



ORIGINAL ARTICLE

Communication processes in intercultural transdisciplinary research: framework from a group perspective

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Abstract

Transdisciplinary research (TDR) that aims at the co-production of knowledge in the process of addressing sustainability problems requires effective communication among scientists and practitioners. In international TDR cooperation, it is recognized that particular attention must be paid to intercultural communication, to enhance knowledge integration and mutual learning. However, there is little knowledge about the role of communication in TDR and how TDR group members with diverse socio-cultural backgrounds can communicate effectively. In this paper, we present a theoretical analysis on transdisciplinary communication, with a particular focus on group dynamics and intercultural communication. On this basis, we develop a framework for TDR communication that encompasses topics and indicators for successful communication. This framework was applied in a Chinese–German project conducted in Xishuangbanna, Southwest China, to guide the transdisciplinary communication processes. We focused on the development of trusted relationships among scientists and practitioners in the TDR team, while simultaneously accomplishing various tasks, such as problem framing and scenario development. In this study, we provide insights into intercultural communication in TDR, particularly in the context of Europe–Asia transdisciplinary cooperation. Our findings show that power relations, translator roles and researchers' mindsets influence effective communication and successful knowledge integration. In the future, additional attention should be paid to improving the supporting system and institutional arrangement for transdisciplinary communication.

Keywords Communication framework · Transdisciplinary research · Stakeholder · Intercultural communication · Group dynamics

Introduction

Anthropogenic perturbations in the earth system trigger irreversible environmental changes that threaten the sustainable development, and may be catastrophic for human well-being (Rockstrom et al. 2009; Steffen et al. 2015). With the United Nations' new development agenda, “Transforming our World: The 2030 Agenda for Sustainable Development”

(United Nations 2015), a mutual responsibility of developed and developing countries for solving global problems has been emphasized. Disciplinary science alone is inadequate to react to the multiple objectives and uncertainty of sustainability problems (Höchtel et al. 2006). Research increasingly calls for “scientifically robust” and “socially relevant” approaches to tackle these problems (Romero-Lankao et al. 2013). Such approaches require close collaboration among actors from different scientific disciplines and diverse practitioners and societal groups in problem solving and knowledge generation (Harris and Lyon 2013). Transdisciplinary research (TDR) is an approach for addressing sustainability problems to achieve credibility, salience, and legitimacy (Brandt et al. 2013; Lang et al. 2012; Pohl 2011; Russell et al. 2008; Wiek and Walter 2009). Transdisciplinarity (TD) is defined as “a research approach that includes multiple scientific disciplines (interdisciplinary) focusing on shared problems and the active involvement of practitioners from outside academia” (Brandt et al. 2013:1). TD focuses on

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collaborative knowledge generation between scientists and practitioners—including local knowledge, scientific knowledge, and the knowledge of concerned organizations (Balsiger 2004; Wickson et al. 2006)—to investigate uncertainties and to develop solutions to sustainability problems.

As an emerging approach, TDR brings challenges of its own, such as a lack of coherent problem framing, poor knowledge integration, insufficient involvement of practitioners, and vagueness and ambiguity of results (Brandt et al. 2013; Jahn et al. 2012; Lang et al. 2012; Miller, 2012). There is often a lack of agreement among different groups of stakeholders on the problem itself (Harris and Lyon 2014; Lang et al. 2012). Such a situation might occur when scientists from several scientific traditions take different perspectives, and the same goes for various practitioners (Gibbons 1999; Tress et al. 2005). The gap between scientists and practitioners may also lead to disagreement. In situations where problems can be agreed upon, unbalanced ownership of a certain problem might arise, for instance, when practitioners are involved passively answering questionnaires with pre-defined options. When the knowledge of some groups becomes dominant, TDR is often challenged by monopolies and bias (Gaventa and Cornwall 2008). In the co-production of solutions, there is also often a gap between researchers, who focus on the precision of sound academic research and are less concerned with practice and application, and practitioners, who are interested in addressing current practical needs rather than theoretical reasoning (Belli 2010). As a consequence, the solutions for sustainability issues generated in TDR might not be applicable or accepted by practitioners.

The challenges of TDR can be partly attributed to inefficient and ineffective communication among transdisciplinary actors (Hall and O'Rourke 2014; Harris and Lyon 2014). Research on sustainability, transdisciplinarity and TDR project management calls for attention to communication in TDR, which is worded in various ways, e.g., boundary management (Cash 2001; Cash et al. 2003), the role of translators (Ginsburg and Gorostiaga 2001; Hirschhorn and Geelan 2008), and science-practice interaction (Belli 2010). However, only a few articles to date offer concrete solutions for overcoming communication challenges. For instance, Aenis (2010) attempted to discuss communication among consortium actors from the perspective of process-, organizational- and team-communication management. Hall and O'Rourke (2014) proposed heuristics tools and approaches, which are not direct solutions for communication issues but are flexible and nimble in responding to novel circumstances.

