. However, some of the subsamples were too small to get any statements of significance. Furthermore, the Chi-square test is a rather weak statistical method, but the ordinal ranking data does not allow any more powerful methods than non-parametric tests. Nevertheless, the survey contributes to a better understanding of user preferences in landscape visualization. Future quantitative surveys can now go into more detail on the identified relations. Quantitative experiments are recommended as well to test different types of interactions, different interaction metaphors, and interfaces on their usability (cf. Salter 2005).

10.5.5 Benefits of the transdisciplinary research approach

The mutual exchange between researchers, stakeholders, managers of the UNESCO Biosphere Reserve, and software developers proved very successful for all participants. Geodata, visualizations, and a polymer terrain model of the Entlebuch region were handed over to the UBE management. In the UBE, not only did the stakeholders assess the visual input as helpful, but the UBE management is also using the visualizations in their communication with politicians and stakeholders. Above all, the collaboration provided the actual context of real planning processes that is necessary if participatory tools should be analyzed from a planning perspective.

10.6 Implications of the results for planning

In real-time visualizations, the choice of visualization types is extended by the various possibilities to explore and communicate the virtual landscape interactively. In a general sense, interactivity extends the scope of planning in two ways. First, the individual perception of landscape change becomes more process-oriented. Secondly, interactivity emphasizes the group processes of participation.

10.6.1 Focus on the processes of landscape change

It has been argued in the literature part that real-time movement supports the experience of landscapes, especially of their topography. In the words of the survey respondents, the interactive landscape visualizations facilitate their imagination of the landscape. Most evident, the illustration of landscape change over time with the help of the time-travel metaphor is ranked high by all groups. In conclusion, interactive tools may lead to a stronger perception of the dynamic dimension of landscape and to a better understanding of long-term landscape processes. Elaborating a long-term vision for regional rural landscape change is urgently needed in order to achieve a more sustainable landscape management than today.

10.6.2 Focus on the participation process

Participation in general tends to become more process-oriented – in contrast to blueprint plans, which were typical for the static technocratic planning approach (Healey 1997). Particularly in landscape planning, the change from static pre-rendered images to interactive tools may contribute to a more process-oriented perception of planning.

In collaborative workshops, interactive visualizations play an important role by facilitating the construction of shared mental models among the stakeholders. If the construction of a shared mental model is successful, issues can be located in space and conflicts of interest become more rational. Then the landscape visualizations may act as a catalyst, which accelerates consensus-building, as happened in the forest management plan. Hence, interactive visualizations are powerful tools, although they have to be used with careful consideration and under ethic guidelines such as suggested by Sheppard (2001; 2005).

Most users assess the provision of scenario alternatives with navigation options as important. The ranking confirms that the visualization tools are an appropriate support of the scenario method. Although the scenario method traditionally focussed on written scenarios, the use of maps (Stiens 1998) and photo-manipulated images (Tress and Tress 2003) has already proved successful. With regard to today's techniques and the results from this questionnaire, an enhanced use of 3D visualization tools in combination with the scenario method seems promising (e.g., Sheppard and Meitner 2005) and may contribute to a renaissance of the scenario method. Visual scenarios are also predestined to enrich the wider political discussion. According to Friedman (1987), it is the main task of planning to initiate a political dialogue in society. In political dialogue, images have traditionally played an important role. Now, interactive landscape visualizations can put the dialogue into motion.

10.6.3 Outlook on the future of interactive landscape visualization

Finally, it can be said that interactive landscape visualizations are likely to become a standard tool in collaborative workshops. As part of a broader toolbox, interactive landscape visualizations will complement other tools and media. In this context, the interactivity of landscape visualizations will become more important, perhaps even more important than the level of realism. The following outlook on 2015 describes some likely developments:

In 2015, virtual reality has become a standard and lost the "wow effect" of early days. The technology has grown up and early bugs and flaws in usability have been solved. Interactive landscape visualizations are not only applied in landscape planning, but also in climate change and urbanisation, two key topics in 2015. Online visualization tools, the successors of early virtual geo-environments like GoogleEarth, VirtualEarth or EarthWind, make the technology accessible via Internet and workshop participants are better informed in 2015. The facilitator can direct the user's attention to the key planning problem and address diverse target groups with regard to their individual interests. The tools address a broad variety of stakeholders for the following workshop series, bringing together experts and lay people. Beforehand, the planners and external experts involved collaborate online in the preparation of the workshops. Above all, the accessibility of data and the visualization possibilities have an equalizing effect for experts and lay people, leading to a truly bottom-up visualization process. Various personalization features allow creating an individual "MyMap", and the ubiquitous availability of open-source software and data, anybody is free to use geo-spatial tools. Against the background of these trends, Crampton (2007) asks: "Can peasants map?" He answers his own question by a strong affirmation.

Despite the rich opportunities of future interactive landscape visualization, core dialogue and consensus-building among stakeholders will still take place face-to-face. Furthermore, the workshops do not require a high-tech virtual arena, and can still come into the local neighbourhood. The necessary technology has become highly mobile and almost pervasive, so that small laptops run the complex models. The landscape visualizations are applied in a mix with other media, i.e., pen and paper, flip charts, or physical models. It is likely that future interfaces will also facilitate direct interaction, so that the visualizations will not need any mediation anymore. Most of the future tools are computer-supported as well, but in an almost invisible way and with a low barrier for lay people. Sketches can directly be transferred into the geodatabase and translated into a real-time 3D landscape, and participants can use their mobile phones to interact with it.

The landscape visualizations do not dominate, but they are applied with their purpose in mind. In the beginning of the workshop, the stakeholders start a set of analyses to explore the causes of landscape change and document the results in the virtual model. With this input, a brainstorming session starts and after a coffee break, scenarios are worked out on the basis of the analyses and brainstorming sessions. Ideas are rendered in a sketchy style and stand out from the current situation, which is rendered photo-realistically. The "Landscape Information Model" LIM (Ervin 2006) immediately responds to queries and to changes of the input factors. Precondition was the development of geodatabases that truly incorporate the temporal dimension and allow alternative timelines. The results are uploaded online, so that each participant can reconstruct the workshop at home or post additional feedback.

In the final workshop, the stakeholders discuss the developed alternatives with regard to previous comments and objections. In the landscape visualizations, participants can now interactively adapt the level of realism to the state of the scenarios. The more specific the proposal gets, the higher the level of realism is, all based on the same database. One factor does not change though: As in 2007, it is not the technology that determines people's commitment, but their interest in the planning issue and the level of participation.

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Appendices

Preface

- The layout of the original documents has been adapted to fit the layout of this thesis. However, the content has not been changed.
- Material from the EU Project VisuLands is marked by the VisuLands logo.
- The interview and observation guidelines and questionnaires are presented in their original language German.
- The data that was conducted on the basis of these interviews and observation guidelines is documented in the separate case study database.
- Additional explanations to the original documents are set in brackets and printed in italic.

