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Multiple-Case Study of Landscape Visualizations as a Tool in Transdisciplinary Planning Workshops

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ABSTRACT This paper presents a transdisciplinary multiple-case study, set in Switzerland, that was part of the European Fifth Framework Program project VISULANDs—Visualization Tools for Public Participation in Managing Landscape Change (2003–2005). The project sought production of new visualization tools enabling public participation in landscape management. In cooperation with workshop participants, researchers constructed three-dimensional (3-D) landscape visualizations to represent various scenarios of landscape change. The planning objective was to develop sustainable solutions for landscape-related planning problems in tourism, agriculture, and forestry. Two of the case studies produced implemented results. The research objective was to analyze the effectiveness of landscape visualization as a tool in transdisciplinary workshops with external researchers and local stakeholders. The research illustrates how the interactive construction of different types of landscape visualization may contribute to solutions for planning problems on local to regional scales through transdisciplinary knowledge construction, dialogue, and consensus building.

KEYWORDS Participatory planning, landscape planning, landscape visualization, transdisciplinary action research, interactivity

TRANSDISCIPLINARY ACTION RESEARCH IN LANDSCAPE ARCHITECTURE AND PLANNING

This paper presents three case studies centered on the rural area of Entlebuch, a United Nations Environmental, Scientific, and Cultural Organization (UNESCO) Biosphere in central Switzerland. All three cases are transdisciplinary because they involve external researchers and integrated local and scientific knowledge from various disciplines. The case studies are participatory (Healey 1997), as they include equal collaboration among local stakeholders involved in decision making.

Stokols (2006, 66) defines transdisciplinary action research (TDAR) as including various types of collaboration as determined by their organizational scope (integration across organizations), analytic scope (integration across disciplines), and geographic scales (moving from local to global). Jantsch's (1972) initial idea of transforming the university into a transdisciplinary institution has evolved into two common threads of research (Pohl and Hirsch Hadorn 2007): TDAR addresses knowledge beyond disciplines and includes working with researchers as well as affected non-academic stakeholders.

Tress, Tress, and Frey (2005) distinguish disciplinary, multi-, inter-, and transdisciplinary research by their levels of collaboration and knowledge integration across researchers and non-academic stakeholders. Disciplinary research occurs within a single disciplinary field with its own tools and goals. Multidisciplinarity adds cooperation across disciplines, each with its own goals. Interdisciplinarity involves the highest level of collaboration among participating disciplines and a sharing of common goals and knowledge. Finally, transdisciplinarity retains the same high level of scientific collaboration that interdisciplinarity does, while also including non-academic participants in the process (Tress, Tress, and Fry 2005).

TDAR involves the same level of collaboration and joint decision making (Wiek 2007) characterizing the highest levels of citizen power in Arnstein's (1969) ladder of citizen participation, with the distinction that TDAR also includes researchers. Collaboration and knowledge construction in both participatory planning and TDAR, while limited by cognitive barriers, confounded agendas, value conflicts, and various traditions of data collection, rely on interaction and dialogue for mutual learning (Wiek 2007). While TDAR does not necessarily create consensus out of conflict and transform all land-use conflicts into win-win situations among all engaged stakeholders (Fry 2001), it is well suited for use in landscape planning because landscape-related issues are typically complex and uncertain, involving diverse stakeholders with conflicting values and interests (Fry 2001; Hirsch Hadorn et al. 2006).

Participatory Planning

Accommodating the increased complexity of stakeholder interactions that characterize the production of today's landscapes has resulted in a "communicative shift" (Healey 1997) towards more participatory approaches in landscape architecture and planning, including both "collaborative planning" (Healey 1997) and "plural design" (Crewe and Forsyth 2003). Plural design seeks environmental justice and the empowerment

of public participants, often minorities, over their environments (Crewe and Forsyth 2003). Toward those ends, community-oriented projects in landscape architecture and planning build knowledge and social capacity to give every participant a voice in decision making. The small number of evaluations among participatory projects, however, leave it unclear as to how, and under which circumstances, TDAR contributes to participation (Stokols 2006).

Landscape Visualization as a Tool to Facilitate Participatory Planning

Visual techniques such as sketching have always been part of participatory planning. Geographic information systems (GIS) and 3-D landscape visualizations, defined as computer generated representations of perspective landscape views, have long held promise for facilitating plural design (Zube, Simcox, and Law 1987). The presentation of landscape visualization may be static or dynamic in immersive or non-immersive displays with varying levels of interactivity and portraying varying levels of realism (Bishop and Lange 2005; Danahy 2001; Lange 2001; Sheppard and Salter 2004). Visualizations may portray egocentric perspectives, providing typically eye-level perspective views from within the landscape, as well as exocentric regional or panoramic views of the landscape (Orland, Budthimedhee, and Uusitalo 2001). Sheppard (2001) provided the crystal ball gazers with ethical guidelines for using 3-D visualizations in landscape architecture.

When used to support participatory planning in workshops (Danahy 2001), 3-D landscape visualization provides “a common language for all participants” (Al-Kodmany 1999, 45). Interactive visualizations (those permitting direct engagement by stakeholders) provide an even more realistic basis for people’s visual experience of landscape change (Danahy 2001). In Zurich, Switzerland, the application of interactive and immersive 3-D landscape visualizations helped facilitate a stakeholder workshop on the siting of wind turbines (Lange and Hehl-Lange 2005). In exploring alternative density policies on Bowen Island, British Columbia,

similar visualizations permitted interactive comparison of build-out scenarios with various densities (Salter et al. 2009). Three-dimensional landscape visualizations have facilitated the engagement of the public in discussing local impacts of climate change as well as in exploring possible mitigation and adaptation measures (Dockerty et al. 2006; Shaw et al. 2009).

