Allegretti, A. M., J.L. Thompson and M. Laituri. 2015.
Engagement and accountability in transdisciplinary space in Mongolia: principles for facilitating a reflective adaptive process in complex teams.
Knowledge Management for Development Journal 11(2): 23-43
http://journal.km4dev.org/

Engagement and accountability in transdisciplinary space in Mongolia: principles for facilitating a reflective adaptive process in complex teams

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This paper explores how *reflective adaptive processes* (RAPs) may facilitate communication in transdisciplinary research and examine stakeholder engagement across funders, researchers, and research end users. RAP is a change process wherein participants collectively question, reflect, and address challenges facing research and teamwork. We examine RAPs through frameworks of reflective inquiry, systems thinking, social and transformative learning, and participative reflection. We introduce a case study of the *Socio-ecological complexity* (SEC) project in Mongolia to highlight stakeholder complexity, knowledge integration, and potential tensions in transdisciplinary research. Bridging theory and lessons from the SEC project, we provide stakeholder engagement and accountability indicators for research teams and organizations to reflect and take action. Based on literature and SEC experiences, we provide our lessons learned and principles for facilitating RAPs across transdisciplinary research teams. These principles may facilitate the communication of transdisciplinary research needs, transformative learning, and the development of outreach action plans for bridging science-management gaps.

Keywords: reflective adaptive process; transdisciplinary research; stakeholder engagement; complexity; Mongolia

Natural resource management problems are experienced, understood, and evaluated differently by diverse stakeholders. Transdisciplinary research may be critical for a comprehensive approach in addressing these problems and engaging diverse interest groups or stakeholders (Klein, 2008; Lang et al., 2012; Stokols, 2006). Transdisciplinary research teams in academia involve researchers from multiple disciplines with the goal of integrating knowledge, language, and methods for developing novel conceptual frameworks (Miller et al., 2008; Roux, Stirzaker, Breen, Lefroy, & Cresswell, 2010; Stokols, 2008). These frameworks have the potential to address societies' complex socio-ecological issues and contribute to greater theoretical and

applied knowledge useful across disciplines and various stakeholders (Roux et al., 2010). Transdisciplinary research goes beyond emphasizing researchers as the producers of information and involves collectively managing challenges through the processes of social learning and stakeholder engagement (Miller et al., 2008; Mollinga, 2010; Stokols, 2008). As a result of these processes, disciplinary knowledge may become a shared understanding among different stakeholders with potential to bridge the science-management gap (Pohl, 2005; Roux et al., 2010). The gap involves the separation of managerial applications from the growth of scientific knowledge production, where stakeholders are typically disengaged from the scientific research process (Roux et al., 2010). While transdisciplinary research is not the panacea for engaging stakeholders in the scientific research process, the potential for bridging the science-management gap has attracted funders, researchers, and research end users to transdisciplinary research. Funders such as the National Science Foundation (NSF) attracted inter- and trans- disciplinary research projects with the capacity for linking the science-management gap and cultivating accountability for engaging diverse stakeholders.

There remains considerable work to be done on applying and evaluating transdisciplinary approaches, particularly at engaging stakeholders and integrating the knowledge and needs of funders, researchers, and research end users. Roux et al.'s (2010) framework for participative reflection outlines an application of a reflective adaptive process (RAP); where accountability indicators for bridging the science-management gap are collectively evaluated by research funders, providers, and end users (e.g., policy makers, NGOs, local citizens). Roux et al. emphasize knowledge integration and communication of stakeholder needs in transdisciplinary research. In this paper we present a case study, in which we apply Roux et al.'s RAP framework to the efforts of a transdisciplinary, socio-ecological project team. We selected the RAP framework because of the emphasis on facilitated reflection at multiple scales. As members of the project team and facilitators working with this team, we believe Roux et al.'s framework privileged the role of facilitation in ways that other transdisciplinary evaluation frameworks did not. Currently, the RAP framework falls short in articulating the micro-scale aspects of communication and the narratives and language used for sharing knowledge. In this paper, we aim to expand and adapt RAP for a complex, multi-national, transdisciplinary research project.

First, we bridge education and communication theory to understand how RAP may facilitate transdisciplinary work and research (Figure 1). We introduce a research team investigating Mongolian rangeland socio-ecological systems, henceforth the *SEC* project, to illustrate RAP's potential to facilitate and examine stakeholder engagement in transdisciplinary research (Figure 2). Then, we provide stakeholder engagement and accountability indicators for transdisciplinary research teams to reflect upon (Table 1). These indicators allow teams to collectively reflect, discuss, and examine the differential needs of stakeholders in transdisciplinary research. The

SEC project is a singular application of the RAP framework and presents stakeholder engagement indicators that may be useful for similar transdisciplinary teams working across disciplinary and national boundaries. In sharing some of the SEC project's experiences and best practices from the literature, we provide principles for applying RAP in transdisciplinary research teams (Table 2). While these principles do not serve as the blue print for all transdisciplinary teams, we hope that they will be useful in facilitating transdisciplinary communication and transformative learning in other, similar contexts.

