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Meeting the Challenges of Transdisciplinary Knowledge Production for Sustainable Water Governance

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Increasing pressure on mountain water resources is making it necessary to address water governance issues in a transdisciplinary way. This entails drawing on different disciplinary perspectives, different types of knowledge, and

different interests to answer complex governance questions. This study identifies strategies for addressing specific challenges to transdisciplinary knowledge production aiming at sustainable and reflective water governance. The study draws on the experiences of 5 large transdisciplinary water governance research projects conducted in Austria and Switzerland (Alp-Water-Scarce, MontanAqua, Drought-CH,

Sustainable Water Infrastructure Planning, and an integrative river management project in the Kamp Valley). Experiences were discussed and systematically analyzed in a workshop and subsequent interviews. These discussions identified 4 important challenges to interactions between scientists and stakeholders—ensuring stakeholder legitimacy, encouraging participation, managing expectations, and preventing misuse of data and research results—and explored strategies used by the projects to meet them. Strategies ranged from key points to be considered in stakeholder selection to measures that enhance trustful relationships and create commitment.

Keywords: Water governance; transdisciplinary knowledge production; water resource management; stakeholder integration; science–practice interface; Austria; Switzerland.

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Introduction

Sustainable water governance is gaining importance worldwide with the realization that human activities strongly affect water resources and changed water regimes affect ecosystems and thus human wellbeing. Water governance has to cope with growing uncertainties due to sociodemographic and climate change. Mountain regions such as the European Alps are likely to be especially sensitive to projected warming, precipitation, and other changes (Viviroli et al 2011). For example, the expected increase in precipitation extremes (Kysely et al 2011) is likely to increase flood risks or water scarcity (Figure 1). Moreover, the economies of many mountain regions depend heavily on water-related activities such as agricultural irrigation, hydropower production, and tourism. Rivalries among these uses have become more

frequent in recent decades (Hill 2012; Reynard and Bonriposi 2012). Because water-related problems are likely to be accentuated in the Alps, these regions provide particularly good learning opportunities for sustainable water governance.

Various authors postulate an urgent need for more flexible, adaptive, and integrative approaches to adequately address the growing uncertainty and complexity in water management (eg Gleick 2003; Pahl-Wostl 2007; Milly et al 2008; Viviroli et al 2011). These approaches should be based on reflective, participatory, and deliberative dialogue among everyone involved (Pahl-Wostl 2002; Rist et al 2007) (Figure 2). Sustainable water governance has been defined as a process “coordinating all relevant actors and their water-related...activities in a way that ensures...social and economic welfare without compromising...the supporting hydro-ecosystems in the

FIGURE 1 Agricultural irrigation in Crans-Montana-Sierre, Switzerland. (Photo by Flurina Schneider)



long term” (Wiek and Larson 2012: 3156). Current research, however, tends to focus on isolated components such as the physical system, the socioeconomic system, or technical issues (Wiek and Larson 2012). Key points for more holistic, sustainable water governance have emerged (Hedelin 2007; Pahl-Wostl et al 2010; Wiek and Larson 2012), but ways to put them into practice still seem somewhat elusive.

Transdisciplinary research may provide the missing link between sustainable water governance theory and implementation by providing so-called transformation knowledge about “whether and how practices and institutions should be changed for sustainable development” (Hirsch Hadorn et al 2006: 126; also see Jahn et al 2012). Transdisciplinary knowledge production has emerged in recent years as a new paradigm that aims to integrate different disciplinary perspectives, as well as the knowledge and interests of stakeholders, to address complex sustainability problems (eg Hirsch Hadorn et al 2006; Pohl and Hirsch Hadorn 2007; Jahn et al 2012; Lang et al 2012). It occurs when an implementation or transformation phase is already taking place. Thus, transdisciplinary knowledge production between scientists and stakeholders can be considered an important contribution to more reflective and deliberative water governance.

Recently, transdisciplinary scientists have started to develop a model, including proposed principles, quality

criteria, and success factors, for the coproduction of knowledge by scientists and stakeholders (Bergmann et al 2005; Pohl and Hirsch Hadorn 2007; Wiek 2007; Jahn et al 2012; Lang et al 2012). These include joint problem definition, assignment of appropriate roles to scientists and stakeholders, integration of different kinds of knowledge, and generation of target products for both parties. Implementing these principles in research projects, however, can be difficult (Wickson et al 2006; Truffer 2007; Wiek 2007; Lang et al 2012). Stakeholder integration is especially challenging. Therefore, Lang et al (2012) point to the need for experience-based guidelines that build on empirical success (and failure), as well as learning processes involving different scientists to create knowledge beyond the boundaries of individual projects. However, there are few scientific studies on the topic.