The multiple-case study presented here investigates the benefits of using interactive 3-D landscape visualization in a workshop setting with multiple stakeholders. It provides evidence that interactive visualizations facilitate collaboration and transdisciplinary dialogue in participatory planning workshops.

RESEARCH DESIGN: TRANSDISCIPLINARY MULTIPLE-CASE STUDY

Research Questions and Propositions

Interactive knowledge construction, dialogue, and consensus building through collaboration are essential in participatory planning and TDAR and may be facilitated with the use of interactive 3-D landscape visualizations. The following research question¹ combined the premise of collaboration with the potential of interactive 3-D landscape visualization: How can different types of interactions with landscape visualizations facilitate the process and improve the outcome of participatory planning?

The planning theory literature (Friedmann 1987; Healey 1997) suggests interactive knowledge construction, dialogue, and consensus building as criteria to guide exploration of this research question.

Proposition 1: Interactive landscape visualizations can facilitate interactive knowledge construction about dynamic landscape processes. The integration of conceptual and empirical knowledge across scientific disciplines and community stakeholders is a major barrier to collaboration in landscape planning (Luz 2000) and TDAR (Fry 2001; Stokols 2006; Wiek 2007). Additional tools for interactive knowledge construction may help overcome the barrier between experts and laypeople.

Interactive landscape visualizations have greater potential than static visualizations to more comprehensibly communicate dynamic landscape processes (Bishop and Lange 2005). Interactivity enables laypeople to better understand underlying data relationships, to work across a range of scales from ground level egocentric perspectives to regional exocentric panoramic views, and to explore landscape change over time (Orland, Budthimedhee, and Uusitalo 2001). The complexity of spatial patterns and scalar changes in the landscape represented in interactive visualizations also increases the amount of information that must be considered by viewers, thereby increasing cognitive demands and potentially confounding viewer use of the visualizations (Harrower and Fabrikant 2008). Finally, there is still a lack of guidance as to the effectiveness of interactivity in different contexts.

Proposition 2: *Interactive landscape visualizations can add the flexibility necessary to facilitate open-ended transdisciplinary planning dialogues.* The “Theory of Communicative Action” (Habermas 1981) suggests that dialogue is a major premise for knowledge generation and consensus building in both participatory planning and TDAR (Healey 1997; Hirsch Hadorn et al. 2006; Stokols 2006). Visual communication and exploration of interactive visualizations (DiBiase et al. 1992; Dransch 2000) facilitate the development of mutual understanding required in public dialogue (Stokols 2006). For example, use of an animated choropleth map permitting adjustment of the map presentation proved helpful and ethical in generating dialogue among map users (Harrower and Fabrikant 2008). In contrast with static visualizations (for example, pre-rendered images) pushing participants towards predefined decisions, 3-D interactive landscape visualizations enabling users to explore alternative planning responses facilitated higher levels of dialogue among stakeholders (Orland, Budthimedhee, and Uusitalo 2001; Salter et al. 2009; Von Haaren and Warren-Kretzschmar 2006).

Proposition 3: *Interactive landscape visualizations may provide a shared platform for consensus building.* Consensus in which every stakeholder has a voice is the major goal of participatory planning processes and an important requirement in TDAR (Hirsch Hadorn et al. 2006). Often difficult or even impossible to achieve, the lack of consensus is a major challenge for TDAR (Stokols 2006) and participatory planning (Rydin 1998). Transparent communication of underlying agendas to all participants is a first step in assessing the possibilities for, and constructing consensus among, stakeholders. A shared visual platform for laying out spatial conflicts and arguments by revealing differences, misunderstandings, and potential agreements helps construct consensus.

The UNESCO Biosphere Entlebuch Case Studies

The three cases in this study examined tourism, agriculture, and forestry in the UNESCO Biosphere Entlebuch (UBE) in Switzerland. Collaboration took place in six face-to-face workshops (Table 1). The following paragraphs provide the framing of the case study site using Stokols’s (2006) thematic criteria of geographical scale, organizational and analytical scope, time frame, and education. Some of these TDAR scales and dimensions recur in the writings of other authors who have examined TDAR from the perspectives of knowledge construction (Wiek 2007) and the disciplinary integration and inclusion of community members (Tress, Tress, and Fry 2005).

Framing. The UBE served as the case study area for the VISULANDS project for two reasons: First, the area has a diverse landscape that is spatially, scenically, administratively, and culturally coherent, and is accredited by the federal government as landscape of national importance with regional park status. Second, the Biosphere management has already established a high level of public participation in regional planning. The European Union (EU) and local UBE partners made it possible to secure three years of funding (2003–2005) and

Table 1. Comparative Overview of the Three Cases.