Appendix 1: Case study database overview

In order to ensure the reliability of the case study, a case study database (Yin 2003: 34; 37-39) was set up. The full record of the case study database is provided as a separate book. In the following table, a summary of the main data sources is given:

Case	Dates	Activities	Visual support	Collected Data
Tourism	13.05.2004	Discussion of future strategies	Yes	• Screenshots • Group discussion transcript (planning part) • Group discussion transcript (visualization) • Direct observations (3 protocols from 3 observers) • Photos • Expert interview (facilitator) • Questionnaire
Agriculture	12.06.2003	Introduction	No	-
	19.06.2004	Presentation of dummy prototypes	Limited	-
	22.11.2004	Discussion of alternative management scenarios	Yes	• Screenshots • Group discussion minutes • Direct observations • Video • Expert interview with a participating expert on agriculture, Kanton LU, transcript, 30.11.2004
	20.06.2005	Discussion of alternative management scenarios	Yes	• Screenshots • Group discussion minutes; partly transcript (planning part) • Group discussion transcript (visualiza-

Case	Dates	Activities	Visual support	Collected Data
				tion) • Direct observations (3 protocols from 3 observers) • Photos • 2 expert interviews (facilitator; external researcher) • Video
Forest management plan	4.10.2004	Kick-off meeting with parallel discussions	Yes	• Screenshots • 2 group discussion minutes • Direct observations (2 protocols from 2 observers) • Photos • 2 expert interviews (facilitators)
	18.10.2004	Sectoral meeting by local administration	No	• Protocol
	25.10.2004	Sectoral meeting on tourism and the protection of species	Yes	• Screenshots • Group discussion minutes • Direct observations • Photos
	28.10.2004	Sectoral meeting on agriculture and forestry	Yes	• Screenshots • Group discussion minutes • Direct observations (1) • Photos
	17.01.2005	Final meeting	Yes	• Screenshots • Group discussion minutes • Direct observations (1) • Expert interview (facilitator) • 2 participant interviews • Video • Photos
	Additional material	Forest management plan		• Official documents: Forest management plan • Newspaper article with comments • Expert interview with a representative of the Forest Department, Canton Lucerne, transcript, 1.02.2005

Table A1: Case study database, qualitative data (see the case study database on CD-ROM or as separate book for the complete transcripts and protocols).

Survey on user preferences towards different types of interactivity (self-reported, quantitative data)				
Pretest	03.08.2005	User assessment of different types of visualizations, including different types of interactivity	Yes	Minutes
Survey at local Biosphere event	20.08.2005	User assessment of different types of visualizations, including different types of interactivity	Yes	Screenshots 39 questionnaires, including qualitative feedback 2 direct observations Video Photos
Survey in a local school	31.08.2005	User assessment of different types of visualizations, including different types of interactivity	Yes	Screenshots 18 questionnaires, including qualitative feedback 1 direct observation Photos

Table A2: Case study database, quantitative survey data.

Appendix 2: Workshop scripts

A2.1 Case one: Tourism

For the tourism case, no written script was set up before the workshop. However, the workshop was discussed with the facilitator in a previous informal meeting.

A2.2 Case two: Agriculture

a) Script for the first workshop on agriculture, 22 November 2004

Zeit	Grobablauf	Feinablauf	Methodik	Hilfsmittel	Wer?
10' 5' 15'	**Einleitung**	• Begrüssung • Einleitung: Thema, Programm • Einführung: Rahmenbedingungen aufzeigen	Impulsreferat	Flipchart Beamer	
15'	**Visualisierung der Trends: Auswirkungen im Raum aufzeigen**	• Präsentation der Szenarien Visualisierung	Impulsreferate	Beamer	Ulrike, Olaf
20'	**Brainstorming: Visionen zukünftiger Bewirtschaftungsformen**	• Wie passen sich die Landwirte den Rahmenbedingungen (siehe Einführung) an? Brainstorming für Visionen einer nachhaltigen Alp- und Berglandwirtschaft	Plenumsdiskussion	Karten, Pinwände	Engelbert

Zeit	Grobablauf	Feinablauf	Methodik	Hilfsmittel	Wer?
30'	**Konkretisierung der Visionen (max. 4 Visionen)**	Konkretisierung der Visionen anhand der folgenden Punkte: • Organisation: Stufenbetrieb, nur Alpbetrieb • Bewirtschaftungsart: Tierart, Produktion, Betriebsgrösse • Ökologische Massnahmen: Pflege • Politische Massnahmen:ökol. Leistungen	Gruppenarbeit	vorbereitete Pinwände, Karten, Stifte, Nadeln	
20'	**Pause**				
30'	**Plenumsdiskussion und Bewertung der Konkretisierungen**	• Präsentation der konkretisierten Visionen • Bewertung der Visionen aufgrund ihrer Machbarkeit	Plenumsdiskussion	Pinwände	Engelbert
30'	**Ökol. Auswirkungen der ökon. Veränderungen**	Welche landschaftswirksamen Veränderungen sind bei der jeweiligen Vision zu erwarten?	Plenumsdiskussion Visualisierung	Beamer, Pinwände	Engelbert, Ulrike, Olaf
20'	**Auswertung der Visualisierung**	• Fragebogen zur Visualisierung	Fragebogen Plenumsdiskussion	Fragebogen Beamer	Ulrike, Olaf
15'	**Abschluss**	• Zusammenfassung weiteres Vorgehen Erhebungen Dank und Verabschiedung		Beamer	

Table A3: Script for the first workshop on agriculture, 22nd of November 2004.

b) Script for the second workshop on agriculture, 20 June 2005, revised version

Oberziel: Landwirte sollen wieder mehr als Unternehmer denken = Wo kann ich Kosten einsparen, wo soll ich investieren?

Ziel: Landwirte sollen selber Massnahmen erarbeiten, und deren Konsequenzen möglichst konkret unter ökonomischen und ökologischen Aspekten beleuchten, um mögliche Bewirtschaftungsalternativen zu entwickeln, die dem Nachhaltigkeitsansatz gerecht werden.

Alp: alle Alpen; Visualisierungsbeispiele bezügl. Landschaftsbildveränderung anhand der Alp Änzihütte und Rischli-Salwiden