This article identifies strategies to address specific challenges of transdisciplinary knowledge production to promote sustainable and reflective water governance. We focus on difficulties related to stakeholder integration that were experienced in 5 large transdisciplinary water governance projects in Austria and Switzerland. We synthesize this empirical evidence with the help of a common framework, identifying 4 common challenges to effective stakeholder–scientist interactions and deriving a rich set of strategies to address them. We discuss methodological implications that apply broadly to

FIGURE 2 Stakeholders discuss sustainable water use strategies during a workshop in Veyraz, Switzerland. (Photo by M. Rey)



transdisciplinary research in general and to the sustainable management of natural resources.

Research design

This analysis is based on empirical evidence from 5 large water governance research projects carried out completely or partially in Austria and Switzerland: Alp-Water-Scarce, MontanAqua, Drought-CH, Sustainable Water Infrastructure Planning (SWIP), and an integrative river management project in the Kamp Valley. They were all designed in a transdisciplinary way and deal with issues that are highly relevant to water governance in alpine areas: water scarcity, early recognition of critical drought conditions, sustainable water infrastructure planning, and integrative river management. In addition, the projects represent a broad variety of sizes, stakeholder groups, and approaches to the form and purpose of stakeholder integration. Selection of cases was guided by 2 main criteria: focus on water governance in Austria and Switzerland and use of a high number of different transdisciplinary approaches. To select the cases, the method of theoretical sampling was followed (eg Flick

2005). Despite different perspectives, all projects integrated stakeholders in the research process to produce knowledge that would aid transformation to more sustainable practices. Table 1 gives an overview of the projects' characteristics and the types of transformation knowledge produced.

This article is the result of joint reflection by the authors, all scientists who participated in the stakeholder integration processes of these 5 projects. Thus, the research design is part of what Burawoy (1998) calls a "reflective model of science," which embraces not detachment but engagement as the broad road to knowledge. As a first step, the authors discussed challenges they experienced and strategies they adopted with regard to stakeholder integration in a 2-day structured workshop. Discussions were audio-recorded and transcribed. Next, the primary author conducted semistructured interviews with the other authors to deepen the insights, and they jointly reflected on the effects of the strategies. The workshop transcripts and interview notes were subjected to qualitative content analysis (Mayring 2010) to identify the strategies discussed in this article.

Challenges and strategies in transdisciplinary water governance projects

The following text analyzes the 4 most striking challenges experienced by the scientists responsible for stakeholder integration. All challenges concern the stakeholder–scientist interaction that is essential in any transdisciplinary project (Raymond et al 2010). The first challenge concerns the legitimacy of the stakeholders involved and of their stakes. The second concerns participation by stakeholders—which may be insufficient, for example, due to a lack of commitment or time constraints. Third is the difference between the expectations of stakeholders and those of scientists; the latter are driven by the requirements of science, even in transdisciplinary research projects. The fourth is the potential for misuse of the projects' aims, the data, and the study results. Most of these challenges have already been discussed (eg Lang et al 2012). However, we know of little empirical evidence of strategies to prevent and overcome them. The following 4 sections explore in detail strategies, both proactive and reactive, that were identified in our analysis of the projects under study as options for addressing the preceding challenges. A summary table appears at the end of each section.

Ensuring stakeholder legitimacy and balance

Stakeholder legitimacy requires a sufficient number of representatives of all groups affected by a given case (including victims, water owners, farmers, energy and tourism entrepreneurs, private users, and representatives of nature conservancy and animal protection groups) and responsible parties (eg political representatives and regional planning officers) (Lang et al 2012). In water governance projects, complexity is generally high due to the different legislative levels and disciplines involved and the large number and variety of stakeholders. In the projects under study, some parties were overrepresented—for example, a small number of individuals dominated the discussion, or so many representatives were asked to participate that the process became unmanageable. Underrepresentation was also a problem in some projects. In addition, the ideal composition of a project team was at times jeopardized by conflicts among relevant parties that were not necessarily related to the research topic but still affected people's willingness to participate.