Cases	Tourism	Agriculture	Forestry
Geographical scale	Skiing area Sörenberg up to the region	Single farms up to the region	Single forests up to the region
Organizational scope	Tourism board Skiing facilities	Farmers	Forest owners, farmers, forest department, timber industry, hunting association
	Local facilitators and teachers Scientists from multiple disciplines Local teachers	Local facilitators and teachers Scientists from multiple disciplines Local teachers	Local facilitators and teachers Scientists from multiple disciplines Local teachers
Analytical scope	Setting up a sustainable future strategy for tourism	Development of alternative management strategies	Submissions to the Forest Management Plan
Level of participation	Informal collaborative setting, self-binding	Informal collaborative setting, self-binding	1. Information, consultation 2. Collaborative planning 3. Legally binding plan outcome
Scientific scope	Climate change, Infrastructure	Subsidies, Management systems	Low market prices for timber, bark beetle damage in mono-cultures, needs for recreational activities versus protection of wildlife
Community engagement	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
Number of workshops (case units)	1	2	3

to complete the full TDAR cycle. In the beginning, the researchers and the UBE facilitator negotiated the intended goals and outcomes. All parties agreed that local planning participation must have priority at all times. In exchange, the UBE granted access to local data, technical support, and the workshops.

Geographic scale and organizational and analytical scope. All three cases were discussed across local to regional *geographical scales*, covering local landscapes as well as the entire 400 km² UBE. The participatory process used in the workshops provided for discussion of specific measures at various scales—for example a model farm—and in a range of typical landscape configurations (Table 1). Final recommendations from the workshops addressed the UBE at the regional scale.

The *organizational scope* of the VISULANDS project included researchers from landscape planning and agricultural economics at the Eidgenössische Technische Hochschule (ETH) Zürich as well as local stakeholders from tourism, agriculture, and forestry, as well as local and regional authorities collaborating across organizational boundaries (Table 1). As is often true in landscape planning, stakeholders came from diverse backgrounds and disciplines and brought diverse interests and perspectives to the process. Most farmers strongly identified with the landscape; they were committed to the stewardship of landscape resources while also feeling a need to maintain the economic viability of their agricultural enterprises. Tourism stakeholders were interested in recreational landscape functions. Controversy arose in the forestry case as farmers owning forested

tracts participated with foresters, hunters, and tourism stakeholders. Public authorities responsible for facilitating the local decision process with external scientific information also pursued their own political agendas. Creating a shared understanding in this diverse setting was a difficult task, and the single-case analyses illustrate how landscape visualization became a shared transdisciplinary platform for mutual dialogue.

A regional organization operating as an intermediary between local and state (cantonal) government manages the Biosphere. This organization was the central facilitator bringing together research, planning, and community building for the project. While the forums were open to the public, the broad criterion of inviting the participation of those stakeholders directly affected by or holding any stake in the planning topic (Healey 1997) allowed stakeholder selection to be representative without becoming unwieldy. Using the networks and resources of the Biosphere management, the stakeholder selection process started with established stakeholder groups that had previously participated in UBE forums. The homogeneity of these forums provided the continuity to ensure that the process continued beyond the end of the research project. This longer time frame ensured the continuity of stakeholders, who together could build their capacity to implement planning outcomes over time.

The *analytical scope* of the project focused on local strategies to respond to the most pressing planning issues identified from previous stakeholder workshops (such as tourism, agriculture, and forestry) (Table 1) as well as the relevant supra-regional drivers of change (for example, the liberalization of the agricultural market). While resolution of these issues received the highest priority in conduction of the TDAR process, the research team's analytical scope focused on the use of visualization tools and other factors that affected stakeholder engagement in the participation process.

Time frame. The amount of time during which stakeholders could participate in these cases was a major limitation. For example, workshop dates had to fit

around agricultural harvesting schedules to enable participation by farmers. Time constraints required researchers to plan and pretest their methods carefully (Stokols 2006), and for each workshop, time was short. To avoid influencing stakeholders by presenting pre-rendered landscape change scenarios, researchers and stakeholders collaboratively constructed visualizations of these scenarios. Storyboarding and extensive pretests were necessary to make the process of constructing the visualizations interactively with the stakeholders as time efficient as possible.

Education. Educational institutions played an important role in the process. The local agricultural school, Landwirtschaftliches Bildungs- und Beratungszentrum (LBBZ), in Schüpfheim, hosted the workshops, and its teachers were among the participants. Furthermore, local students and teachers supported the data collection. LBBZ also received outcomes of the workshops for further educational use (Table 1).

Typology of 3-D landscape visualizations used in the workshops

The workshops used 3-D visualizations containing various levels of realism (Figure 1) and different types of interactivity. Topographic 3-D maps (Häberling 2003), consisting of digital elevation models (DEMs) providing a three-dimensional representation of topography overlaid by two-dimensional corresponding aerial imagery as well as thematic map layers (Figure 1, left), constitute one form of visualization used in the workshops. Another type of visualization comprised 3-D images of vegetation and specific textures and geometries of human-made structures, raising the level of detail to realistic representations of the landscape (Appleton and Lovett 2005; Bishop and Lange 2005; Danahy 1997) (Figure 1, right). The use of 3-D maps and eye-level views of the landscape enabled coordinated representation of both synoptic and panoramic views of the broader setting (or exocentric views) as well as intimate, ground level (or egocentric) views (Orland, Budthimedhee, and Uusitalo 2001).

Figure 1. Examples of abstract 3-D map and realistic 3-D visualization types (3-D map: Schroth 2005, realistic 3-D visualization: Wissen 2005; geo-data courtesy of GIS Canton Lucerne).

Atlas cartography (Harrower and Fabrikant 2008; Hurni 2006) allows multiple types of interaction with visual representations and informs the definition of interactions in 3-D landscape visualizations. Particularly important are spatial, temporal (Figure 5), and scenario interactions allowing navigation through space, time, and themes of landscape change. We adapted the overlay metaphor (Figure 6) (combining different layers in multiple ways to create new information) and spatial analysis functions to enable representation of spatial data from axonometric 3-D perspectives (Figure 4).