RAP theory and transdisciplinary research

RAP is a change process where stakeholders collectively and iteratively question, reflect, and take action on issues and challenges facing their work (Balasubramanian et al., 2010; Stroebel et al., 2005). RAP's core concepts and processes include systems thinking, social and transformative learning, reflective inquiry, and participative reflection (Figure 1). These processes may facilitate the transformation from disciplinary to transdisciplinary research, especially when teams collectively reflect about their study system, roles, and relationships with team members and project stakeholders.

Stokols et al. 2008 discuss the differences among disciplinary, multi-disciplinary, interdisciplinary, and transdisciplinary research. In contrast to interdisciplinary research, transdisciplinary work involves an integrative process where researchers develop novel conceptual frameworks, methods, and languages spanning beyond discipline specific theories and involving practitioners or non-academics, end users, and policy makers at *all* stages of the research (Cummings, Regeer, Ho, & Zweekhorst, 2013; Stokols, Hall, Taylor, & Moser, 2008). It is possible for researchers to perform transdisciplinary work and yet return to disciplinary research, hence the cyclical process illustrated in Figure 1. We bridge Stokol's conceptual framework of trandsciplinarity with RAP tools of participatory reflection and processes of systems thinking, social and transformative learning, and reflective inquiry.

Systems thinking is a process for examining the interconnectedness and consequences of change within a system (Cundill, Cumming, Biggs, & Fabricius, 2012; Senge, 1997). RAP involves systems thinking by exploring relationships among research system constructs and facilitating collective thinking. RAP frames teams as complex adaptive systems (CAS) where members relate to one another in dynamic ways influencing team relationships, communication, and research outcomes (Daniels & Walker, 2001; Lissack, 1999; Stroebel et al., 2005).

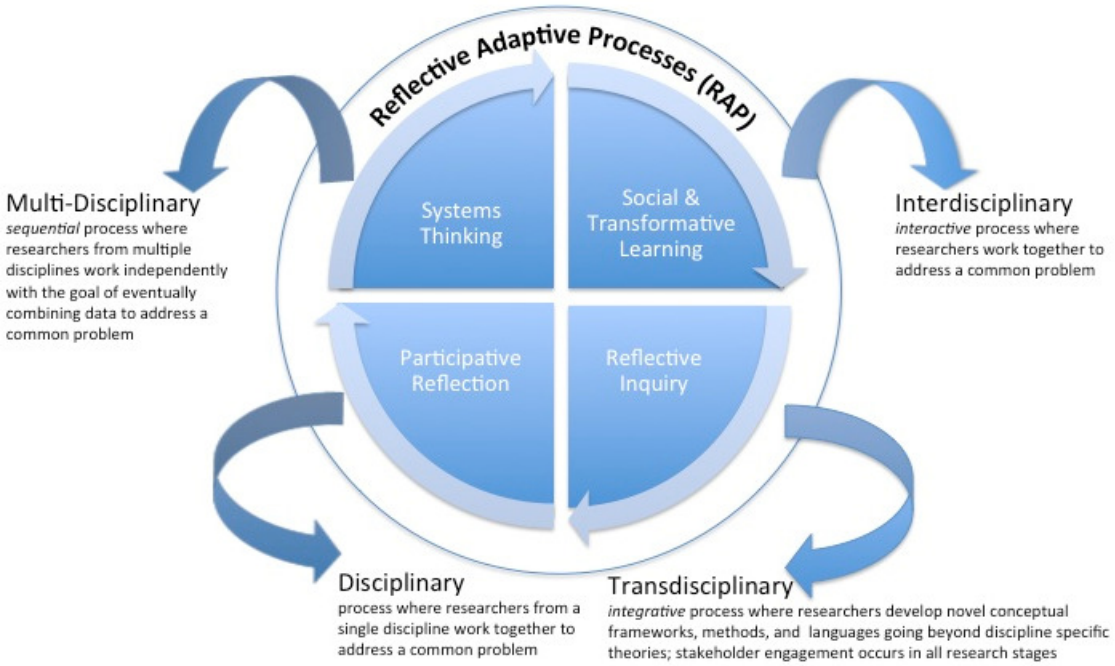

Figure 1. Reflective adaptive processes is based on social and transformative learning, systems thinking and reflective inquiry that facilitate the transformation from disciplinary to transdisciplinary research and stakeholder engagement (adopted from Stokols, 2008).

Social learning builds off systems thinking where teams collectively examine consequences of changing knowledge and management within a system (Keen, Brown, & Dyball, 2005). For transdisciplinary research teams, change management refers to the management of teams and study systems (e.g., socio-ecological system). Social learning in this context is a strategic learning-by-doing approach which facilitates collective and interactive reflection among stakeholders (Fernandez-Gimenez, Ballard, & Sturtevant, 2008). Through facilitated social learning opportunities, project team members reflect and relate their own and others' interests through collaborative deliberation (Daniels & Walker, 2001). Social learning has also been found to foundational in forming communities of practice and networks, especially as actors adapt and tune their work in achieving their goals (Cummings & van Zee, 2005).