To cope with the challenge of legitimacy, it was important to use caution in selecting stakeholder representatives. Thus, a first strategy applied on several projects was to conduct a sound stakeholder analysis. To form a team of legitimized stakeholders, problem-affected sectors and responsible parties were defined from a scientific point of view based on a clearly defined set of criteria. Hence, the existing literature, including policy

documents and reports, was reviewed, but stakeholder mapping or network analysis was also conducted (eg Lienert, Schnetzer, et al 2013). In addition, social networks were investigated to find key individuals with strong local knowledge (eg representatives of communities) who were able to draw attention to unrecognized but relevant stakeholder groups and recommend individual representatives.

A second strategy was related to ensuring a balanced group composition. Several projects applied a stratified procedure that included local, cantonal, and national representatives, as well as seemingly less important actors in the local infrastructure planning process (eg professional engineering associations; Lienert, Schnetzer, et al 2013). The fair representation of different levels and sectors, such as the inclusion of stakeholders from the local, cantonal, and national levels, increased the probability of balanced representation. The communication of clearly defined criteria for the selection process proved to be useful to justify exclusions in the case of overrepresentation. This helped explain the delineation between stakeholders who actively participated in the working group and those who could be interviewed and kept informed but would otherwise not participate themselves. The latter would be represented by someone in the working group.

A third strategy to help ensure the representatives' legitimacy was to delegate their selection to the sectors being represented. For example, it proved beneficial to include elected community representatives.

Finally, it is important to ascertain that not only the stakeholders but also their stakes are legitimized. This means that stakes must represent not individual interests but interests of an entire stakeholder group. Moreover, the entire range of interests of all stakeholder groups needs to be considered in a balanced fashion. Thus, a fourth legitimacy strategy was to promote fairness by establishing rules that encourage a just and balanced debate among stakeholders. Objectivity was encouraged in discussions involving diverse interests and led by professional moderators and mediators (Kruse et al 2010). Their techniques made it possible to differentiate between individual conflict-driven stakes and broader, legitimized stakes and to keep the discussion objective (eg Schneider 2011). Moderators scheduled the speaking time of workshop participants and supported those who were not used to advocating their interests.

Water issues always affect future generations. Their interests were considered in one of the transdisciplinary water governance projects by applying multicriteria decision analysis (Gregory et al 2012). In that project, it seemed likely that the objective of intergenerational equity would be regarded as less important by most stakeholders, because it received less weight than, for example, a safe water supply. By applying multicriteria decision analysis, the scientists were able to include the

TABLE 1 Project characteristics and transformation knowledge produced. (Table continued on next page.)

Project	Alp-Water-Scarce	MontanAqua	Drought-CH	SWIP	River Kamp Valley
Water governance issue addressed	Water scarcity	Water scarcity	Early recognition of critical drought and low-flow conditions	Sustainable water infrastructure planning	Integrative river management (flood protection)
Scale and countries	Local to transnational: 22 study sites in Austria, France, Italy, Slovenia, and Switzerland	Regional: 11 communities in Switzerland	National: Switzerland	Local and regional: towns in Switzerland	Local and regional: Austria
Stakeholders involved	Water managers; representatives of NGOs, local administration, and fields of politics and agriculture	Representatives of cantonal and communal administration, NGOs, politics, tourism, agriculture, viticulture, and hydropower	Representatives of fields of agriculture, forestry, water supply, fishery, tourism, environmental protection, and meteorology and the shipping industry	Engineers; operators; representatives of local, cantonal, and national authorities (eg water protection, drinking water quality, landscape, and fire)	Representatives of the government (transport, commerce and industry, and cultural and social affairs); the hydropower group; and fields of agriculture and silviculture and fishing and tourism associations
Main purpose of stakeholder involvement	Raising awareness on water scarcity issues and joint development of options for sustainable water governance	Joint development of options for sustainable water governance	Integration of stakeholder knowledge in the development of a drought information platform	Integration of stakeholder knowledge in the development of a procedural planning tool	Stakeholder counseling and joint development of river management options
Methods and phases of stakeholder involvement^{a)}	(B) Transnational stakeholder survey (10–30 people per country) (B+C) 3–10 workshops per pilot site during the lifetime of the project (5–30 people each)	(A) 2 workshops before and after project start (15–30 people) (B) 50 interviews, participation at local events (B+C) 12 workshops over 3 years (12 people)	(A) Stakeholder survey before the project's start (15 people); workshop with water users at the beginning of the project (15 people) (B+C) workshop (15 people)	(A+B) 27 interviews and 2 workshops (20 people) (B) 3×10 interview sets, personal contacts (C) 2 workshops with advisory board and stakeholders (about 30 people)	(A+B+C) Kickoff conference for the region (80 people); 12 workshops in 3 years at pilot sites (157 people)

TABLE 1 Continued. (First part of Table 1 on previous page.)