Current reflections on TDR communication issues are fuzzy and fragmented. There is no focused communication platform and no commonly shared framework for integration and collaboration among different disciplines, knowledge

types and thought styles (Brandt et al. 2013; Jahn and Keil 2015; Lang et al. 2012). Additionally, TDR communication in practice even lags behind theory because of its sophistication (Blaettel-Mink and Kastenholtz 2005); thus, a systematic framework and practical guidance are required. To this end, there is a need to develop a comprehensive understanding of communication processes with both theoretical and practical considerations to improve TDR management.

TDR is considered as “team science” because it targets issues covering various disciplines and involving multiple groups of stakeholders (Falk-Krzesinski et al. 2011; Klein 2014). Therefore, team management is indispensable and sometimes decisive for the success of such projects. To provide valuable insights for TDR management, particularly in response to communication challenges, it is important to look at transdisciplinary communication from a group perspective. Additionally, increasing international and cross-cultural cooperation adds intercultural dimensions to transdisciplinary group communication. Different groups of people from various cultural contexts—especially those from the East and the West—encounter communication difficulties and even conflicts because they fail to understand each other in their intercultural communication (Liu 2003). Therefore, the cultural aspect and its consequences should be included in intercultural transdisciplinary research.

The objective of this paper is two-fold. First, we aim to contribute to the theoretical discussion in transdisciplinary communication, with a particular focus on group dynamics and intercultural communication. Second, we intend to develop a framework for facilitating communication in TDR management. The empirical basis is a TDR project on sustainable land management in Southwest China conducted by an international transdisciplinary team consisting of German researchers and Chinese researchers and practitioners. With both theoretical discussion and an empirical case study, we intend to bring the theory further and give some practical orientations for TDR projects conducted in an intercultural context, particularly in Europe–Asia interaction.

Communication in transdisciplinary research

Communication processes and their intended outcomes can be understood using different approaches, such as transmission models (e.g., Berlo 1960; Shannon and Weaver 1949), diffusion models (Rogers 1983), signs and signification (Jakobson 1960), or cultural approaches (Newcomb 1953) that perceive that people construct social reality by constantly communicating values, attitudes, and ideas. In a transdisciplinary context, Wiek (2007) distinguished four modes of communication in terms of knowledge generation among scientists and practitioners: (1) one-way information, a unidirectional relationship in which information goes from

scientists to practitioners or the other way around; (2) mutual one-way information, a bi- or multi-directional relation to exchange relevant information; (3) collaborative research, where scientists and local experts jointly generate (new) knowledge based on their expertise; and (4) joint decision making, where transdisciplinary actors pass the new insights on to strategic agents for decision making. The ultimate goal of TDR communication is for groups of both scientists and practitioners to reach co-construction and generate knowledge collaboratively (Balsiger 2004; Wickson et al. 2006). As Hall and O'Rourke (2014: 121) stated, “Transdisciplinary communication is best captured in a socio-cultural conception of communication as the co-construction of meaning in pursuit of a goal.”

Several models have been developed to illustrate communication among scientists and practitioners. Lang et al.'s (2012) model consists of a sequence of three phases: team building and collaborative problem framing (phase A); co-producing solution-oriented and transferable knowledge through collaborative research (phase B); and (re-)integrating and applying the produced knowledge in both scientific and societal practices (phase C). Similarly, Hall et al. (2012) proposed a four-phase model: (1) the development phase, defining the primary goal and the relevant scientific and societal problem; (2) the conceptualization phase, developing research questions, hypotheses, a conceptual framework, and a research design as a group; (3) the implementation phase, carrying out the primary goal and stabilizing the membership of the group; and (4) the translation phase, applying research findings to address real-world problems. These models are commonly accepted in the TDR literature with slight differences in wording (e.g., Jahn 2008; Scholz et al. 2006); they begin with problem identification and end

with joint decision making or implementation. However, in practice, the distinctions of different phases are not clear-cut, and the phases often overlap and iterate. In addition, such three- or four-phase models often merge team building and task activities, and they fail to provide insight on how the team reacts to the problems and how the team members interact.

Transdisciplinary communication from a group perspective

Group communication

Transdisciplinary processes are seen as “communication and cooperation between scientists and practitioners, usually within a group, with the aim of a joint, integrative resolution of societally relevant problems” (Aenis 2010: 507). In TDR, various groups of actors communicate at different levels and in different domains, namely, intra-group communication, inter-group communication, and transdisciplinary communication, as shown in Fig. 1.