Muro and Jeffrey (2008) describe transformative learning as a process where individuals gradually change their perspectives of the world and themselves. This transformation may occur when individuals are faced with perplexing and uncomfortable dilemmas unexplainable by current ways of knowing (Muro & Jeffrey, 2008). RAP may facilitate transformative learning, specifically when the facilitator presents these dilemmas by encouraging group reflection. In

this manner, the facilitator "holds up the mirror" to a research team, reflecting these complex issues and facilitating group experiential learning (Thompson, 2007). Tangible group experiences lead to introspection and eventually concerted action and transformation (Kolb, 2005).

Reflective inquiry is also fundamental to the RAP framework. Lyons (2010) describes reflective inquiry as examining how we think, practice, and engage the socio-political contexts of our learning to achieve reflective consciousness. We emphasize Freire's (1970) work on the necessity to actively reflect on the contexts of learning and communicating within a research team.

Participative reflection is a component of the RAP process where team members are asked to reflect on their individual and project needs, and take action on issues collectively evaluated by the team (Roux et al., 2010). The participative reflection process is similar to the reflection-plan-action cycle that may take place in a meeting or retreat, where collective reflections are shared on what and how team members are currently doing (outcomes and processes) as well as lessons learned to improve future work (Cummings et al., 2013). While program evaluation often occurs during mid-term or completion of the project, Roux et al. stress that participative reflection involves a combined intent of evaluation and reflection throughout the project to enhance collective understanding, clear purpose, and integrated action among research team members.

Roux et al. develop a framework for integrating participative reflection in the accomplishment and evaluation of transdisciplinary research. The framework includes differing emphases of success and needs of funders, research providers, and research end users as stakeholders in transdisciplinary research. The framework also allows these stakeholders or parties to purposefully co-reflect about the progress of transdisciplinary research in a manner that is structured, continuous, and adaptive throughout the research program. In our project, we have adopted Roux et al.'s framework to facilitate a participative reflection process, and we contribute stakeholder engagement discussion points and indicators as one of the key components of reflection. Specifically, we highlight the Socio-ecological Complexity (SEC) project team, which includes stakeholder roles crucial for fully examining the impact of transdisciplinary research communication and stakeholder engagement.