Project	Alp-Water-Scarce	MontanAqua	Drought-CH	SWIP	River Kamp Valley
Approach to transdisciplinary research	Social learning ^{b)} by stakeholders from different countries and scientists from different disciplines	Social learning by stakeholders and researchers from different academic disciplines	Applied, user-oriented research and development of an information platform	Social learning by stakeholders and researchers from different academic disciplines	Participatory processes for integrative river management
Transformation knowledge produced	Options for sustainable water governance in times of water scarcity; early recognition system for water scarcity	Options for sustainable water governance in times of water scarcity	Early recognition system for critical drought and low-flow conditions that is based on stakeholders' needs	Efficient procedure for sustainable water infrastructure planning	Common options for river management according to good governance practices
Sources for further information	www.alpwaterscarce.eu Hohenwallner, Saulnier, Castaings, et al 2011 Hohenwallner, Saulnier, Brancelj, et al 2011 Saulnier et al 2011	Schneider 2011 Schneider and Homewood 2013	www.wsl.ch/fe/wisoz/projekte/drought/index_EN Kruse et al 2010 Kruse and Seidl 2013 Stähli et al 2013	www.eawag.ch/forschung/init/nfp61/forschung/wasserinfrastruktur/index_EN Lienert, Schnetzer, et al 2013 Lienert, Scholten, et al 2013 Scholten et al 2013	Muhar et al 2006 Preis et al 2006

^{a)}Phases are defined as follows: (A) definition of problems and objectives, (B) analysis, and (C) solution finding.

^{b)}Social learning represents a philosophy focusing on participatory processes of social change. This implies integrating the knowledge of different people, whether they are practitioners, scientists, or experts, in a deliberative process that might lead people to change their understanding of the situation and consequently to adapt their practices (Woodhill and Röling 2000; Schneider et al 2009).

NGO, nongovernmental organization.

interests of the future generation (Lienert, Scholten, et al 2013). Table 2 summarizes the preceding findings.

Encouraging stakeholder participation

It is one thing to select a legitimized group of stakeholders; it is another to persuade them to participate and to maintain their participation and interest during the life of the research project. This challenge was central to the projects under study in many ways. Our analysis revealed that an absence of mutual trust among local partners and scientists and a lack of interest led to interrupted or declining participation by stakeholders. The projects addressed this challenge using 3 broad strategies: building trusting relationships, making the benefits of participation clear, and creating commitment.

In several projects, building trusting relationships (the first strategy) could be supported by intermediaries who

were located between science and practice. In some cases, these intermediaries had gained stakeholders' trust during earlier collaborative projects. The support of people with a good reputation in the region and the use of an individual's institutional or personal reputation proved to be of high importance. As an example for an individual's institutional or personal assets, the excellent reputation of a project leader, that of his aquatic research institute in Switzerland (Eawag), and their long-lasting relationships with the water governance community substantially increased the stakeholders' willingness to participate in the project. In addition, the strong personal commitment and dedication of the scientists and their representatives (eg professors and deans) helped foster mutual trust and personal networks. This included the devotion of time for face-to-face contacts with stakeholders on their home ground, rather than at the

TABLE 2 Strategies for ensuring balanced and legitimate stakeholder representation.