Ort: LBBZ Schüpfheim, 19:30-22:00 Uhr

Datum: 20.06.2005

Zeit	Grobablauf	Feinablauf	Methodik	Hilfsmittel	wer?
15'	**Einleitung**	• Begrüssung Einleitung: Thema, Programm MTW-Film als Einstimmung		• Flipchart • Beamer	Engel-bert
10'	**Rückblick**	• Rückblick letzter Workshop Planungsfrage und Ziel des heutigen Workshops: Optimierung eines Alpbetriebes unter Berücksichtigung ökonomischer und ökologischer Aspekte	Impulsreferat	• Beamer	Engel-bert
20'	**Indikatoren für die Planung der Standortoptimierung**	• Ökonomische Indikatoren: allgemeine Tendenzen in der Alpwirtschaft (Auswertung Fragebogen). Tendenzen auf dem einzelnen Betrieb (Auswertung Diplomarbeit) • Ökologische Indikatoren: Höhenlage, Steilheit, Erschliessung, Vegetationstyp, Futterertrag, Tierart (Indikatoren WP 10)	Impulsreferat	• Beamer • Visualisierungen zu Standortfaktoren	Sabine, Andrea
30'	**Diskussion zur Frage, wo Effizienz-steigerungen auf den Alpbetrieben möglich sind**	Vorschläge zu Bewirtschaftungsvarianten, bei denen Kosteneinsparungen möglich sind: • z.B. LGS, tierangepasster bealpen, weniger Zäunen, etc. Allgemeine Diskussion der ökonomischen und ökologischen Veränderungen, die durch vorgeschlagene Massnahmen ausgelöst werden	Plenumsdiskussion	• Flipchart • Beamer • Visualisierungen zur Darstellung der Auswirkungen verschiedener Bewirtschaftungsintensitäten (3 Szenarien) • Videokamera	Engel-bert
15'	**Pause**				
30'	**Detaildiskussion der konkreten Konsequenzen verschiedener Bewirtschaftungs-alternativen für den Einzelnen**	Für einzelne Alpbetriebe werden die konkreten Auswirkungen von Massnahmen diskutiert: • Konkrete Massnahmenformulierung (z.B. 50% weniger Zäune) • Ökonomische Auswirkungen • Ökologische Auswirkungen	Plenumsdiskussion	• Beamer • Visualisierungen mit Angaben zu aktuellen Kosten für das Zäunen auf den Alpen sowie bei Reduktion der Zäune um best. Prozentsatz • Visualisierungen verschiedener Daten spontan möglich (z.B. neue Schlageinteilung, Vergandungsgefahr, Weide-	Engel-bert

Zeit	Grobablauf	Feinablauf	Methodik	Hilfsmittel	wer?
				eignung etc.) • Videokamera	
10'	**Einteilung der Weiden unter Berücksichtigung ökonomischer und ökologischer Aspekte***	Neueinteilung der Weiden auf Anweisung der Landwirte unter Berücksichtigung des Arbeitsaufwands sowie der Vergandungsgefahr am Beispiel einer Alp (Planspiel)	Planspiel	• Beamer • Visualisierungen zur Schlagverteilung (Möglichkeit aktiver Veränderung der Schläge in der Visualisierung u. Berechnung der Kosten sowie Information zur Vergandungsgefahr) • Videokamera	Engelbert
10'	**Auswertung der Visualisierung**	**Diskussion** • Wie nützlich sind solche Planungsverfahren? • Können sie Anregungen für ihren eigenen Betrieb mitnehmen? • Konkrete Fragen zu Informationsgehalt und Interaktivität	Plenumsdiskussion	• Beamer • Tonbandgerät	Ulrike, Olaf
10'	**Abschluss**	• Zusammenfassung • weiteres Vorgehen • Dank und Verabschiedung		• Beamer	Engelbert

*Dieser Punkt kann eventuell wegfallen, wenn die Zeit zu knapp wird

Die 3D-Visualisierungen sind Hilfsmittel, die während der Diskussionsrunden nur verwendet werden, wenn sie zum Diskussionsverlauf passen und das Gesagte näher erläutern, konkretisieren oder helfen, noch einen weiteren Aspekt zu beleuchten, der zunächst nicht offensichtlich ist. Sie sollen die Diskussion unterstützen, jedoch nicht ihre Inhalte bestimmen.

Table A4: Script for the second workshop on agriculture, 20nd of June 2005, revised version.

A2.3 Case three: Forest management plan

a) Script for the public kick-off meeting on the forest management plan

Luzern, 25. August 2004

WEP ZUKUNFT ENTLEBUCHER WALD

UNESCO Biosphäre Entlebuch

Detailprogramm Öffentliche Veranstaltung vom 4. Oktober 2004, LBBZ Schüpfheim

Letzte Vorbereitungen, Einrichten, Einstimmung

Zeit		**Was**	**Wer**	**Wo**
16.00	60'	Letzte Absprachen, Programm besprechen	LG, alle RF	Zi Nr.
17.00	60'	Saal, Foyer und Arbeitsräume einrichten Beamer, Notebook, Leinwand, Hellraumprojektor, Pinwand, Flipcharts einrichten	LG, alle RF BS	LBBZ
18.00	60'	gemeinsames Nachtessen	LG, alle RF	Kantine?
19.00	15'	letzte Vorbereitungen	LG, alle RF	LBBZ

Workshop

Zeit		**Was**	**Wer**	**Wo**
19.15	15'	**Film** über Entlebuch (während Eintreffen der Teilnehmer)	BS	Saal
19.30	10'	**Begrüssung** durch Projektleitung ▪ Beteiligte mit Funktion vorstellen ▪ Ziel des Abends: - Waldentwicklungsplanung vorstellen - Inputs zur Planung einholen - Möglichkeit zur Mitwirkung aufzeigen ▪ Ablauf erörtern	BS	Saal
19.40	10'	**Waldentwicklungsplanung** vorstellen ▪ Ziel der Planung: - Interessen, Bedürfnisse und Konflikte aufzeigen, Lösungsansätze finden - Entwicklungsabsichten und Bewirtschaftungsgrundsätze formulieren - Freiraum für Eigeninitiative der WE erkennbar machen - Resultat: Plan mit Vorrangfunktionen und Objektblätter (Themen und Massnahmen) ▪ Aufbau Waldentwicklungsplanung (Pyramide) ▪ Ablauf der Planung → Mitwirkung ▪ Grobübersicht Inhalt Leitbild Wald, WEK (Flyer)	AA	Saal
19.50	10'	Referat **Zukunft Entlebucher Wald** Inhalt: ▪ Ausgangslage, Angaben zum Entlebucher Wald ▪ Inhalt Leitbild Wald ▪ Vision Zukunft Entlebucher Wald ▪ Aufruf zur Mitarbeit	BB	Saal
20.00	10'	**Moderation** ▪ Rolle Moderator ▪ Spielregeln für den Abend	KG	Saal
		▪ **Mitwirkung** erörtern - Organigramm und Zeitplan - Vergleich Mitwirkung mit Benützungsreglement		
20.10	10'	**Überleitung** Gruppenarbeit ▪ Themen der Gruppen vorstellen → Thesen ▪ Aufgabe in den Gruppen erklären - Diskussion zu den Thesen (15') - eigene Thesen aufstellen (15') - Fragen sammeln (15') ▪ Was ist wo? → Leitsystem ▪ Gruppeneinteilung → Anfrage → Entscheid über weitere Gruppen, falls in Gruppen zu viele ▪ wann geht's weiter?	KG	Saal
20.20	5'	Verschiebung in Gruppenräume	KG	