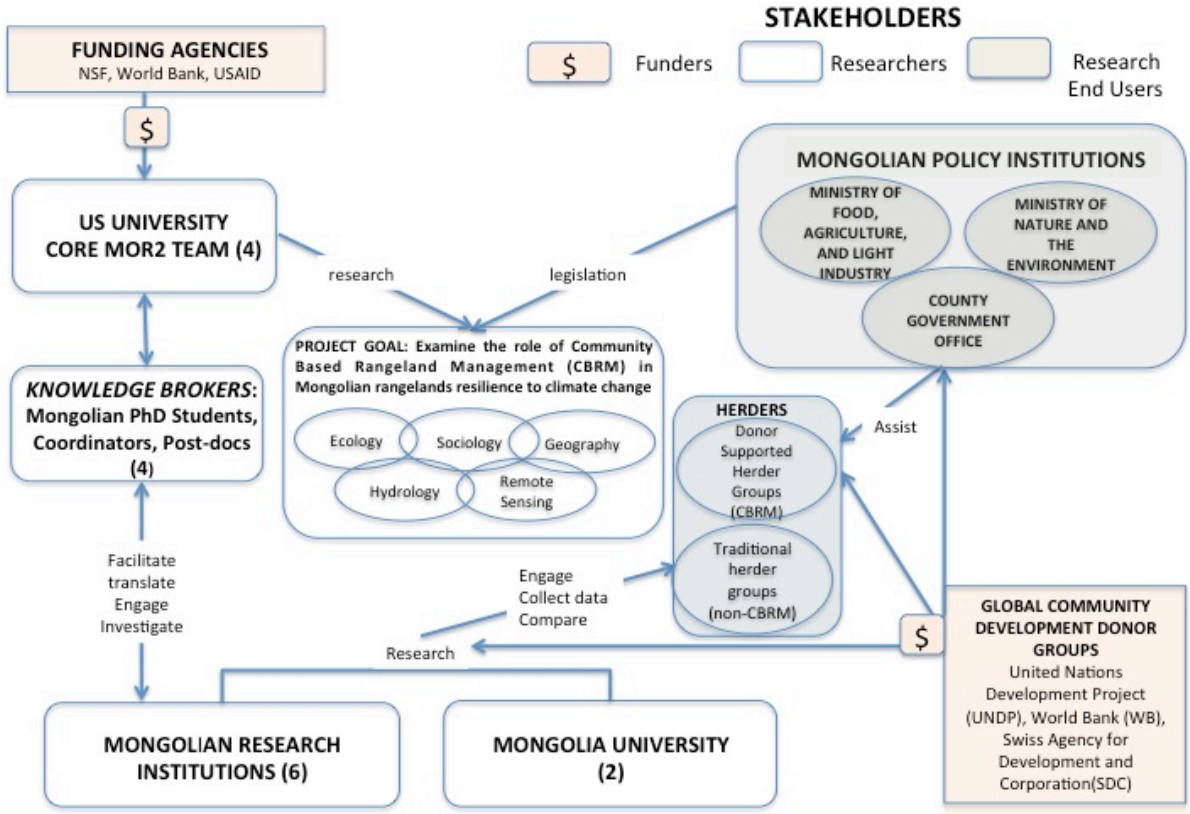

Figure 2. Complex socio-cultural research landscape where multiple actors and networks of funders, researchers, and research end users are stakeholders in the knowledge integration processes and outcomes of transdisciplinary research. Peach colors refer to funders, white for researchers, and grey for research end users. Arrows indicate roles and numbers indicate number of institutions in partnership with SEC.

SEC setting, research landscape, and stakeholders

The SEC project is a pseudonym for a transdisciplinary research project led by a team of academics at a large university in western USA. The SEC project is a multiple-scale research effort, with numerous levels of stakeholders, which includes the funders, researchers and research end users (Figure 2). SEC's examines how climate change influences Mongolian rangeland socio-ecological systems and the role of community-based rangeland management (CBRM) herder groups in Mongolian rangelands' resilience. A team of US researchers partnered with Mongolian researchers, herders, and Mongolian policy institutions to examine Mongolian rangeland systems. Research hypotheses and proposal ideas were developed with Mongolian partners and herders in workshops prior to acquiring a National Science Foundation

(NSF) grant. Funding from the US Agency for International Development (USAID) Collaborative Research Support Program and the World Bank helped to develop and deliver ecological training workshops with our Mongolian partners. In SEC, herders, natural resource practitioners, and Mongolian policy institutions such as county government offices are considered research end users who may apply SEC's research results into rangeland policy and decision-making (depicted as grey polygons in Figure 2).

Researchers in SEC specialize in rangeland ecology, hydrology, geography, sociology, remote sensing, and environmental communication. These researchers are at various points in their careers, including senior and junior faculty. The SEC team also includes Mongolian post-doctoral and PhD students serving as *knowledge/cultural brokers* and *boundary spanners* who facilitate team communication with Mongolian partners and US researchers (Figure 2). Knowledge brokers and boundary spanners are those who bridge knowledge across disciplinary and cultural boundaries essential for adaptive-capacity building and collaboration (Cheruvelil et al., 2014; Meyer, 2010; Pennington, 2008; Williams, 2002). In SEC, some tensions and challenges include integrating knowledge, engaging stakeholders, facilitating accountability in project roles and duties, and sustaining commitment among US and Mongolian researchers. SEC's knowledge brokers address these tensions by translating languages, ideas, and knowledge crucial for project logistics and stakeholder engagement.

SEC's complexity reminds us that knowledge integration does not function in isolation; rather it is embedded in the management of relationships, institutions, and norms. Researchers and practitioners represent different departments and institutions, each with varying resources and norms specific to their department and disciplinary paradigms. For example, many of our Mongolian partners were educated and trained under the Soviet research model, which is much different from the scientific method used in Western research institutions. It is not our purpose to analyze all the interactions between these stakeholder relationships, but to recognize the role that disciplinary and institutional distinctions play when reflecting on knowledge integration and stakeholder engagement within transdisciplinary and multi-cultural endeavors in research and development.

Methods

This project is part of a larger ethnographic case study, in which we are using qualitative methods to explore, explain and better understand knowledge integration and communication processes within coupled natural-human systems research teams. In this paper, we focus on transdisciplinary team communication, accountability, and stakeholder engagement processes.

The authors of this paper are part of the SEC research team and consist of two co-PIs and a PhD candidate. As participant observers and researchers, we take part in all team events, such as writing sessions, monthly meetings, workshops in Mongolia, and social events since the inception of SEC in 2010. The relationships developed during the last four years cultivated camaraderie and trust crucial for gaining emic perspectives of transdisciplinary team communication.

We provided a 'consent to participate' letter to team members, where we clarified our research intentions, potential products (e.g., publications), and confidentiality limitations, including the possibility of identities being indirectly recognized due to the size and closeness of the team. The PI and all co-PIs, graduate students, and post-doctoral fellows signed this consent to participate form. The team was also aware of our role as participant observers and our research goals of examining communication and knowledge integration within transdisciplinary research teams. This awareness, we believe, created a communication climate in which team members were encouraged to express their thoughts about the team in personal interviews, emails, and team events. As participant observers and SEC team members, we are aware of social desirability biases where respondents provide comments believed to be desirable by the researchers. To avoid these biases, we triangulated respondents' comments at team events with follow-up personal interviews and participant observation notes.

Data collection and analyses

We conducted four years of participant observation in SEC events including monthly meetings, annual meetings, two summer field seasons in Mongolia, conferences, informal social gatherings, and annual team retreats. Our team retreats were mostly modeled after Roux et al.'s framework, where facilitators crafted participative reflection sessions based on pre-retreat interviews and writing assignments. The facilitators asked the team members to reflect and share their observations, frustrations, research needs and concerns about the project's progress in pre-meeting interviews and questionnaires. Facilitators consisted of the SEC co-PI and her PhD student.