Strategy	Examples	Effects	Projects applying the strategy
1. Conduct sound stakeholder analysis.	Define clear criteria for stakeholder selection based on the underlying research problem.	Ensured content-related representativeness	Alp-Water-Scarce, MontanAqua, Drought-CH, SWIP
	Evaluate existing literature, policy documents, reports, and other documents, and conduct workshops or interviews with key stakeholders (eg community representatives).	Gave a thorough overview of the study area and actors involved	Alp-Water-Scarce, MontanAqua, Drought-CH, SWIP
	Use techniques such as stakeholder mapping, social network analysis, or both.	Enabled systematic selection of stakeholders	SWIP
2. Ensure balanced group composition.	Use sampling methods (eg stratified sampling).	Ensured balanced representation of the affected people (eg sectors, user groups, scales, and demographic groups)	Drought-CH, SWIP
	Communicate selection criteria in a transparent way.	Justified exclusions in cases of overrepresentation	MontanAqua
3. Take advantage of the legitimacy of democratically elected representatives.	Delegate the selection of the representatives to organizations representing identified stakeholder groups (eg farmers union or tourist association), and ask democratically elected representatives (eg presidents of communes) to participate.	Increased the acceptance and legitimacy of the representatives	MontanAqua, River Kamp Valley
4. Facilitate fair and balanced debate.	Provide professional moderation and mediation.	Helped ensure discussions of diverse interests and conflicts were balanced and objective	MontanAqua, River Kamp Valley
	Set up fair interaction rules at the beginning of the project.	Provided a basis for addressing problem behaviors; helped ensure interactions were characterized by respect, mutual acknowledgement, and fairness	MontanAqua
	Organize more informal workshops at the community level; nominate a group speaker; and conduct face-to-face interviews.	Allowed consideration of the needs of stakeholders who are not used to speaking in public	Alp-Water-Scarce, MontanAqua, SWIP, River Kamp Valley
	Use methods that allow consideration of the interests of future generations (eg multicriteria decision analysis or scenario planning).	Ensured intergenerational equity	SWIP

research center, or at social events that respected local traditions, such as wine tastings at the local winery. In some projects, stakeholders were strategically integrated at various steps, such as when defining the problem and research questions and when developing future visions to maintain their continuous participation.

A second strategy was ensuring that stakeholders recognized that they would benefit from their collaboration. Research aims and questions needed to reflect local problems (eg property destruction and lack of adequate flood protection) to raise stakeholders' interest in participation; at the same time, focusing on local problems decreases their investment costs. To achieve this, it was necessary to allot time for partners to express requests and for their repeated "looping and reframing" (Bader 2010). This meant that scientists repeated their understanding of what stakeholders said in a form of mirroring that demonstrated that stakeholders' contributions became part of the research. Emphasizing stakeholders' unique chance to influence the future development of their region and other benefits of participation was an effective strategy used by other projects. For example, scientists incorporated stakeholders' interests into meeting agendas and dedicated time during the meetings for stakeholders to express themselves.

Stakeholders' interest in participation was especially increased when opportunities were created in which different stakeholders were able to jointly work on an issue (eg in workshops or small working groups in which flood-affected citizens, technical experts, and local politicians together developed a vision for future local river management). This increased the possibility of finding new solutions, visions, and perspectives based on integrated knowledge of real-world local problems. Hence, it increased the benefit of participation in the water governance process. Finally, some projects found it helpful to find central meeting places, organize meetings at alternate sites convenient to different stakeholders, and set limited and clearly defined time frames.

The third strategy involved fostering commitment by establishing rules and transferring responsibility. Stakeholders agreed at the beginning of the project on how to collaborate. For example, it was important to agree on goals, confidentiality provisions, and how to deal with dropouts. Outgoing members, for instance, nominated a replacement to ensure the continued representation of their interest group. Some scientists transferred responsibility to stakeholders, for example, by asking them to organize and document certain discussions. Table 3 summarizes the preceding findings.

Managing stakeholder and scientist expectations

In the projects under study, the scientists perceived the expectations of stakeholders to go far beyond general

research requirements. Expectations ranged from fairly concrete outcomes, such as receiving an easy-to-use software program for planning water infrastructure or continuing to receive financial or technical support after the research was completed. For instance, in a project aimed at developing strategies for integrated flood management in vulnerable regions, stakeholders asked for continued consultancy support during the implementation phase. Besides these typical nonscientific tasks, stakeholders sometimes expected outcomes that went beyond contemporary technical possibilities or scientific expertise, such as a 3-week forecast of dry periods. Moreover, the variety of worldviews increased the danger of discrepancy between the expectations of stakeholders and those of scientists.

Three main strategies were used to align the expectations of stakeholders and scientists: clarification, continuing communication, and integration of practice and science.

First, most transdisciplinary scientists in this study clarified the expectations and needs of their partners and remained connected and informed—either directly in stakeholder–scientist interactions or indirectly, such as by establishing an advisory board or engaging with knowledge brokers. The advisory board was able to assess stakeholders' needs, because the participants were well connected to science and practice. Knowledge brokers (eg provincial government officials responsible for water governance) in the transnational project were important to communicate local stakeholders' expectations to scientists. Knowing all expectations, even if some could not be met, helped project managers focus preresearch activities and communicate the possibilities and limits of the project.