Zeit		Was	Wer	Wo
		mobile „Lotsen“: Lokalkenner Aktiviert und leitet die Leute zu den ihnen zusagenden Posten, vermittelt Kontakte.	Revierförster	
20.25	45'	**Gruppenarbeit** ▪ Gruppe **Natur** (Waldfläche und Waldeinwuchs / Biodiversität / Natürliche Lebensgrundlagen) ▪ Gruppe **Nutzung** (Nutzung erneuerbarer Ressourcen / Waldeigentum und Waldwirtschaft) ▪ Gruppe **Naturgefahren** (Schutz vor Naturgefahren) ▪ Gruppe **Tourismus** (Bildung und Erholung) - - **Bemerkung:** Alle Gruppenräume werden für maximal 50 Personen eingerichtet. Bei mehr als 200 Teilnehmern halten sich für die Übernahme weiterer Gruppen bereit: ▪ Natur oder Tourismus ▪ Nutzung oder Naturgefahren - **Administration:** ▪ Posten „Information, Anmeldung“ (Broschüre WEP, WEP-Entwurf Grundlagen Wald, Rückmeldeformular,) mit „Briefkasten“ für diskrete Meldungen	Moderation Roland Wöhr Reto Derungs Karl Grunder Salome Martin Urs Felder Roland Stalder Revierförster	Gruppenräume Zi Nr. Zi Nr. Zi Nr. Zi Nr. Zi Nr. Zi Nr. Foyer
21.10	10'	**Auswertung Gruppenarbeiten** (pro Gruppe 2-3') ▪ Zusammenfassung der Diskussion ▪ erarbeitete Thesen vorstellen, Fragen bündeln	Moderatoren	Saal
21.20	5'	**Gesamtbild zusammenfügen** ▪ neutrale Darstellung der Resultate ▪ Bündelung der Themen	KG	Saal
21.25	10'	Fragen an die Dienststelle lawa	KG	Saal
21.35	10'	**Schlussbemerkung Moderation** ▪ Bewertung der Thesen während Apéro ▪ Erinnerung an Anmeldung für Mitmachen bei den Workshops mit Foren ▪ Posten Information und Briefkasten erwähnen ▪ weiteres Vorgehen erläutern ▪ Hinweis auf Schlussveranstaltung vom 25.4.05 ▪ Dank und Weiterleitung an BS	KG	Saal
21.45	5'	**Überleitung** zur WEP-bewerbs-Auflösung ▪ warum Wettbewerb? ▪ Jury vorstellen, Dank an Sponsoren	BS	Saal
21.50	10'	**Auflösung WEP-bewerb** ▪ Sprüche der 3 Hauptgewinner vorstellen ▪ Preis an die 3 Hauptgewinner übergeben	Präsident Jury	Saal
22.00	2'	**Abschluss durch Projektleitung** ▪ Dank ▪ Aufruf zum Mitmachen	BS	Saal
		Apéro ▪ Vorbereitung für 50 bis 300 Teilnehmer	BS	Foyer

Table A5: Script for the public kick-off meeting on the forest management plan. The group work session, in which landscape visualizations were applied, is marked by a red frame.

Appendix 3: Observation and interview guidelines

The following observation and interview guidelines were formulated as part of the VisuLands project and were used in the three cases. The original version was set up for the tourism case and included a short quantitative questionnaire for the participants. However, the experience from the tourism case showed that the guidelines were too detailed. The administration of questionnaires after the workshop meetings was not pursued further because the benefit was less than that from the group discussion feedback. There was not enough time during the workshops to run both measures. Therefore, the Swiss VisuLands team decided to shorten the guidelines and skip the quantitative questionnaire in the case studies.

It has to be noted that the changes to the guidelines limit the comparability of the cases. For future multiple-case study research, it is suggested to keep the observation and interview guidelines unchanged across all cases. As discussed in the introduction to the thesis, the limited control over the formulation of the guidelines and questionnaires was also a limiting factor to the study. However, the opportunities offered by the VisuLands project, e.g., access to real-world planning settings, balanced this disadvantage by far. In the forest management plan case, it was not possible to conduct feedback sessions on the visualizations because the group was too large. As a substitute, single participant interviews were conducted. Further observation guidelines were used by Wissen (2007). Those additional guidelines are not included in this study because they were not related to the issue of interactivity.

A3.1 Observation and interview guidelines – Original version, applied in the tourism case

VisuLands

a) Observation guidelines

Gibt es Probleme durch unverständliche Darstellungen? Welche Darstellungen waren gut? (eventuelle Nachfragen, Verständnisfragen?)

Verlauf der Diskussion (Themen, Reaktionen, Konflikte, Dominanz bestimmter Gruppen?)
An welchen Stellen der Diskussion beziehen sich die Teilnehmer auf die 3D Abbildungen?

1. Wie werden die Visualisierungen in die Diskussion eingebunden? Welche Argumente und Ideen wurden auf Visualisierungen bezogen?
2. Welche Hierarchien sind erkennbar? Wer nimmt an der Diskussion und der Entscheidung teil und wer nicht?
3. Wer nutzt die Instrumente für seine/ihre Argumentation?
4. Wie reagieren die Teilnehmer auf die Visualisierungen oder wie interagieren sie mit ihnen?
5. Bewertungen der Visualisierungen durch die Teilnehmer? Vergleiche oder Bezüge

zu den anderen gesehenen Visualisierungen?

6. Werden andere Medien genutzt (2D-Karten, Flip-Chart,…)?
7. Befürchtungen und Kritik bezüglich der Visualisierungen?

Nachbereitung:
Wie kann der Planungsprozess in diesem Stadium beschrieben werden?

• Planungsphase
• Welche Entscheidungsbefugnisse haben die Teilnehmer? Level of Participation.
• Was ist die Planungsfrage?
• Wer sind die Akteure und welche Rollen besitzen sie?

b) Observation guidelines for the visualization navigator

1. 1. Wie gestaltet sich die Handhabung der Visualisierung in der Diskussion (z. B. Aufwand für den Aufbau, technische Zuverlässigkeit, Flexibilität)? Welche Schwierigkeiten treten bei der Einbindung in die Diskussion auf?
2. Wie reagieren die Teilnehmer auf die Visualisierungen oder wie interagieren sie mit ihnen?
3. Welche Unterschiede können hier zwischen den unterschiedlichen Gruppen festgestellt werden?

c) Interview guidelines for the expert interview with the facilitator
Leitfragen für das Interview mit dem Moderator

1. Fragestellungen zur Eröffnung der Diskussion
2. Zusammensetzung der Kleingruppe (vertretene Akteursgruppen, Dominanz einer bestimmten Gruppe?)
3. Wie verlief die Diskussion mit den Teilnehmern? (Inhalte, offene Fragen, Kritik, Konflikte?)
    - Diskussionsstruktur (Organisation des Ablaufs)
    - Diskussionsebenen (Sacheben, Persönliche Ebene, Strukturebene)
    - Sachinhalt / offene Fragen
    - Visualisierungsinhalt / offene Fragen
4. Welche Rolle spielten die Visualisierungen in der Diskussion? (Nutzung, Integration, Vorteile und Schwierigkeiten)

d) Interview guidelines for the feedback session on the use of visualizations
Leitthemen:
<u>Unterstützung der Informationsverarbeitung:</u>

- Nachvollziehbarkeit / Transparenz der Information
- Ablesbarkeit / Verständlichkeit / Richtigkeit / (Vollständigkeit) der Information (Darstellung)
- Kombination der Medien (2D / 3D)

- Transfer-Leistung (eindenken: vom Modell in die Landschaft)
- Orientierung

Unterstützung von Aufgaben im Planungsprozess:

- Bewertungsmöglichkeit (sozio-ökonom, ökolog, ästhet.)
- Rolle d. Aufzeigens der zeitlichen Entwicklung
- Grad der Verarbeitung der Information (für Analyse, Bewertung, Planung)
- Missbrauch

Leitfragen:

Unterstützung der Informationsverarbeitung:

- Wie gross ist das Vertrauen in die gezeigten Visualisierungen? Besteht das Gefühl, dass die Daten stimmen (Vertrauen)? Sind Fehler ablesbar? (Hypothese: Daten sind dann nachvollziehbar, wenn Fehler erkennbar sind und damit ist eine Validierung / Korrektur möglich)
- Wie ist die Ablesbarkeit der Information? Können die einzelnen (touristischen) Elemente in der Landschaft gut zugeordnet werden (Seilbahn, Wanderwege, Unterkünfte,…)? (= ist Darstellung verständlich?)
- Ist die für die Konzeptfindung relevante Information vollständig? Was fehlt?
- Welche Rolle spielt das Landschaftsbild für die Beurteilung? (Hypothese: Wichtige Rolle, deshalb evtl. mehr Detail erforderlich. Info fehlt in 2D-Karten) evtl. Fotos d. Viewpoints zeigen?
- Welche Zusammenhänge (räumlich-funktional) werden erkannt? (Bettenbelegung (Indikator) = Touristenandrang, Angebotspalette)
- Welche Information wird eher aus 2D-Karten entnommen, welche aus den 3DVisualisierungen?

Unterstützung von Aufgaben im Planungsprozess:

- Welche Beurteilungen können getroffen werden anhand der Visualisierungen? (Stärken und Schwächen im Hinblick auf Tourismus erkennbar?)
- Formulierung von Potentialen? (Ideenfindung)
- Verortung von Massnahmen / eines Konzepts im 3D-Modell?
- Wäre die Darstellung einer zeitlichen Entwicklung hilfreich?
- Welche Zusatzinformationen (Indikatoren) sind für die Beurteilung der zeitlichen Entwicklung relevant?
- Welche Entscheidungen fallen leichter durch die Visualisierungen?
- Welche Befürchtungen sind mit dem Einsatz der 3D-Visualisierungen verbunden? (evtl. auch nur potentielle, wenn die Bilder realistischer werden)

c) Questionnaire on the use of 3D visualizations in the planning discussion - Applied in the tourism case only

Fragebogen: 3D Abbildungen (Visualisierungen) in der Planungsdiskussion

Während der Diskussion haben Sie heute 3D Abbildungen gesehen. Wir interessieren uns für Ihre Meinung. **Bitte kreuzen Sie die zutreffenden Antworten an.**

1. Sind die Themen aus dem Diskussionsverlauf richtig dargestellt worden?

ganz richtig	grösstenteils richtig	mehr oder weniger richtig	teilweise richtig	gar nicht richtig
☐	☐	☐	☐	☐

Wenn Antwort „grösstenteils richtig“ bis „gar nicht richtig“: **Was wurde falsch dargestellt?**

---

2. Sind die Themen aus dem Diskussionsverlauf verständlich dargestellt worden?

ganz verständlich	grösstenteils verständlich	mehr oder weniger verständlich	teilweise verständlich	gar nicht verständlich
☐	☐	☐	☐	☐

Wenn Antwort „grösstenteils verständlich“ bis „gar nicht verständlich“: **Was war nicht verständlich?**

---

3. Wussten Sie in der 3D Abbildung wo Sie sind?

genau	grösstenteils	mehr oder weniger	teilweise	gar nicht
☐	☐	☐	☐	☐

4. Wie beurteilen Sie den Einfluss, den Sie auf die Entstehung der 3D Abbildungen gehabt haben?

sehr grossen Einfluss	grossen Einfluss	mittelmässigen Einfluss	geringen Einfluss	keinen Einfluss
☐	☐	☐	☐	☐

5. Würden Sie sich wünschen, dass mehr Informationen mit der 3D Abbildung verknüpft werden?

Ja	Nein
☐	☐

Wenn „Ja“, welche Informationen würden Sie sich wünschen? (mehrere Antworten möglich)

Statistische Daten (sozio-ökonomische, ökologische)	☐
Fotos	☐
Zukunftsbilder	☐
2D Karten	☐

Bitte geben Sie uns auf der Rückseite des Fragebogens noch ein paar **Angaben zu Ihrer Person**. Hier ist auch Platz für sonstige Anmerkungen.

Sonstige Anmerkungen zum heutigen Einsatz der 3D Abbildungen können Sie uns hier mitteilen:

Angaben zur Person:

Geschlecht:

weiblich	männlich
☐	☐

Alter:		Beruf:	
☐	<20	☐	Schüler/ Student/ Ausbildung
☐	21-30	☐	Selbständige/r
☐	31-40	☐	Angestellte/r
☐	41-50	☐	Arbeiter/in
☐	51-60	☐	Arbeitsloser
☐	<60	☐	Rentner/in

Das visualisierte Gebiet ist (mehrere Antworten möglich):

- ☐ Mein Wohnort
- ☐ Mein Arbeitsort
- ☐ Mein Urlaubsort

Vielen Dank! Das ETH VisuLands-Team

A3.2 Revised observation and interview guidelines - Applied in the cases on agriculture and forest management plan

a) Observation guidelines

Verlauf der Diskussion (Themen, Reaktionen, Konflikte, Dominanz bestimmter Gruppen?)

– Welche Diskussionsteilnehmer beziehen sich in ihrer Argumentation auf die Visualisierungen?
– Welche Argumente und Ideen wurden auf Visualisierungen bezogen?
– Wie reagieren die Teilnehmer auf die Visualisierungen?
– Bewertungen der Visualisierungen durch die Teilnehmer? Vergleiche oder Bezüge zu den anderen gesehenen Visualisierungen?
– Befürchtungen und Kritik bezüglich der Visualisierungen?

Wie kann der Planungsprozess in diesem Stadium beschrieben werden?

– Was ist die Planungsfrage?
– Planungsphase
– Welche Entscheidungsbefugnisse haben die Teilnehmer? Level of Participation.
– Wer sind die Akteure und welche Rollen besitzen sie?

Diskussionsverlauf

– Welche Hierarchien sind erkennbar? Wer nimmt an der Diskussion und der Entscheidung teil und wer nicht?
– Wer nutzt die Instrumente für seine/ihre Argumentation?

b) Observation guidelines for the visualization navigator

– Wie gestaltet sich die Handhabung der Visualisierung in der Diskussion (z. B. Aufwand für den Aufbau, technische Zuverlässigkeit, Flexibilität)?
– Welche Schwierigkeiten treten bei der Einbindung in die Diskussion auf?
– Wie reagieren die Teilnehmer auf die Visualisierungen oder wie interagieren sie mit ihnen?
– Welche Unterschiede können hier zwischen den unterschiedlichen Gruppen festgestellt werden?

c) Interview guidelines for the expert interview with the facilitator

Fragestellungen zur Eröffnung der Diskussion

– Zusammensetzung der Kleingruppe (vertretene Akteursgruppen, Dominanz einer bestimmten Gruppe?)