We systematically collected detailed field notes during team events and stored team documents including annual meeting reports, meeting minutes, presentations, and website information in a team database. We also recorded and stored emails and interviews with team members (n= 27) in a separate database for maintaining confidentiality and Institutional Review Board standards. Finally, we recorded and transcribed team conversations and field reflections into 584 pages of ethnographic notes.

We have open-coded and re-coded our field notes and transcriptions of meeting minutes and interviews. Our analyses involved reflexive iterative processes for examining recurring codes and themes describing SEC communication processes. Reflexive iteration involves revisiting and connecting our data with emerging insights, leading to more polished and refined themes (Srivastava & Hopwood, 2009). Consistent with this paper's purpose, we weave in a selection of themes to illustrate SEC's experiences in participative reflection and engaging stakeholders.

Insights and discussion

Participative reflection in transdisciplinary research teams

Our interviews revealed participative reflection to be an applicable tool for our research team in integrating knowledge and gaining trust crucial for transdisciplinary research communication. A co-PI shares his thoughts about participative reflection during the team retreat:

It made things come full circle with the social, ecological, and physical data [integration] and started the whole roundabout of ideas… wow, we could bring this together! … It helped me see other places on the data that I'm working on and what could be helpful as well as how we could answer some questions not placed proposal in the beginning…[The team reflections] kept "egos in check" and focused on us working together rather than promoting own ideas…

After coding retreat interviews, we discovered that the PI, co-PIs and doctoral students shared specific expectations and tensions concerning themes of (1) time commitment to the project, (2) roles and accountability, (3) expertise, (4) translation and cross-cultural communication, and (5) funding concerns. These themes were evident in the reflections of SEC colleagues:

> *I do feel that that there is no recognition of the time commitment demanded and the competition with other activities. [time commitment]*
> *Translation is the most challenging and time-consuming business that we need to acknowledge. We might need to be less demanding in requiring things in two languages. [translation]*
> *At times feel like I've become the default 'expert' on things I know little about. It has pushed me--which is fine--and I've learned quite a lot, but my role is still a little odd. [expertise]*
> *It [project] is my major priority and I hoped it would be the opportunity of a career for many of us, but not everyone has the same level of stake in it and this shows in their level of commitment. [roles & accountability]*

Based on follow-up interviews and participant observation experiences, we found that presenting these themes and tensions in team retreats facilitated deeper reflection on researcher needs, and allowed for transparency and candor among team members. For example, one of the early career co-PIs publicly shared her challenge on being accountable for project management duties while managing another large NSF project, and her desire to move forward with new and evolving research directions outside of SEC. Instead of being critical to this co-PI's challenge and conflict, a senior co-PI empathized with her and mentioned that the early career researcher's candor made her reflect about research directions and juggling her own priorities. The candid sharing of co-PIs' perspectives during the team retreat evoked other team members to reflect on their roles. In post-retreat interviews, several team members mentioned similar challenges related to the themes of commitment and individual accountability.

Accountability and stakeholder engagement indicators for transdisciplinary teams

Accountability and stakeholder engagement in transdisciplinary research is critical, particularly for addressing societal needs and bridging the science-management gap (Mathur, Price, & Austin, 2008; Pade-Khene et al., 2013; Pahl-Wostl, 2002). Accountability involves not only being responsible for project duties, but also taking ownership over agreed upon initiatives within transdisciplinary team. Roux et al. (2010) framework for participative reflection includes accountability indicators for transdisciplinary teams to reflect upon and apply in their research project evaluation. However, accountability indicators alone are not sufficient for applying transdisciplinary research that engages and targets diverse stakeholders. Hence, we have developed stakeholder engagement discussion points or indicators for research teams to reflect upon, discuss in participatory reflection sessions, and potentially apply these for the evaluation of transdisciplinary research (Table 1). These include 1) emic or insider perspectives for engaging stakeholders, 2) stakeholder identification processes, 3) transparency on research interests, 4) time and budget for stakeholder engagement, and 5) outreach and communication efforts for diverse audiences. In our SEC experience, we feature stakeholder choice and identification indicators crucial for being sensitive to "consultation fatigue," where over engaged stakeholders may be consistently interviewed with similar questions by several local and international research groups (Reed, 2008). Our main Mongolian colleague and cultural broker for communicating SEC project logistics shared her thoughts on consultation fatigue:

> *We have to consider one fact that herders and [county] officials are not happy with so much data collection, because they are almost getting tired of different kinds of people and projects who come almost every month to collect the same information again and again without sharing the results back and with no benefits to them.*

Table 1. Stakeholder engagement and accountability indicators in transdisciplinary research (Adapted from Roux et al., 2010)