Second, continuing communication among the project partners enhanced social capital; it was important to stay informed about political, social, and other developments that might influence stakeholders' expectations. The communication of interim results was far more important to the stakeholders than scientists expected. For example, one project elaborated a map showing municipalities' water rights as part of a scientific synthesis concept. Even though this map only summarized information that was already known, the new visual presentation was interesting and satisfying for stakeholders. The presentation of methods to the group also made it clear how much scientific work had been done even if there seemed to be few results. This helped encourage stakeholders to form realistic expectations.

Third, several projects found it indispensable to adapt project aims and research questions to stakeholders' expectations. Therefore, scientists started at an early stage to integrate collaboratively developed first outcomes into practice, to reflect on their action, and to improve these outcomes. These trial-and-error steps made scientific sense in several projects under study because of 2 resulting benefits. First, they made it possible

TABLE 3 Strategies for encouraging stakeholder participation.

Strategy	Examples	Effects	Projects applying the strategy
1. Build trusting relationships by using reputation and interaction.	Involve recognized personalities and organizations. Involve intermediaries capable of building bridges between researchers and stakeholders and among stakeholders.	Helped convince people to participate, especially at the beginning of a project	Alp-Water-Scarce, MontanAqua, SWIP, River Kamp Valley
	Establish respectful personal relationships, for example, by maintaining regular informal contacts through bilateral interactions and social events (eg cocktail hours and excursions) and by integrating stakeholders in various project phases.	Increased trust	Alp-Water-Scarce, MontanAqua, SWIP, River Kamp Valley
2. Make participation as easy as possible for stakeholders, and make the benefits of participation clear.	Have a flexible project structure.	Helped adapt research activities to stakeholders' needs	MontanAqua, River Kamp Valley
	Apply a looping technique (repeat understanding of what stakeholders said). Get a realistic view of stakeholders' needs and the problems they face.	Enhanced mutual understanding and thus increased identification with the project	Alp-Water-Scarce, MontanAqua
	Increase the benefit of each meeting for stakeholders; for example, focus on their thematic interests, give them room to express themselves, and plan activities (eg participatory scenarios or vision development) in which participants work together on an issue.	Increased awareness of benefits and motivation to participate	MontanAqua, Drought-CH, SWIP, River Kamp Valley
	Minimize stakeholder costs (eg by limiting the length of meetings and using a central meeting place).	Allowed stakeholders to participate more fully	MontanAqua, SWIP, River Kamp Valley
	Highlight the stakeholders' relevance for the project.	Increased understanding of the meaning of participation	MontanAqua, Drought-CH, SWIP, River Kamp Valley
3. Promote commitment by establishing rules and transferring responsibility.	Define the rules of participation with the stakeholders at the beginning (eg how to deal with dropouts).	Created a sense of commitment and enabled continuing participation	MontanAqua, Drought-CH
	Organize the meetings at places convenient to less-cooperative stakeholders, or let stakeholders organize and document workshops.	Increased motivation and willingness to participate	MontanAqua, River Kamp Valley

to verify ideas and research outcomes at an early stage and thus prevent too much time from being spent on ineffective approaches. In addition, transforming research into practice, and vice versa, directly satisfied stakeholder expectations of concrete outcomes. This was

important during the research phase during which interim results and preliminary versions of products were tested. The trial-and-error practice could be supported by the early integration of intermediaries who were located between science and practice.

TABLE 4 Strategies for managing stakeholder and scientist expectations.

Strategy	Examples	Effects	Projects applying the strategy
1. Clarify expectations, possibilities, and limitations.	Collect and discuss stakeholders' expectations and needs at the beginning through interviews, advisory board, dialogue group, knowledge broker, and other methods.	Made stakeholders' expectations explicit	Alp-Water-Scarce, MontanAqua, Drought-CH, SWIP, River Kamp Valley
	Clarify possibilities and limitations of the project repeatedly.	Helped construct a common perception of the research goal and the possibilities and limitations of the project	Alp-Water-Scarce, MontanAqua, Drought-CH, SWIP, River Kamp Valley
2. Continue communication.	Invest in continuing contact.	Developed social capital and kept scientists informed (eg about changing expectations)	Alp-Water-Scarce, MontanAqua, Drought-CH, SWIP, River Kamp Valley
	Communicate research efforts, methods, and results.	Helped keep stakeholders' expectations realistic	MontanAqua, SWIP
	Present interim results.	Satisfied stakeholders' concerns and demonstrated success	Alp-Water-Scarce, MontanAqua, Drought-CH
3. Integrate practice and science.	Integrate stakeholders' needs and adapt project aims or research questions.	Met stakeholders' needs and showed that their concerns were heard	Alp-Water-Scarce, MontanAqua, SWIP
	Integrate first outcomes into practice, and work in trial-and-error mode.	Allowed reflection and improvement of outcomes, enabled balance between theory and practice, demonstrated a focus on implementation, and satisfied stakeholders' desire for concrete outputs	River Kamp Valley
	Integrate outreach activities from the beginning (support the creation of spinoffs, integrate actors located between science and practice, and integrate discipline-specific educational organizations or advisory boards).	Relieved scientists from additional nonscientific work and supported translation of research outcomes into practice	SWIP, River Kamp Valley