- Wie verlief die Diskussion mit den Teilnehmern? (Inhalte, offene Fragen, Kritik, Konflikte?)
- Welche Rolle spielten die Visualisierungen in der Diskussion? (Nutzung, Integration, Vorteile und Schwierigkeiten)
- Haben die bildlichen Darstellungen Ihnen geholfen, die vorgestellten Maßnahmen und ihre Auswirkungen besser zu verstehen und beurteilen zu können? Welche besonders und wie?
- Haben die Visualisierungen Ihrer Ansicht nach die Diskussion unterstützt? Welche besonders und welche nicht? Warum?
- Welche Schwierigkeiten sehen Sie durch den Einsatz der bildlichen Darstellungen? Welche Befürchtungen sind damit verbunden?

d) Interview guidelines for the feedback session on the visualizations

1. Navigation, Orientierung

- Orientierung:
    - Standbilder / Modell
    - Landmarken (Städte, Berge) erkannt?
    - Konnten Lage und Dimension der Schutzzonen bestimmt werden?
    - Flexibel und einfach genug? Bedienbarkeit?
    - VTP: Nutzen der Spaziergängerperspektive [falls im Diskussionsteil kein VTP genutzt wurde, nochmal zeigen]
    - Vergleich photorealistische Standbilder aus dem Input-Referat oder weniger realistische Bilder mit freier Wahl der Perspektive und Daten im Diskussionsteil
- Einfluss auf die Diskussion?

2. Analysefunktionen

Interaktive Analysemöglichkeiten, z.B. Hangneigung <-> Relevanz?
Wie stehen Sie zu den Ergebnissen? Transparenz und Nachvollziehbarkeit

3. Verknüpfung zu den ökonomischen Daten

Diagramme / Symbole in das Modell <-> Flächenschärfe

4. Interaktives Einzeichnen von Zonierungen etc.

- Haben Sie beim Einzeichnen der Schutzzonen lieber mit der Karte oder mit der computergestützten Wandprojektion gearbeitet?
- Computertechnik als Barriere?
- Computer lässt sich nur durch eine Person bedienen, Karte kann von mehreren parallel bearbeitet werden?

Allgemeines
– Fachbegriffe vermeiden
– Diskussion mit möglichst vielen Teilnehmern unterstützten, keine Fragerunde
– in der Pause / im Anschluss die Möglichkeit geben, selber mit den Tools zu interagieren

e) Guidelines for the participant interviews in the case of the forest management plan

1. Wurden Sie durch die Visualisierungen motiviert sich zu äussern? Welche Darstellungsform hat Sie eher angesprochen – 2D oder 3D?
2. Worin konnten Sie sich besser orientieren? In der 2D Karte oder im 3D Modell?
   - Landmarken (Städte, Berge) erkannt?
   - Konnten Lage und Dimension der einzelnen Themen bestimmt werden?
3. Frage zur Verständlichkeit der Informationen
   - Ablesbarkeit
   - Organisation der Information / Schrittweiser Aufbau der verschiedenen Kartenebenen
   - Verständlichkeit
   - Korrekte Darstellung?
4. Anwendungen zur Konfliktlösung

	Überlagerung v. Kartenebenen	Vergrössern, Perspektive verändern	Verändern d. Karte, neue Flächen einzeichnen	Verknüpfung mit Tabellen, Fotos etc.
Themensammlung & Informationsaustausch				
Klärung der Bedürfnisse und Interessen				
Entwicklung von Lösungsoptionen				
Bewertung und Auswahl v. Lösungsansätzen				
Entscheidung f. optimale Lösung				

Bewertung: ++, +, °, -, --

In Worten: Hat Ihnen die Möglichkeit,
- Verschiedene Kartenebenen zu überlagern
- Kartenausschnitte zu vergrössern und die Perspektive zu ändern
- Neue Flächen einzuzeichnen und alte zu verändern
- Karten mit Tabellen, Fotos etc. zu verknüpfen

bei der Lösungsfindung geholfen / hätten Sie diese Möglichkeit gerne genutzt?

5. Hat die Computertechnik Ihre Mitwirkung eher motiviert oder eher gehemmt?
6. Haben Sie es als Nachteil empfunden, dass sie die Computerkarten in diesem Workshop nicht selbst bearbeiten konnten? Vorteil der Karten?

Appendix 4: Coding and counting methods in the qualitative analysis

A4.1 Coding by computer-added analysis

To a large extent, the analysis is supported in the **qualitative data analysis (QDA) software Atlas.ti**, which is recommend by Mayring (2003) for use in qualitative content analysis. The software does not predetermine the method, but it helps with the research database organisation and allows quick queries across all data.

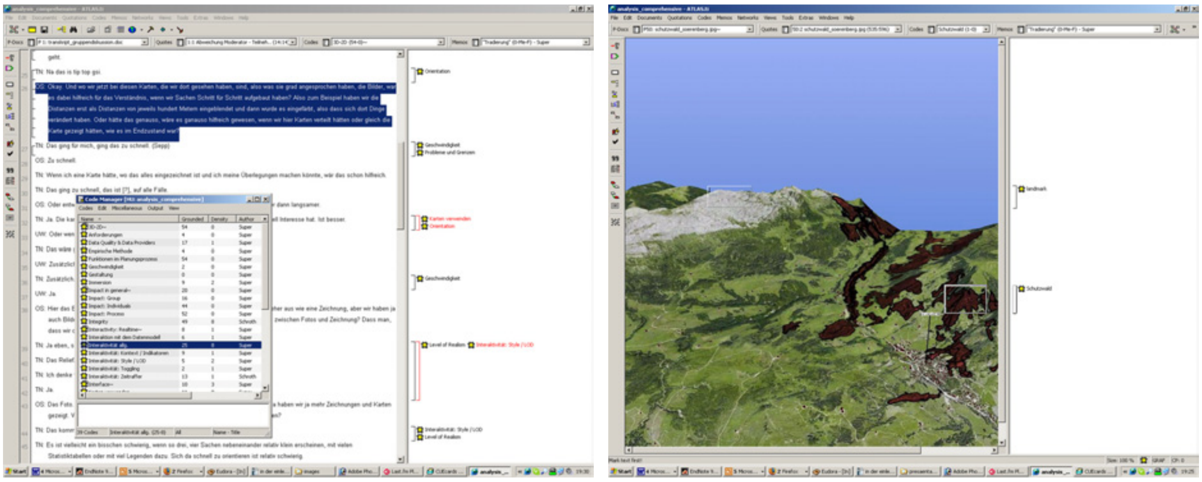

Figure A1: Coding of texts (left) and image elements (right) in Atlas.ti.

Codes from the hypotheses						
Dialogue	**Consensus**	**Credibility**	**Enrichment of information**	**Inclusiveness**	**Learning**	**Behavioural indicators**
Course (of the dialogue)	Decision (outcome)	Data correctness	Working with visual scenarios	Activating user groups	Understanding the visualizations	Look at / study image
Flexibility	Collaborative assessment	Data completeness	Imagination		Illustrating processes	Unquiet
Tempo	Conflicts (that hinder consensus)	Manipulation	Emotions		External input	Reference to image
Problems and limitations			Local knowledge		Behavioural change	Gesture / waving
			Spatial phenomena			No response
			Change in perspective			Use of spatial references
			Change over time			

Table A6: List of codes that refer to the impact of the interactive visualizations (classified on the basis of theory and research questions).