Stakeholder	Stakeholder Engagement Indicators	Accountability Indicators
Research Funders/ Donors	*Broader Impacts:* Research focuses on societal needs identified by stakeholders *Methods and Stages of Engagement:* Involves stakeholders at initial research stages and informs stakeholders of researcher intentions.	*Sustainability of research programs* includes inter-project learning and student mentoring. Encouraging *discourse* for strengthening relationships Research teams have *flexibility* to change methods within scientific and financial limits. Input from research are used to *improve organizational practices.*
Research Providers	*Researchers apply emic perspectives* that are culturally meaningful and relevant to stakeholders (Albrecht, Freeman, & Higginbotham, 1998). *Stakeholders Choice and Identification Process:* Researchers are sensitive to consultation fatigue (Reed, 2008). *Transparency on Research Interests:* Researchers clarify intentions and outcomes. *Appropriate Time and Budget:* Partners and researchers feel that sufficient time and budget is set aside for stakeholder engagement. *Overall Outreach Efforts*: The research team provides sufficient time to communicate research to different audiences in appropriate multi-cultural contexts.	*Authorship Inclusivity*: Researchers develop transparent guidelines or a protocol for authorship. *Data Sharing*: Protocols for data-sharing are developed, accepted and complied by *all* research team members. *Capacity building*: Students and researchers are mentored throughout the entire project. *Leadership and facilitation* of time and space to go beyond individual tasks and discuss team experiences in a safe and open environment. *Budgeting contracts and Compensation of Research Partners:* Appropriate budgets and compensation are openly discussed *Commitment:* Researchers are committed to the project during the entire course of the research program.
Research end users (e.g., Policy makers, NGOs, citizens)	*Beneficiaries:* Identifying which stakeholders will benefit the most from the research. Trade-offs inevitably exist in identifying beneficiaries. Being transparent about trade-offs may enable research end users to reflect on and target non-participants appearing to be excluded from the research project. *Bridging the stakeholder-researcher divide:* The presentation of research findings involve culturally appropriate stakeholder engagement strategies. *Integrating Stakeholder Feedback:* Stakeholder perspectives communicated to researchers for matching research direction with societal needs.	*Adoption and organizational capacity*: Partners have the funding and technical capacity to sustain and conduct research. *Adaptive decision-making and policy revision*: Research end users can incorporate findings into their management plans and policies. *Co-location*: Research partners can host research staff and students for conducting field research.

The team's sensitivity to the tension of consultation fatigue and the willingness to engage stakeholders inspired the discussion of outreach plans and funding. These included a Mongolian nationwide radio talk show and a *soum* book funded by SEC and the *Center for Collaborative Conservation*. The radio show broadcasted an honest dialogue about project intentions and preliminary results on the social outcomes of community-based herder groups in Mongolia. The *soum* book was written in Mongolian and co-created by SEC Mongolian colleagues, local Mongolian teachers, and herders who partook in SEC ecological training workshops and field data collection. This book showcased local herder observations of rangeland health and hydroclimatic events for each *soum*, SEC preliminary data, and participatory maps created by local herder groups. The *soum* book and radio show are the result of SEC's team reflection on engaging our Mongolian research partners and herders as stakeholders within SEC. The stakeholder engagement indicators that we provide may enable other researchers to be sensitive to diverse stakeholder needs and the interrelationships of their research within the larger societal context. Note that SEC's knowledge and cultural brokers such as our Mongolian PhD students, Post-docs, and coordinators facilitate the SEC team to take action on stakeholder engagement and accountability needs within SEC. SEC's knowledge brokers may also facilitate transdisciplinarity and RAP by engaging funder and research-ender users as stakeholders in our research project (Figure 1, Table 1).

Accountability indicators and discussion points for research providers include challenges of (1) authorship inclusivity, (2) data sharing, (3) capacity-building, (4) leadership and facilitation, (5) budgeting contracts and compensation of research partners, and (6) commitment. We feature these as challenges because we have witnessed tension and the need to co-reflect on these issues as participant observers in the SEC team. These challenges are evident in the PI's thoughts on authorship:

The other part is authorship and I said that we have to be careful when you are writing … people feel ownership over it…We are going to have some hard conversations on this…that is the reality and we have to be transparent about it…

Underlying these communication challenges are group research norms and trust. We found that the more candor or transparent team communication is, the more individuals are able to openly discuss related issues, such as cultural sensitivity, group acceptability, and consensus for these norms. For example, our team decided to create a formal guideline or "protocol" for authorship and data sharing. In interviews and at team meetings, team members cite the creation of this document and the related discussion as key events that facilitated greater transparency among the team. The discussion at times included direct disagreement about the protocol, particularly

when all team members do not agree upon approaches to data sharing. The SEC members share their thoughts on data sharing in a retreat:

> *We need to be careful about how we behave in terms of gatekeepers to the data…. And that is what we are setting up here… maybe that is the thing we communicate effectively to say yeah, we do have a gate-keeping situation set –up here.*
> *We just need to be transparent about our fears and concerns instead of trying to hide it or mask it.*
> *I feel a bit like I am becoming the "bad guy" on some issues—like the data sharing protocol. I sometimes feel that I am being cast as rigid and overbearingly "western" in my approach. This is uncomfortable for me. I agree there is an element of truth. But I also feel that sometimes the "culture card" is played when it is convenient and that no real/genuine effort is made to explore how we could tackle the alternative*