Some projects found it helpful to plan early for additional ways to use research results. For example, the aquatic research institute Eawag is responsible for both research and education; thus, one approach was to discuss research results not only with direct stakeholders in a workshop but also with other interested parties through the institute's education courses. The early involvement of people responsible for outreach supported scientists and helped ensure that research results were implemented. Table 4 summarizes the preceding findings.

Preventing misuse of data and research results

Water governance research problems are often complex and the subject of intense stakeholder concern and emotion. Droughts and floods can rapidly threaten quality of life, as well as property. Water is vitally important, and competition for water rights increases in times of scarcity. Thus, there is often a temptation for internal or external actors to misuse the research agenda or results, which can rapidly jeopardize the problem-solving process.

TABLE 5 Strategies for preventing misuse of data and research results.

Strategy	Examples	Effects	Projects applying the strategy
1. Moderate power imbalances to prevent misuse by actors within the project team.	Set up an advisory board.	Secured more appropriate division of responsibility	Alp-Water-Scarce, MontanAqua, SWIP
	Document communication rules in coordination with stakeholders (advisory board) at the beginning of the project.	Reduced danger of information superiority by individuals	Alp-Water-Scarce, MontanAqua, River Kamp Valley
2. Control project information to prevent misuse by actors outside the project team.	Plan public relations strategies (eg publish the purpose, possibilities, and limitations of the project on the project website).	Allowed targeted action instead of defensive reaction	Alp-Water-Scarce, MontanAqua, Drought-CH, SWIP, River Kamp Valley
	Sensitize media members regarding possible consequences of their reporting.	Encouraged mindful reporting and enhanced media willingness to cooperate	MontanAqua
	Address the media proactively.	Provided more control of media relations and the project's image	Alp-Water-Scarce, MontanAqua, SWIP
	Use interest of the media and public.	Enabled powerful scientific communication	Drought-CH

In the projects under study, misuse by internal actors (stakeholders who actively participated in the project) occurred when, for instance, powerful individuals (eg mayors) claimed the rights to sensitive research results to secure their own positions. For example, publishing existing water use data was prohibited because it could trigger public dissatisfaction and a demand to restructure access to water. In addition, the media were mentioned in some cases as having sensationalized the research topic.

Two strategies appeared to be useful to discourage such misuse. First, the moderation of power imbalances reduced the danger of information control by powerful internal actors. For example, one project established an advisory board consisting of the inner circle of the transdisciplinary scientist and stakeholder team (including the most powerful members) to reduce power imbalances. The establishment of communication rules within this board, which then collectively decided what and how to communicate to a broader public, helped prevent the manipulation of information by individuals. Nevertheless, in most projects, bilateral negotiations with some powerful stakeholders were also necessary and often made a compromise possible, such as the publication of sensitive data in a research paper but not in regional newspapers.

Second, to discourage misuse by external actors (eg inaccurate reporting by the media), it was important to establish a proactive public information strategy. This was

found to be an effective way to manage the profile of the project as it appeared in the media. Establishing trusting relationships with media representatives and encouraging media members to think about the possible consequences of their reporting increased the media's willingness to collaborate with researchers. Transdisciplinary scientists also perceived the importance of using public concern about water-related crises such as droughts and floods to communicate important project goals and results. During the lifetime of the transdisciplinary water governance project Drought-CH, a drought occurred in the research area. The scientists updated their project website and published interim project outcomes, thus taking advantage of a powerful opportunity for scientific communication. Table 5 summarizes the preceding findings.