Most authors (Bishop and Lange 2005; Orland, Budthimedhee, and Uusitalo 2001; Sheppard 2001; Wissen 2009) agree that varying levels of realism evoke variability in both cognitive and affective response. There is less research on the response to different types of interactions, though Von Haaren and Warren-Kretzschmar (2006) suggest that the level of interaction (or direct engagement) afforded to viewers of 3-D visualizations also impacts response. The workshops used visualizations with varying levels of realism and varying types of interaction, allowing exploratory comparisons. The setting is similar to an experiment, though it provides less control over the variables due to the limitations of the real world planning process.

Phasing and Timing of the Workshops

The face-to-face collaboration taking place during workshops at the local agricultural school was crucial. Facilitators led each of the workshops, which lasted approximately three hours. All stakeholders engaged in the workshops pro bono and outside of their normal work

hours. The workshops followed a standard workflow containing three phases (Schmid 2004):

1. Orientation (introduction)
2. Working (collecting, discussing, choosing, editing, planning)
3. Finishing (consensus building, conclusion)

Conducting the interactive construction of visualizations within a three-hour time period became an issue because of the temporal availability of stakeholders (Stokols 2006). Accomplishment of the task required significant workshop preparation and extensive procedural pretesting.

Much of the workshops' flow revolved around the planning dialogue, generated by the presentation of the abstract and realistic visualizations. Consultations before each workshop determined the content to be included in the visualizations. The construction of the visualizations involved interactions among workshop participants and researchers. The researchers rendered the visualizations presented to participants and revised them in-situ based on the ensuing dialogue as recorded in workshop proceedings. The temporal sequencing and presentation format of the abstract and realistic visualization types were coordinated with the workshop facilitator. A schedule established for each workshop defined the overall goal of the workshop and listed a description of the single tasks in the various phases of the workshop, the time available for each task, the chosen method of elaboration, the required media, and the responsible person.

Table 2. Categories of Situational Factors.

Planning topic and objectives	Individual stakeholders	Facilitation	Workshop setting
Geographical scale	Learning style	Facilitator	Place
Planning objectives	Knowledge of the topic	Level of participation Group size	Media mix
Role of topography	Knowledge of the place Role in the process	Group composition Phase of the process External input	Selection of visualizations Combination of visualizations and text

Multiple data sources in transdisciplinary action research

Use of various tools, including observations, expert interviews, and group discussions enabled the collection of multiple sets of data during the workshops. Method design and data collection focused on group rather than on individual response because participatory planning and TDAR are inherently group processes. An observation protocol guided participating researchers to look for so-called triggers in stakeholder response such as unease, gestures, or attention changes (Lewis and Sheppard 2006). Expert interviews with workshop facilitators used a shared interview protocol to gather information about process and participants (Meuser and Nagel 1991). These interviews provided information on the effect of varying stakeholder roles and discussion processes, as well as the benefits and limitations of the visualizations in generating stakeholder dialog relating to alternative proposals for landscape change.

The communicative action among researchers and participants facilitated by group discussion led to social learning and the construction of new understandings about the landscape visualization tools. All stakeholder groups engaged in 10-minute group discussions following the initial planning workshops. Questions about the representation and interactivity of the previously used visualizations guided the discussions. These questions focused on the benefits and limitations of the interactive visualizations in relation to orientation, temporal dimension, indicators, overlays, and spatial analysis. Also discussed were the 3-D maps as compared with highly realistic 3-D landscape visualizations and the role of visual landscape representation relative to stakeholder perception and information processing. Researchers triangulated data from the group discussions with other source data to increase empirical validity (Yin 2003).

Coding

Coding, a process relating data to theoretical propositions, is a standard approach to multiple case study analysis. While reviewing transcripts of the workshops, researchers assigned codes to all stakeholder quotes referring to the situational factors (such as planning topics and objectives explored in the workshop, individual differences among stakeholders, facilitation, and workshop setting) (Table 2) or to the study's basic research propositions. Reference to situational factors and guiding propositions enabled the clustering of quotes from all three cases. For example, researchers clustered quotes referring to decision making, to collaborative assessment, and to conflicts, under the proposition of consensus building. A qualitative data analysis research database (Atlas.ti) helped organize co-occurring codes identified in a software-supported query of the transcripts.

Multiple case study design and cross-case synthesis

Case study research is the in-depth, primarily qualitative investigation of a single social phenomenon based on multiple data sources. Its ability to accurately portray contemporary spatial phenomena in their real world context is strong (Whyte 1993; Yin 2003). Using meta analysis—conducting investigations across individual cases—multiple case study design increases the validity of conclusions about causation through cross-case comparison and synthesis. Typically, cross-case synthesis (Figure 2) compares and contrasts findings, insights, and propositions across multiple cases. The meta analysis of the three cases compares effects of situational factors (Table 2) and the role of interactive visualization in generating dialogue among stakeholders pertaining to landscape change.

Figure 2. Diagram of case-study method (Yin 2003, 50).

Although the sampling logic of multiple case analysis prohibits statistical generalization beyond the three cases, the qualitative nature of the meta analysis of findings across the three cases suits the technique well for examining the role of group processes in the context of collaborative landscape planning (Scholz and Tietje 2002; Yin 2003). In the context of scholarship in the design disciplines, meta-analysis in the form of a cross-case synthesis represents the disciplinary analysis of a transdisciplinary process (Thering and Chanse 2010).