Despite the challenges in these conversations, it was through this conflict, tension and participative reflection that the team members were able to reflect on the social norms reinforced in the team and from external experiences. These collective reflections have lead the team, along with the full support and leadership of the PI to encourage and actively guide our Mongolian colleagues to submit proposals and dedicate a significant portion of our annual workshop in Mongolia for writing scientific proposals. Once proposals were submitted, the SEC PI travelled to Mongolia and designed a two-day workshop in scientific writing for our colleagues and Mongolian students who participated in our fieldwork. SEC also developed a conference in Mongolia open to international scholars, where SEC team members and local Mongolian students built their capacity in sharing their scientific work and learning about socio-ecological rangeland systems. Budget contracts have been carefully crafted to waive Mongolian student registration fees, obtain local sponsorships, and hire Mongolian firms for conference organization. These actions may mollify cross-cultural communication challenges and instill commitment among the SEC team and our Mongolian colleagues.

Another example of transdisciplinary and cross-cultural communication challenge in SEC is that many team members outside the United States have difficulty accessing the data collected and writing joint publications in the U.S. and Mongolia. These cross-cultural challenges are manifested when interacting with our Mongolian partners who are not fluent in English and were trained within a traditional Soviet scientific framework. Open discussions about data collection processes and methods for analysis sharply differ and fuel productive debate and reflection. This complex cultural scenario poses challenges for the team, especially the PI and our Mongolian project coordinator as knowledge brokers who continually strive to facilitate accountability and commitment among Mongolian partners while maintaining differential U.S.

and Mongolian project norms in scientific writing. We highlight these scenarios to acknowledge the diverse ways in which science is approached and negotiated within the team. Examining intra-group differences within a transdisciplinary team sheds light on conflicting norms manifested through data sharing guidelines and communication styles differentially expressed and validated by academic disciplines and cultures. While conflict, tension, and issues of power may be inherent in transdisciplinary research teams, we have found that collectively and openly reflecting on group research norms such as authorship and data sharing guidelines is essential for achieving sustained commitment, transparency, and trust. These findings corroborate with Turner et al.'s (2015) work highlighting the roles of transdisciplinary tensions and team leaders as they address these tensions through process-oriented and self-reflective management of complex teams.

Principles for facilitating RAP

Strong transdisciplinary teams require regularly scheduled face-to-face meetings, a facilitator and team leader to initiate open dialogue and reflection (Cheruvelil et al., 2014; Max-Neef, 2005). In complex teams, transformative learning is necessary for creating a shared understanding of the dynamic issues at play (Roux et al., 2010, Lyons, 2010). Facilitating RAP throughout research stages, especially at the initial stage is important for establishing teamwork norms and fostering a shared level of collaboration and commitment among diverse stakeholders. A key principle for facilitating RAP involves encouraging and accepting multiple ways of framing problems in transdisciplinary research. The latter is fundamental for co-creating knowledge and social learning. As Roux et al. posit, 'transdisciplinary learning involves the process of participative reflection through the sharing of experiences and ideas with others, leading to co-creation of new understanding and adaptation' (p. 737).

Lessons learned from Roux et al.'s framework for participative reflection and this case study involve the following:

1. Time and emotional energy is essential for gaining consensus among funders, researchers, and research end users.
2. Leaders must be skilled at encouraging team members to share their diverse ways of knowing and viewing the world.
3. Facilitators may apply social learning theories to enhance collective understanding among research teams.
4. Sub-teams are good only if frequent meetings and exchanges among the entire team occur. An integrative framework among sub-teams must be developed and continually communicated in the entire research team to understand how new knowledge relates to complex issues framed by various disciplines.

5. Learning in transdisciplinary teams has costs and is not efficient in an academic sense, particularly when researchers potentially change their ways of doing research to integrate other world views, cultures, and languages within the diverse research team (Goring et al., 2014; Roux et al., 2010). Despite this inefficiency, researchers commit and make the choice to invest in transdisciplinary research because they acknowledge their interdependencies among researchers for developing a holistic view of complex issues. Without this commitment, researchers may come to the realization that new paradigms will not be collectively developed. Researchers may recognize that transdisciplinary research may lessen the science-management gap as stakeholder relationships and research frameworks are collectively developed.
6. Discomfort, tension, and resistance may occur when researchers are faced with changing their mode of thinking, sharing data with individuals from different disciplines, and doing research (Turner, Benessaiah, Warren, & Iwaniec, 2015; Rüegg et al., 2014). However, discomfort may often be an indicator as a team shifts from being multi-disciplinary to being transdisciplinary (Roux et al., 2010). Change, discomfort, and reflection are inherent aspects of learning (Daniels & Walker, 2001; Lyons, 2010) and transdisciplinarity (Turner et al. 2015). Despite this discomfort, researchers thrive on learning and may recognize that commitment to learning may entail change, critical discourse, and sharing of diverse experiences and perspectives.
7. Personal team relationships cultivate trust and develop a sense of community moving beyond the research effort. These relationships foster candor within a team to bring up conflict and project issues, reflect on team accountabilities and collectively come up with options for engaging research end users and funders as stakeholders of transdisciplinary research.