1. Intra-group communication manifests within a group. Researchers of a certain discipline or non-academic stakeholders (such as politicians, experts, and farmers) communicate with each other directly, share a similar field of knowledge, and focus on the task of solving the problem from their perspectives. A large group could be subdivided into more precise sub-groups, e.g., a farmer group might include large farm owners, smallholder farmers, and active innovators, according to different classification criteria, e.g., their capacities or assets.

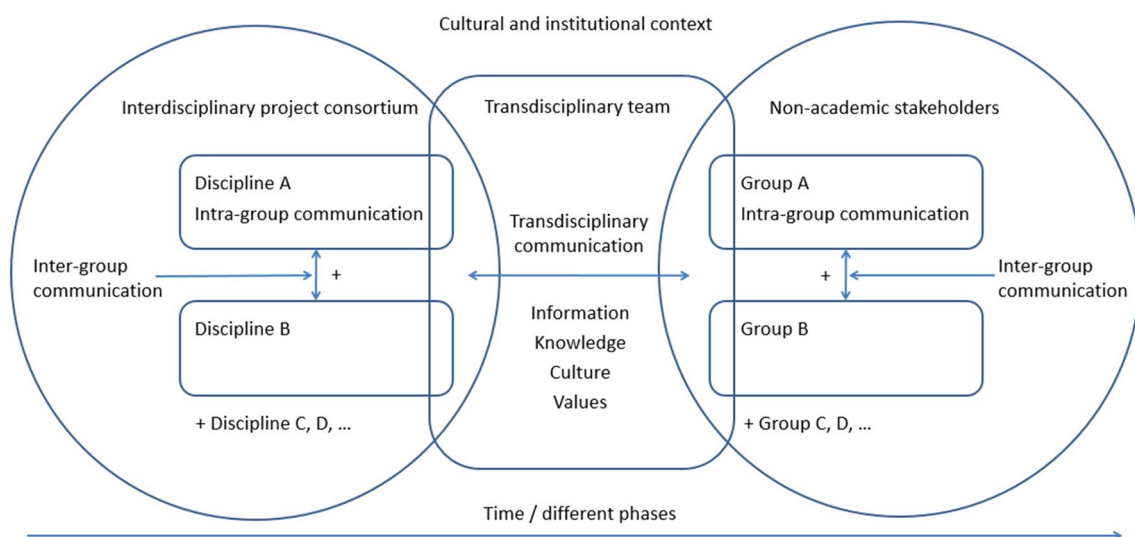


Fig. 1 Group communication in TDR. Note: Authors' illustration

2. Inter-group communication is indirect and more complex than communication within a group. Despite having common interests, researchers from different disciplines might face difficulties in communication since they hold different ontological, epistemological, and methodological perspectives. Communication is even more complex and difficult when the interactions occur across non-academic stakeholder groups and/or are related to dynamic social contexts, power relations, and hierarchies.
3. Transdisciplinary communication crosses the boundary between research and practice. It is conceived as a multi-layered relationship with various networks and nodes involving information exchange between actors from different groups. As shown in Fig. 1, TDR projects involve various groups of actors, but not all of the actors are involved in transdisciplinary communication processes. Transdisciplinary communication takes place in transdisciplinary teams, where representatives of various groups meet, interact, and lead the TDR work. For effective communication and successful TDR, a transdisciplinary team must be large enough that the team embraces diverse perspectives and knowledge types but small enough for the team members to build relationships with one another (Harris and Lyon 2014).

Transdisciplinary group dynamics

Groups go through typical development stages, as Tuckman (1965) first proposed based on his observation of group development in the settings of group-therapy and human relations training-group. These stages are as follows: (1) forming: coming together and becoming orientated, (2) storming: power struggle and conflict resolution, (3) norming: development of cohesiveness and open exchange, and (4) performing: functioning as a team and engaging in highly productive cooperation towards common goals. Later, he added “adjourning” as the fifth stage in the model to refer to the termination of the group (Tuckman and Jensen 1977). Each stage is characterized by a specific frame, purpose, observable behaviors and feelings. Tuckman’s five-stage model has been applied in group development outside the therapy context (Cassidy 2007). This model is useful for describing the way people work together, understanding the development process, and predicting the stages of growth in groups (Bonebright 2010). However, Tuckman’s model does not explain how a group moves from one stage to the next, and the development processes are more complex in reality than linear models can reflect (Gersick 1988, Miller 2003, Rickards and Moger 2000). Despite these issues, Tuckman’s model, as a model for group development of small work groups and organizations, can reflect the transdisciplinary team building process.