SINGLE CASE ANALYSES

Case 1: Tourism

Context. The tourism infrastructure in the UBE was partially out of date and very dependent on skiing. In recent years, the number of overnight ski tourists decreased. Climate projections at ETH Zurich (Perry et al. 2007) suggest a decrease in snow cover for low altitude areas such as Sörenberg (1,165–2,350 meters above sea level). Research at the University of Zurich (Bürki 2000) and management guidelines for the UBE suggest that infrastructure investments must create more sustainable, regional, tourism development.

Transdisciplinary collaborative workshops with researchers and community stakeholders. The goal of the participatory workshop was collaborative evaluation of the future objectives for tourism in the Entlebuch area in an open forum, with relevant stakeholders. The 3-D visualizations needed to support the planning

phase of the workshop by defining the areal extent of (spatializing), and translating scientific information on climate change and its implications for touristic infrastructure. Using data collected during the workshop, researchers analyzed the performance of 3-D visualizations in fulfilling these supporting functions as well as the impact of the visualizations on the planning process and outcomes.

The workshop, facilitated by a Biosphere manager at the LBBZ in May 2004, was attended by 11 community stakeholders (10 men, 1 woman), including the cable car owners, hoteliers, a local farmer engaged in agritourism, and representatives from the Tourism Board. The visualization research team comprised two people—one navigator, who interactively prepared the content of the 3-D visualizations according to the content of the discussion, and one annotator, who explained the visualization. An additional researcher took minutes and documented the workshop with photographs.

The workshop discussed the visual landscape as a tourism asset and the implications of tourism on the landscape. Overall, the participants were of the opinion that the 3-D visualizations represented the discussion topics in a comprehensible manner, contributing evidence for Proposition 1. Interactivity was the means for communicating the effects of changes in snow-cover projections. Climate change is likely to affect local ski tourism, but the extent of change in this particular valley is unclear and could range from low impact (scenario 1) to high impact (scenario 3). The visualizations were effective in demonstrating to workshop participants how

climate change might produce landscape changes that would no longer support the existing tourism economy. Although stakeholders understood before the workshop that such changes were possible, the 3-D visualizations raised the participants' awareness and evoked an emotional reaction as they revealed the effect of the change on the local landscape. This shift in stakeholder insight was vividly illustrated by one workshop participant's comment: "The green will then be without snow!" Visualization of the differences in snow cover elevation in the three scenarios (Figure 4) was the turning point of the discussion, shifting focus from the enhancement of winter sports to diverting tourist opportunities towards hiking, educational trails, farm holidays, and making better use of the landscape as an asset. One participant, however, expressed concern about the credibility of the visualizations as related to the difficulties of applying climate change models to regional and local scales (Dockerty et al. 2006; Shaw et al. 2009). Participants reached consensus that diversification and a stronger emphasis on summer tourism should be the main objective of the future tourism strategy.

Case 2: Agriculture

Context. Agriculture, in particular cattle breeding and dairy farming, dominates the landscape character of the Entlebuch region. Traditional agriculture is likely to change due to pressing political, economic, and demographic forces such as agricultural market liberalization and an aging rural population. This will cause major changes in the landscape with negative impacts on local socioeconomic and ecological conditions. Within the framework of the EU project Landscape Development, Biodiversity and Co-operative Livestock System (LACOPE), farmers from the Entlebuch area, administrative representatives, experts, and researchers worked collaboratively on a concept for future management systems on the alpine farms.

Transdisciplinary collaborative workshops with researchers and community stakeholders. The primary

goal of the workshops, which were organized by the LACOPE research team and held at the local agricultural school, was to develop sustainable land-use practices on alpine farms that would keep forest and pastures in balance and the landscape open. At the first workshop in November 2004, 18 community stakeholders (14 farmers and 4 representatives from public offices) plus 3 researchers from LACOPE discussed the impact of future landscape developments and their consequences for alpine farms. Eight of the stakeholders and two researchers met again in June 2005 to discuss solutions for optimizing the management of alpine farms with consideration of economic and ecological factors. In close collaboration with the LACOPE and VISULANDS teams, the stakeholders developed concepts for the 3-D visualizations supporting the workshops. Presenters at the first workshop used interactive, abstract, 3-D visualizations to illustrate current spatial trends. Stakeholders attending the second workshop viewed realistic 3-D visualizations depicting landscape change over 30 years based on the agricultural trend scenario and stakeholders' descriptions (Figure 5). Workshop participants viewed the realistic visualizations for six seconds each in a continuous loop, which allowed them to examine each image several times before rendering comments. Presenters at the second workshop also used abstract visualizations to discuss analyses of the economic and ecological factors affecting landscape character. As was the case in the tourism workshops, the visualization research team consisted of a navigator preparing interactively the content of the 3-D visualizations and an annotator explaining the visualization (Figure 3).

The abstract visualizations were useful in representing spatial change in vegetative structure among open fields, meadows, and forests at varying distances from the observer. As evidenced in many participant comments, the visualizations assisted stakeholders in forming opinions about the spatial and temporal patterns of the vegetative structural change associated with a changing agricultural landscape. For example:

Figure 3. Presenting simultaneously realistic and corresponding abstract visualizations to the workshop participants (photograph courtesy of E. Ruoss).

“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).