Codes from the type of interaction							
Customiza-tion	Navigation - spatial - temporal - thematic	Orientation	Contextual-izing functions	Database functions	Model usage functions (incl. spatial analysis)	Design functions	Document-ation

Table A7: List of codes that refer to the type of interaction.

Codes from the context								
3D-2D	Interface	Level of realism	Design	Immer-sion	Participation process	Map use	Social-cultural context	Setting

Table A8: List of codes that refer to context factors.

A4.2 Counting interactions on the basis of video documentation

The interaction schemes in the cross-case analysis in chapter 8.2.1 are based on counts of gestures and references during the video documentation. The count presented is an example from the agriculture case:

Interaction partners	Type of interaction	Frequency
Experts – stakeholders	Explanations	13 documented
Stakeholders – experts	Question	1 documented
Navigators - visualiza-tions	Navigation, Interactions with the landscape, work-shop tools	about 15 documented
Experts – visualizations	Reference to image ("now you see...")	About 25
Stakeholders – visualizations	Verbal: Refer to image: 3/8 with 5 references overall **Non-verbal:** Stare at / study image: 8/8 Gesture/ wave at image: 1/8 with 2 gestures Laughter, whisper (only documented in observa-tions; no numbers)	About 3 verbal references documented for all stake-holders together; prob-ably more

Table A9: Interactions during the discussion phase of the second workshop on agriculture (source: observation protocols).

Appendix 5: Quantitative questionnaire

VisuLands - TEIL A

Teil A: Karten von dem Gebiet Sörenberg

In diesem Teil werden Sie zu den gezeigten Karten von dem Gebiet Sörenberg befragt.

1. Wie erfahren sind Sie im Umgang mit Karten?

1. Überhaupt nicht
2. Sehr wenig
3. Ein wenig, aber nicht viel
4. Erfahren
5. Sehr erfahren

Bitte nur eine Antwort ankreuzen

2. Haben Sie die Veränderungsalternativen verstanden, die Ihnen für Sörenberg präsentiert wurden?

1. Ich habe sie nicht verstanden
2. Ich habe sie grösstenteils nicht verstanden
3. Ich habe sie teilweise verstanden
4. Ich habe sie grösstenteils verstanden
5. Ich habe alles verstanden

Bitte nur eine Antwort ankreuzen

3. Wie einfach war es für Sie, bekannte Punkte auf den Karten von Sörenberg, die Sie gerade gesehen haben, wieder zu erkennen?

1. Sehr schwierig
2. Schwierig
3. Teils schwierig, teils einfach
4. Einfach
5. Sehr einfach

Bitte nur eine Antwort ankreuzen

4. Würden Ihnen die Karten helfen, wenn Sie nach Ihrer Meinung zu Landschaftsveränderungen im Raum Sörenberg gefragt würden?

1. Überhaupt nicht hilfreich
2. Sehr wenig hilfreich
3. Weder hilfreich noch hinderlich
4. Hilfreich
5. Sehr hilfreich

Bitte nur eine Antwort ankreuzen

5. Bitte geben Sie eine kurze Erklärung zu Ihrer Antwort in Frage 4

VisuLands - TEIL B

Teil B (i): Visualisierungen von Sörenberg

Sie haben Computervisualisierungen von Landschaftsentwicklungsalternativen für Sörenberg gesehen.

1. Wie viel Erfahrung hatten Sie mit Computervisualisierungen bis jetzt?

1. Keine
2. Sehr wenig
3. Ein wenig, aber nicht viel
4. Viel
5. Sehr viel

Bitte nur eine Antwort ankreuzen

2. Sind Sie der Meinung, dass Sie die Entwicklungsalternativen für Sörenberg verstanden haben, die Ihnen mit Hilfe der Visualisierungen präsentiert wurden?

1. Ich habe sie nicht verstanden
2. Ich habe sie grösstenteils nicht verstanden
3. Ich habe sie teilweise verstanden
4. Ich habe sie grösstenteils verstanden
5. Ich habe alles verstanden

Bitte nur eine Antwort ankreuzen

3. Wie einfach war es für Sie, bekannte Punkte auf den Karten von Sörenberg, die Sie gerade gesehen haben, wieder zu erkennen?

1. Sehr schwierig
2. Schwierig
3. Teils schwierig, teils einfach
4. Einfach
5. Sehr einfach

Bitte nur eine Antwort ankreuzen

4. **Würden Ihnen die Visualisierungen helfen, wenn Sie nach Ihrer Meinung zu Landschaftsveränderungen im Raum Sörenberg gefragt würden?**

1. Überhaupt nicht hilfreich
2. Sehr wenig hilfreich
3. Weder hilfreich noch hinderlich
4. Wenig hilfreich
5. Sehr hilfreich

Bitte nur eine Antwort ankreuzen

5. Bitte geben Sie eine kurze Erklärung zu Ihrer Antwort in Frage 4

____

____

____

____

6. Verglichen mit den vorher gezeigten Karten, sind die Visualisierungen hilfreicher oder weniger hilfreich, damit Sie Ihre Meinung zu Entscheidungen zur Landschaftsentwicklung in Sörenberg äussern können?

1. Sehr viel weniger hilfreich
2. Weniger hilfreich
3. Weder hilfreicher noch weniger hilfreich
4. Ein wenig hilfreicher
5. Sehr viel hilfreicher

Bitte nur eine Antwort ankreuzen

7. Bitte geben Sie eine kurze Erklärung zu Ihrer Antwort in Frage 6

____

____

____

____

8. Zuvor wurden Ihnen verschiedene Möglichkeiten von Computervisualisierungen gezeigt. Bitte stufen Sie diese nach ihrer Bedeutung ein, wenn Sie an der Beurteilung landschaftlicher Planungsalternativen beteiligt wären.

1.Bewegung durch das Modell ___
2. Ansicht verschiedener Standpunkte ___
3. Zeitreise ___
4. Photorealistische Bilder ___
5. Einbindung nicht-visueller Information ___

Tragen Sie 1 für die wichtigste Eigenschaft, 2 für die nächst wichtigste usw. für alle 5 Eigenschaften ein

VisuLands - TEIL B

Teil B (ii): Technik der Computervisualisierungen

In diesem Teil werden Sie zur Technik der Computervisualisierungen befragt.

1. Denken Sie, dass Computervisualisierungen eine Rolle spielen können, um die Bevölkerung an Entscheidungen über landschaftsplanerische Vorhaben zu beteiligen?