Applying the lessons learned from our SEC experiences, we now summarize guiding principles for applying RAP (Table 2) for other transdisciplinary teams to adopt and adapt. These principles are also based on theoretical frameworks of social learning, systems thinking, and reflective inquiry with applications in adaptive co-management and transdisciplinary research (Armitage et al., 2009; Berkes, 2009; Biggs et al., 2011). While time and budget limitations make it challenging for funders and research-end users to develop and attend RAP sessions, discussing stakeholder engagement during RAP sessions enables transdisciplinary teams to openly acknowledge the role of power and the research project's influence on diverse stakeholders. Committing time to understand differing views bridges multiple knowledge systems and promotes a shared understanding of complex issues and appropriate management options (Armitage et al., 2009; Berkes, 2009; Biggs et al., 2011).

Table 2: Guiding principles for applying RAPs	
Principles and strategies	Description and rationale
Collectively developing a mission-vision for a clear identifiable set of norms, goals, and social interests	An agreed-upon mission capacitates individuals to efficiently work toward goals shared by the research team and/or organization (Armitage et al., 2009; Stroebel et al., 2005).
Creating and incentivizing time and space for participatory reflection	Fostering safe environments and time for reflection allows diverse worldviews to be openly shared within teams and organizations (Biggs et al., 2011; Stroebel et al., 2005). Projects that have little or no in-built space for reflection will not have the capacity to effectively engage in a transdisciplinary learning network (Cummings & van Zee, 2005).
Establishing norms for conflict management and flexibility	Standards for conflict management acknowledge that conflict and power differentials inevitably occur in research teams and organizations. Shared standards for conflict management will clarify individual interests, instead of positions that may divide the research team. Flexibility in these standards provides opportunities for individuals to express specific experiences that influence positions and interests (Berkes, 2009; Cheruvelil et al., 2014; Daniels & Walker, 2001).
Bridging and co-producing multiple knowledge systems	Integrating different ways of knowing enhances holistic views of complex issues. (Armitage et al., 2009; Berkes, 2009)
Supportive leadership and facilitation	Supportive leadership facilitates the open discussion of diverse perspectives (Berkes, 2009; Lang et al., 2012; Stroebel et al., 2005).
Democratizing the distribution of power	The facilitator redirects control and power among stakeholders to foster the communication of varying interests (Berkes, 2009).
Collective experimentation	Individuals within an organization collectively experiment with methods for understanding complex issues. Collective experimentation engenders group experiences crucial for transformational learning (Berkes, 2009).
Creating collective cognitive agency, responsibility, and accountability	Collective cognitive agency involves the capacity of individuals to unify interests and collectively act in sync based on shared experiential learning (Roling & Jiggins, 2001). Individuals are accountable for communicating their interests essential for holistic views of study systems (Berkes, 2009).

Conclusions

The guidelines for facilitating RAP are the result of participative reflection within the SEC team and literature combining theory on RAP and adaptive management (Table 2). These guidelines are presented as principles for facilitating transformative learning and engaging stakeholders crucial in complex teams. Our SEC project probed into how RAP can serve as a tool for transdisciplinary teams to facilitate, apply, and collectively examine stakeholder engagement across funders, researchers and research end users in transdisciplinary research.

Roux et al. (2010) stress that program evaluation should consider reflection on research team achievements in the context of society's needs and goals. The role of participative reflection in transdisciplinary research is critical in fostering social and transformative learning, reflective inquiry, and acquiring a shared understanding of complex issues framed by varied disciplines, stakeholders, and worldviews. Participative reflection as part of RAP allows for adaptive management among stakeholders in transdisciplinary research (Biggs et al., 2011)

Future work could investigate the role of participative reflection on team perceptions of transdisciplinarity, and how these perceptions influence behavior and actual outcomes of transdisciplinary work and stakeholder engagement. Project views, leadership, and team relationships shift as research teams metamorphose from multi-disciplinary to transdisciplinary teams. Further research on the stages of transdisciplinarity is also warranted. What are the engagement strategies that facilitate transdisciplinary research teams to move beyond academic accomplishments (e.g., publishing in high impact journals) and foster practical action that directly changes the way socio-ecological systems are being managed? How can individuals and teams work within their institutional boundaries, and move forward with others to create environments that foster social and transformative learning? Reflecting on these questions allows scholars and practitioners to polish existing methods to match stakeholder needs as teams of funders/donors, researchers, practitioners, and research end users collectively address complex societal and natural resource challenges.

Acknowledgements

This research was supported by the National Science Foundation (NSF) Grant No. BCS-1011801. Opinions, findings, and conclusions in this material are those of the authors and do not necessarily reflect the views of NSF. The authors would like to thank all SEC team members for their willingness to reflect and especially the principal investigators for their honesty, energy and trust in this process.

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