Workshop participants discussed and ranked the evaluations of current and future management practices. The map reading skills of the participants varied considerably, and many participants mentioned the need for more time to process the images. In both workshops, lively discussions about the accuracy of the realistic visualizations’ content followed the presentations. The stakeholders responded emotionally according to their experiences and revealed varying opinions on the development of the vegetation. The visualizations supported the exchange of experience among researchers and stakeholders with diverse perspectives. In addition, the farmers stressed that they gained many new ideas about possible land uses in the future landscape.

Case 3: Forestry

Context. In the autumn and winter of 2004–2005, Biosphere management and the regional Forestry Commission organized a series of workshops with researchers from ETH Zurich and community stakeholders on the collaborative development of a forest management plan. The new forest management plan for the UBE required

an analysis of the current conditions focusing on socio-economic, ecological, and aesthetic conditions.

Transdisciplinary intersectoral workshops for designing and implementing public policies. Preparation of the forest management plan in the UBE considered several landscape functions. Multifunctional values associated with the forest included economic, ecological, and social issues connected with harvesting and hunting, species protection, recreation, and education. The workshop series brought together various interests relating to forest use and sought consensus on the spatial distribution of competing land uses in the forest. The purpose of the 3-D visualizations was to support these tasks through the translation of spatial scientific knowledge and community land-use plans into a shared visual platform for decision making.

Use of 3-D visualizations in the agricultural, tourism, and forestry workshops varied with the topics of discussion and the personal moderating styles of the facilitators. Researchers constructed a model of the entire Entlebuch region as an abstract representation of topographic and thematic maps. Following identification of relevant topics by local stakeholders, every interest group (hunters, members of the Tourist Board, Forestry Commission, and so forth) mapped onto an ordnance map its interests, which were digitized and

Figure 4. Average level of sufficient snow conditions for skiing (snow line) compared with existing infrastructure. The very dark areas represent areas without snow; black lines represent the ski lifts; and the grey polygons represent areas covered with artificial snow. The variants reoutpresent alternative climate-change scenarios (3-D visualization: Schroth 2005; geodata courtesy of GIS Canton Lucerne).

Figure 5: Realistic 3-D visualizations demonstrating the impact of agricultural management change on the view of the landscape and on the quality of the habitat (3-D visualization: Wissen 2005; geodata courtesy of GIS Canton Lucerne).

Figure 6. Visualization of conflicts in interest by the interactive overlap of two thematic maps: wildlife areas (left) and additionally summer-/winter-tourism (right) on the basis of a 3-D block model overlaid with the topographic map (3-D visualization: Schroth 2005; geodata courtesy of GIS Canton Lucerne).

stored in a geographic information systems (GIS) format for subsequent use in constructing the 3-D visualizations. This approach allowed for an overlay of varying thematic interest maps in the 3-D landscape model for the final workshop. A visualization team of two people and an observer taking minutes was present in the forestry workshop.

With the visualizations (Figure 6), the conflicting demands of various landscape functions became spatially clear to every participant. For example, stakeholders readily understood the conflict between designating an area for wildlife protection to enhance biological diversity and locating facilities for tourist activities to support recreation in the same area. Workshop participants decided that new zoning for both tourism and wildlife-protected areas must be developed in a special meeting of the relevant forest owners, foresters, hunters, and tourism experts.

Both abstract and realistic visualizations inspired the further discussion of particular topics. The clear representation of management issues in the abstract visualizations allowed participants to suggest proposed solutions. Feedback from workshop participants indicated that the interactive 3-D visualizations supported the communication of spatial situations by putting information from earlier workshops into a shared platform. Furthermore, the facilitator emphasized that the visualizations benefited the discussion and helped him to establish a task force with members of all the interest groups. In this context, an additional value of abstract visualizations was that diverse participants gained a mutual understanding of the spatial extents of underlying land-use conflicts. In the workshop,

the shared platform and the resulting shared understanding accelerated consensus building and decision making: "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" (Forestry Commission co-coordinator).

CROSS-CASE SYNTHESIS: SITUATIONAL FACTORS AND VISUALIZATION TOOLS

In the context of Stokols's (2006) characterization of TDAR, all three cases used interactive landscape-visualization tools in a common analytical scope (community workshops) across a common geographical scale (local to regional levels) and an organizational scope in which an intermediate organization facilitated interaction among researchers and local stakeholders. A cross-case synthesis conducted on the three cases investigated two elements: (1) common situational factors (Table 2), and (2) the three research propositions that interactive 3-D landscape visualizations facilitate interactive knowledge construction, dialogue, and consensus building.

Situational Factors

Situational factors constitute information (for example, regarding activities, individuals, relations, and the location) derived from observations, group discussions, and interviews characterizing the context of TDAR in this study. Corresponding quotes relating to situational factors were gathered and organized into four clusters (Table 2):

1. planning topic and geographic scale
2. individual stakeholders
3. facilitation
4. workshop setting

Planning topic and geographic scale. Each workshop's planning topic and geographic scale had impact on the specific use of interactive 3-D visualizations. Participating stakeholders made more use of the visualizations in deliberating over local as opposed to regional planning topics. When tourism and agricultural cases dealt with more place-specific issues (for example, specific farms), the visualizations were more influential in informing stakeholder opinion. Conflict among stakeholders in the agricultural case was stronger when participants discussed individual farms. Conflict resolution in the forestry case occurred only after identification of specific spatial conflicts through a stakeholder mapping session. These findings reinforce the idea that people are more likely to participate in local than in regional planning topics (Shaw et al. 2009).