Discussion

Analysis of the transdisciplinary water governance projects under study identified 4 key challenges. For each challenge, strategies were applied and had different effects on stakeholder–scientist interactions. Some strategies include methods that are formalized to different degrees (Newig et al 2008) and are mostly proactively applied by project managers to meet the expected challenges. Many of them are described elsewhere in the literature: they include stakeholder mapping (Grimble and Wellard 1997; Hermans and

FIGURE 3 In the tourist resort of Crans-Montana, Switzerland, water is needed for household use, leisure activities, and agriculture. (Photo by Flurina Schneider)



Thissen 2009; Reed et al 2009; Scholz et al 2009), social network analysis (Kenis and Schneider 1991; Wasserman and Faust 1994; Scott 2000), and participatory scenario or vision development (Wack 1985; Schnaars 1987; Ringland 2002). Other strategies were used in a reactive way to respond to problems that occurred during the research process, for example, starting a media campaign after sensationalist coverage in the press. Reactive strategies often are less formalized and are applied intuitively (eg presenting interim results to ensure continuous communication) or in reaction to problems that occurred. All types of strategies—formalized and less formalized, proactive and reactive—have had positive effects on the scientist–stakeholder interaction.

The results of this study show that different strategies are more suitable for different projects, depending on the size of the project, the context, and the participants. For example, it became clear that applying risk management at an early stage to prevent misuse of research results is more relevant for projects that deal with sensitive issues that receive intense public attention (eg water scarcity). Also, large and complex projects that need to integrate a range of stakeholders from different countries may have the greatest need for advisory boards or knowledge brokers to bridge the geographical or mental distances among stakeholder groups. Knowing about the effects of different strategies can help project managers select the best ways to meet the expected challenges. Many of the strategies have been realized proactively by project

managers whose knowledge and experience suggest that certain challenges are likely to occur.

The broad body of transdisciplinary literature makes it clear that the challenges found in the projects under study—ensuring the legitimacy of participating stakeholders, enabling continuous participation, aligning expectations of stakeholders and scientists, and preventing the misuse of study results—are not specific to water governance but also occur in other fields of transdisciplinary research (Lang et al 2012). The strategies employed in the water sector could also be applied to other natural resource issues, such as land use, biodiversity, and forests. Nevertheless, based on our results, we believe that the strategies are especially valid in water governance projects, which are often characterized by a range of stakeholders and a high potential for conflict due to competing interests concerning the use, availability, and quality of water (Figure 3).

We expect that the strategies described here can be transferred successfully to areas with similar governance systems, for example, in northern and central Europe. Other studies have demonstrated, though, that the governance system, power distribution among stakeholders, and cultural context have major influences on the process of stakeholder collaboration (eg Elbakidze et al 2010). Thus, further research is needed to determine whether the strategies that proved suitable in Switzerland and Austria can be transferred to mountain areas with different cultural and governance settings, such as the

Himalaya or the Andes. Similar studies comparing, for example, Nepal, Kenya, Bolivia, and Switzerland suggest that it could be possible to transfer at least the major principles of stakeholder–scientist interaction discussed in this article (Pohl et al 2010). These strategies are not, however, a ready-to-use set of guidelines for managing transdisciplinary water governance research projects. Applying them to specific projects requires scrutinizing their applicability and adapting them to the specific needs and context.

Furthermore, the results show that managing transdisciplinary water governance processes requires both flexibility and persistence. Recent research has shown that in transdisciplinary research, a range of social skills and farsightedness are demanded from both scientists and stakeholders (Kueffer et al 2012). Further research is thus needed to better determine which skills and competencies are required and how these can be developed and expanded to better support those who manage transdisciplinary water governance projects.

Conclusion

The urgency of water issues in mountain regions (eg scarcity, flooding, droughts, and threats to water quality) increases the need for sustainable water governance; this in turn requires transformation knowledge, which may best be

produced through transdisciplinary research. The main finding of this analysis of transdisciplinary processes in 5 water governance projects in Austria and Switzerland is that successful transdisciplinary research in water governance depends on proactive management of stakeholder–scientist interactions. This involves the following:

- Selecting appropriate stakeholders and encouraging fair interactions to establish the legitimacy of their involvement;
- Establishing trusting relationships, making the benefits of participation clear, and promoting commitment to enable continuous stakeholder participation;
- Aligning differing expectations of scientific and nonscientific actors by continuing communication and integrating practice and science; and
- Preventing the misuse of the project by moderating power imbalances and controlling the release of project information.

This study contributes to closing an identified research gap in the transdisciplinary field (eg Lang et al 2012). It offers empirically grounded recommendations on how to design a transdisciplinary process in water governance and how to prevent and respond to some of the most important challenges when coordinating multiple water governance actors.

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