1. Keine Rolle
2. Nützlich
3. Entscheidend

Bitte nur eine Antwort ankreuzen

2. Bitte geben Sie eine kurze Erklärung zu Ihrer Antwort in Frage 1

3. Finden Sie, dass sich der Einsatz von Zeit und Geld für die Entwicklung der Computervisualisierungen lohnt?

1. Verschwendung von Ressourcen
2. Lohnt sich wenig
3. Lohnt sich
4. Lohnt sich sehr
5. Weiss nicht

Bitte nur eine Antwort ankreuzen

4. Bitte geben Sie eine kurze Erklärung zu Ihrer Antwort in Frage 3

5. Vertrauen Sie den Visualisierungen als glaubwürdigen Präsentationen der Landschaft?

1. Ich vertraue ihnen überhaupt nicht
2. Ich vertraue ihnen noch nicht
3. Ich vertraue ihnen teilweise
4. Ich vertraue ihnen vollkommen
5. Weiss nicht

Bitte nur eine Antwort ankreuzen

6. Bitte geben Sie eine kurze Erklärung zu Ihrer Antwort in Frage 5

VisuLands - TEIL B

Teil B (iii): Erfahrungen mit der Beteiligung am VisuLands Projekt

In diesem Teil werden Sie nach den Erfahrungen mit der Einbindung in das VisuLands Projekt Team befragt.

1. Waren Sie am VisuLands Projekt beteiligt?

1. Ja
2. Nein

Bitte nur eine Antwort ankreuzen

2. Haben Sie bereits Informationen zum VisuLands Projekt erhalten?

1. Flugblätter oder Berichte
2. Ausstellung gesehen
3. Erzählungen
4. Fotos
5. Besuche im Untersuchungsgebiet
6. Andere
7. Keine

Bitte kreuzen Sie alle Antworten an, die auf Sie zutreffen

3. Wenn 'Andere', bitte kurz erläutern:

4. Wie schätzen Sie Ihr Verständnis ein, worum es im VisuLands geht?

1. Sehr wenig Verständnis
2. Wenig Verständnis
3. Gutes Verständnis
4. Sehr gutes Verständnis

Bitte nur eine Antwort ankreuzen

5. Wenn Sie daran beteiligt wären, Vorschläge für die Landschaftsentwicklung von Sörenberg zu erstellen oder eines anderen Ortes, der für Sie von Interesse ist, wie würden Sie gerne einbezogen werden?

1. Mithilfe bei der Entscheidung über Nutzungsalternativen
2. Über die eigenen Interessen informieren
3. Abstimmung über Planinhalte
4. Abwägen verschiedener Planungsalternativen
5. Kommentare zu Planungsvorschlägen
6. Ich möchte nicht beteiligt werden

Bitte kreuzen Sie alle Antworten an, die auf Sie zutreffen

VisuLands - TEIL B

Teil B (iv): Feedback zum VisuLands Projekt

1. Auf Grund Ihrer Erfahrung mit der Beteiligung am VisuLands Projekt, wie gut, denken Sie, ist das Projekt Team in der Lage, Ihre Reaktionen in den Visualisierungen zu berücksichtigen?

1. Überhaupt nicht
2. Ein wenig, aber nicht gut
3. Ziemlich gut
4. Sehr gut
5. Weiss nicht

Bitte nur eine Antwort ankreuzen

2. Wurde Ihnen Feedback zu den Ergebnissen des Projektes angeboten?

1. Ja
2. Nein
3. Weiss nicht

Bitte nur eine Antwort ankreuzen

3. Sind Sie zufrieden mit dem angebotenen Feedback?

1. Ja
2. Nein
3. Weiss nicht
4. Es wurde kein Feedback angeboten

Bitte nur eine Antwort ankreuzen

VisuLands - TEIL B

Teil B (v): Über Sie.

Zum Schluss benötigen wir einige Angaben zu Ihrer Person. Diese werden ausschliesslich zu statistischen Zwecken verwendet und helfen uns bei der Auswertung.

1. Was ist Ihr Geschlecht?

☐ 1. Männlich
☐ 2. Weiblich

Bitte nur eine Antwort ankreuzen

2. Zu welcher Altersgruppe gehören Sie?

☐ 1. Unter 20 Jahre
☐ 2. 20 bis 29 Jahre
☐ 3. 30 bis 39 Jahre
☐ 4. 40 bis 49 Jahre
☐ 5. 50 bis 59 Jahre
☐ 6. 60 und älter

Bitte nur eine Antwort ankreuzen

3. Was ist Ihr höchster Ausbildungsabschluss?

☐ 1. Kein Abschluss
☐ 2. Fähigkeitszeugnis Berufslehre
☐ 3. Matura
☐ 4. Lizentiat oder Diplom
☐ 5. Nachdiplomsstudium oder Doktorat

Kreuzen Sie bitte die Antwort an, die Ihrem höchsten Ausbildungsstand entspricht, den Sie erreicht haben.

4. Wo wohnen Sie?

Geben Sie den Namen des am nächsten gelegenen Dorfes oder der am nächsten gelegenen Stadt an, in dem / der sich ihr Wohnort befindet.

5. Wie viele Jahre wohnen Sie schon in dem Gebiet?

☐ 1. Weniger als 5 Jahre
☐ 2. 5 bis 9 Jahre
☐ 3. 10 bis 14 Jahre
☐ 4. 15 bis 19 Jahre
☐ 5. 20 Jahre und mehr

Kreuzen Sie bitte die Antwort an, die der Anzahl der Jahre entspricht, die Sie im Umkreis von 16 Kilometern um Ihren jetzigen Wohnort gewohnt haben. Bitte nur eine Antwort ankreuzen.

6. Arbeiten Sie im Untersuchungsgebiet?

☐ 1. Ja
☐ 2. Nein

'Untersuchungsgebiet' bedeutet innerhalb der UNESCO Biosphäre Entlebuch. Bitte nur eine Antwort ankreuzen.

7. Welches Interesse haben Sie am Untersuchungsgebiet?

☐ 1. Landeigentümer
☐ 2. Landwirt
☐ 3. Erholungssuchender / Tourist
☐ 4. Einwohner
☐ 5. Gemeinde- oder Verbandsvertreter
☐ 6. Beruflicher Experte in Landschaftsdisziplinen
☐ 7. Andere

Es können mehrere Antworten angekreuzt werden.

8. Wenn 'Andere', bitte erläutern:

Fragen 9 bis 11 sind nur für Landwirte. Bitte beantworten Sie diese Fragen, wenn sie in Frage 7 'Landwirt' angekreuzt haben.

9. Wenn Sie Landwirt sind, ist das Ihr Hauptberuf?

1. Ja
2. Nein

Bitte nur eine Antwort ankreuzen

10. Sind Sie hauptsächlich Pächter oder Alleineigentümer?

1. Pächter
2. Alleineigentümer

Bitte kreuzen Sie die Antwort an, die Ihrem Status des Landbesitzes entspricht.

11. Bewirtschaften Sie Land ausserhalb des Untersuchungsgebietes?

1. Ja
2. Nein

'Ausserhalb des Untersuchungsgebietes' bedeutet mehr als 5km von der UNESCO Biosphäre Entlebuch entfernt.

Frage 13 ist nur für Gemeinde- und Verbandsvertreter. Bitte beantworten Sie diese Frage nur, wenn Sie in Frage 7 'Gemeinde- oder Verbandsvertreter' angekreuzt haben.

13. Wenn Sie ein gewählter Vertreter sind, für welche Art von Entscheidungen sind Sie hinsichtlich des Untersuchungsgebietes verantwortlich?