Diverse stakeholder needs. To be effectively integrated into TDAR, scientific knowledge must be translated into terms salient and understandable to the engaged stakeholders. A follow-up survey investigating relationships between user characteristics and responses to the diverse visualization and interaction types found that stakeholders with lower map reading competence (measured through self-assessment) ranked highly realistic landscape visualization and spatial navigation as more effective in communicating information about landscape change than stakeholders with greater map reading abilities. Interviews with workshop participants suggested that the highly realistic landscape visualizations provided less information and more distraction than the 3-D maps. In the words of a participating journalist with high map reading skills: "Maps are clearer; visualizations are more lifelike." Both groups gave high rankings to temporal navigation techniques (Schroth and Schmid 2006).

Importance of good facilitation. Meta analysis also identified the key role of the facilitator in these case studies. While a neutral facilitator is essential for full participation of the stakeholders (Selle 2000), facilitator knowledge of visualization content and procedures is even more important in the use of landscape visualizations as a major workshop tool (Von Haaren and Warren-Kretzschmar 2006). Some of the stakeholders engaged in the tourism workshop also participated in the forestry sessions, but they used the visualizations much less frequently in the latter. Each set of workshops had a different facilitator. The facilitator of the tourism workshop effectively integrated the visualizations into the discussion, while the facilitator of the forestry workshop was less familiar with the tools and did not refer to the maps or visualizations in the discussions. In a post-workshop interview, the forestry workshop facilitator said she would have used the visualizations more if she had been more familiar with their content.

Workshop setting. Often underestimated, workshop setting and presentation have a major impact on participation. A remote, inconvenient place or a place with a negative image may prevent many people from participating (Selle 2000). In these cases, the local agricultural school was ideal because it provided the perfect local infrastructure and was linked to local education. Using the school as a workshop setting forced the researchers to engage the community on neutral ground close to the UBE.

Effectiveness of Visualization Tools

Interactive knowledge construction. In all three cases, researchers and facilitators presented findings from interdisciplinary research related to agricultural economics, forestry, and landscape planning with abstract interactive 3-D maps (Figure 1, left) to explore underlying data relationships (DiBiase et al. 1992). The objective was to support interactive knowledge construction (see Proposition 1). In the tourism case, the spatial

extents of the existing winter tourism infrastructure were compared to the proposed summer tourism infrastructure, showing that a shift towards summer tourism would result in a more dispersed infrastructure network but also in a more equal distribution of tourists throughout the UBE. One tourism stakeholder commented: “If I see how short the distances inside Sörenberg are—that are about 500m—in comparison to larger distances, which constrain themselves. You can walk there [listing some places in walking distance].”

In the agricultural case, the workshops explored the economic and ecological drivers of agricultural abandonment and, in the forestry case, conduct of a forest resource inventory involved use of interactive 3-D maps. In all cases, both stakeholders and facilitators assessed interactive features—including regional flythrough, zooming to areas of interest, and selecting thematic layers for viewing—as helpful to knowledge construction tasks.

In the tourism case, three-dimensional spatial analysis and thematic navigation at a medium level of realism permitted visualization of the tourist impacts of three climate change scenarios. Temporal animations ranging from the abstract to very high levels of realism permitted the exploration of various time steps of land abandonment in the agricultural case. Presentation of these visualizations produced strong cognitive and affective response from workshop participants as evidenced by a high number of participant gestures, signs of unease, and constructive comments. The stakeholders and the facilitators of the agricultural case judged the interactive presentation and exploration as helpful in rendering judgments concerning the issue of land abandonment.

Levels of realism and interactivity are difficult to distinguish from each other, but the abstract visualizations containing higher levels of interactivity received more cognitive responses than those presented in a static format. Highly realistic visualizations (Figure 4) with a simple level of interaction—a slideshow of time steps—evoked even stronger cognitive and additional affective responses. When asked about their preferences

for abstract or realistic visualizations shown over time, the farmers in the agricultural case wanted both. They noted that abstract and realistic landscape visualizations complemented each other in a helpful way. Both high levels of realism and temporal navigation may interact with one another in evoking cognitive and affective response. This issue requires further investigation.

With regard to the cognitive load imposed by interactive navigation, the observation notes showed—in all cases—that after the viewpoint was moved, the participants had to re-orient themselves, as manifested by initially more concentrated and subsequently more relaxed viewing. After about five minutes, they were actively involved through questions, comments, or requests. Facilitators also noticed that people needed sufficient time, guidance, and context to interpret the interactive 3-D map visualizations.

Dialogue. The workshop cases used spatial navigation, especially zooming, thematic navigation, overlays, and spatial analysis to support promotion of the open dialogue specified in Proposition 2. These interactive visualizations were rather abstract (Figure 1, left). In all the cases, facilitators or participants asked the visualization navigator to zoom into areas of interest and show the relevant information layers. For example, in the tourism case, the facilitator requested a presentation of the agro-tourism theme. When shown the locations of farms that offered bed and breakfast lodging, stakeholders shifted the discussion to sustainable tourism. In the agricultural case, individual farmers were asked to zoom in on their farms and then commented on the information layers: “Now, let’s go to Aenzihuetten.” When the visualization navigator zoomed from an exocentric overview to a detailed or egocentric view of the Aenzihuetten farm, a researcher in agricultural economics commented, “There you can see how fragmented the vegetation types are.” In the forestry case, the facilitator requested layers showing habitat zones and educational forest, stimulating responses on these topics. In the interviews, facilitators commented that the interactive visualizations helped focus the dialogue:

“The opportunity to generate any perspective supports factual discussions; all have the same image in front of them and think about it.”

At the same time, interactivity was required to keep the dialogue open and flexible enough to accommodate inputs and requests from the participants. Timing was critical, and ideally, the visualization navigator used short breaks or turned off the projection while navigating to a new area of interest. Participants became distracted when movement on the screen took place during a discussion.

The level of discourse among workshop participants, facilitator, and visualization navigator supports the proposition that using interactively developed landscape visualizations facilitates dialogue. Constant interaction among facilitator, navigator, and participants assured immediate response to stakeholder needs in the open-ended participatory planning process. The interaction among community stakeholders and researchers in constructing the visualizations allowed both parties to more fully understand the analytical scope and geographical scale of the issues under exploration. The visualizations became a shared platform enabling construction of a common mental model of the landscape among all participants.

Consensus building. Consensus building is the outcome of group processes including different types of collaborations and participants with diverse agendas, worldviews, and objectives (Stokols 2006). With regard to Proposition 3, no direct cross-case synthesis was possible because only the third case evoked conflicts requiring mediation. Though reliability and validity of the outcome would be higher with examination of all three cases, discussion of the forestry case may inform future studies.

In the forestry case study, community mapping of individual participants' interests and concerns on the interactive 3-D maps (Figure 6) helped tourism stakeholders and hunters to develop consensus on the location and nature of conflicts in forest management within the UBE. Overlay interactions and zooming in-

teractions were helpful in this case. The prospective use of this visualization technology in more contentious conflict resolution, however, remains untested.

DISCUSSION

The benefit of various types of landscape visualization depends on the planning task, the scale of the task, the planning phase, stakeholders, timeframe, facilitator, and setting. The results of this multiple case study in the UBE indicate that interactivity enhances landscape visualization by contributing to development of a more knowledge driven, dialogue oriented, and transparent participation process. The cross-case synthesis provided evidence that interaction with the landscape visualizations offered additional information, made information more transparent, and enabled the construction of new insights by diverse stakeholders. The interaction of visualization navigator (or creator) and audience facilitated the use of landscape visualization as a tool for promoting dialogue. The forestry case, which addressed a land-use conflict, supported the proposition that use of interactive 3-D visualizations promotes consensus building. Interactive landscape visualizations seem to support collaborative scenario building more readily than do traditional static computer images. These conclusions suggest the interactivity of landscape visualizations will become even more important in future.

Relationship to TDAR and Participatory Design Research

TDAR was part of the method of this research as well as part of the research subject. Although the research question focused on the role of 3-D visualization types and interactivity, Stokols's (2006) dimensions of TDAR (Thering and Chanse 2011) were always present, as portrayed in the following discussion. The cases discussed here produced changes in local and regional planning decisions for various sectors of the organizational scope of these cases. In the tourism case, a key stakeholder revised his investments in skiing facilities after visualizing the external scientific input. In the forestry case,

visualizations facilitated consensus building between two competing stakeholder groups and led to regional policy change.

All of the visualizations in these case studies were constructed by an iterative collaboration of expert capacity embodied in the visualization navigator (or creator), researchers from multiple disciplines, and the local knowledge of community stakeholders. This iterative research process with local stakeholders and experts was a key element of the project and resembles the recursive cycles typical of TDAR in the design professions (Thering and Chanse 2011).

Recommendations for the Use of the Case-Study Method in Transdisciplinary Action-Research

Deming and Palmer (2005, iv) raise the issue of case studies of plural design projects faring poorly in peer review because they often cannot “validly and reliably identify general themes through systematic inquiry across a series of similarly prepared cases.” On the other hand, the TDAR approach makes it possible to gain insight into the role of visualization in real, participatory, planning processes with community stakeholders with competing land-use interests. The use of standard protocols for conducting interviews, behavioral observations, and group discussions as well as for storing data generated from these protocols enhances the construct validity of the multiple-case studies reported in this research. Similarly, the coding and analysis of gathered data on the basis of theory-based propositions, or “working hypotheses” (Thering and Chanse 2011) enhances the internal validity of this study (Yin 2003).

The external validity of a case study or, rather, the ability to generalize from a case study, is often criticized (Feagin, Orum, and Sjoberg 1991). Yin (2003) argues that case-study results can be generalized but that it is an “analytical generalization” and not a statistical generalization. In this multiple case design, replicability of findings relating to three theoretical propositions comparisons across the three cases enhances external validity.

Given these experiences, it seems useful to transfer TDAR in general and multiple case studies in particular to other landscape related issues. One area of focus could be the evaluation of the performance of landscape architecture and planning (Faludi 2001).

Interactive visualization as shared platform for transdisciplinary action-research in the design professions

With regard to methodology, the three cases show that transdisciplinary settings are practicable and appropriate approaches to analyzing questions on landscape planning processes in their real world context. During the process, both researchers and local stakeholders learned from each other. Above all, the role of the facilitator, in linking the researchers to the local communities and guiding the use of visualization, was crucial.

Analysis of these cases suggests that the use of 3-D maps and realistic 3-D visualizations developed through the collaborative interaction of researchers and stakeholders enhanced not only the exchange but also the construction of knowledge and improved planning outcomes. The results indicate that interactivity enhanced landscape visualization and contributed to a better informed dialogue and consensus-oriented participatory process. In this context, the development and use of interactive landscape visualization serves as a shared platform for the development of mutual understanding between researchers and diverse stakeholder groups.

NOTES

1. Schroth (2010) deals with the question in more detail.

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