Tuckman’s model of team building is inconsistent with currently well-accepted three- or four-phase models of TDR (e.g., Hall et al. 2012; Lang et al. 2012) that describe a linear problem-solving process. For instance, in Lang’s three-phase TDR model, transdisciplinary team building is accomplished in Phase A by default. This model fails to reveal the struggles in the process of team building among various actors and the difficulties of knowledge integration. Tuckman (1965) distinguished between interpersonal behavior and task activities in group development. By bringing in the perspective of group dynamics, which includes “storming” as an essential sequence, we can obtain a more profound understanding of how group members interact with each other and how they react to teamwork dynamically. Therefore, we propose that looking at transdisciplinary processes from the perspective of Tuckman’s group development stages could provide valuable insights into TDR team management in terms of both team building and problem solving.

Intercultural communication in TDR

Currently, there is a growing trend of international cooperation in TDR projects (Siew et al. 2016). While successes have been reported, communication difficulties within cross-cultural TDR groups are also raised, particularly due to the visible geographic dispersion as well as cultural differences in international collaboration. A good understanding of intercultural communication is important in TDR. Intercultural communication refers to “interpersonal interaction between members of different groups, which differ from each other in respect of the knowledge shared by their members and in respect of their linguistic forms of symbolic behavior” (Knapp 2015). Theories tend to provide various criteria to categorize different cultures and attempt to explain cultural differences in communication. In particular, as a transdisciplinary group is a work team, the work-related cultural dimensions developed by Hofstede (1984, 1990) are deemed to be suitable for use in transdisciplinary communication. His model includes aspects of power distance, uncertainty avoidance, masculinity–femininity, individualism–collectivism, and Confucian work dynamics. Hofstede argued that in their work contexts, people from different nations tend to behave differently in relation to the five cultural dimensions of the model. Being aware of these dimensions helps team members with different national backgrounds enhance the mutual understanding and mitigate conflicts among each other. From a different perspective, Hall (1976) distinguishes communication patterns in different cultures; there is high-context communication, where most of the information is implicit in transmitted messages (e.g., Chinese and Japanese), and low-context communication, where most information is explicit in transmitted messages (e.g., Americans and Germans). In another theory, Lewis (2006) classifies the

world's cultures into three rough categories: linear-actives are those who have a linear action chain doing one thing at a time (e.g., Germans and Swiss); multi-actives are those who do many things at once planning their priorities according to importance (e.g., Italians and Latin Americans); and reactives are those who listen with respect and reacting carefully to others (e.g., Chinese and Finns). From these theories and empirical evidence, we can see that different countries and sub-regions have special national cultures, and one of the greatest differences lies between the Eastern and the Western cultures. Therefore, it is necessary to take cultural dimensions into consideration during the planning and implementation of cross-cultural TDR projects.

A TDR communication framework

Table 1 shows a communication framework that comprises the stages of the group development process, key communication topics and indicators for successful communication. For each group development stage, the table outlines general issues that must be considered in all groups (G), specific issues raised in TDR teams (T), and cultural aspects in intercultural transdisciplinary cooperation (C). The indicators follow Tuckman's proposition on the distinction of social and task realms in group development stages, which can be used to determine whether TDR communication is successful, i.e., whether the goals of each stage in terms of relationship development and solution development are reached. Such indicators can help project managers or facilitators of TDR projects grasp the dynamics of team building and the process of task accomplishment, diagnose conflicts or problems precisely, and, therefore, apply appropriate countermeasures to overcome the encumbrances in each stage.

Tuckman's (1965) model did not explain multiple possible sequences or the iterative cycle of group development (Gersick 1988). In practice, groups often do not go through a definite sequence of the four stages but rather follow an iterative process (Schauppenlehner-Kloyber and Penker 2015). Therefore, in this framework, transdisciplinary communication is an iterative process rather than a single direction process, i.e., all or parts of the process are repeated with the aim of widening and deepening knowledge (Aenis 2010). In this respect, "loop activities" should be established, so that the effect of communication can be evaluated, feedback can be taken into account, and the process can be adjusted accordingly. Through active and continuous communication and collaboration throughout the lifetime of the project, all or at least most people in a TDR project can reach a favorable decision on certain solutions (Baker et al. 1999; Liu et al. 2008). In this regard, more intensive collaboration and more tolerance of questions and challenges are built on long-term strong relations that result in openness and trust among team

members (Baker et al. 1999; Boon et al. 2014). It is important that every transdisciplinary project consortium be open and honest before planning communication, understand the strengths and limitations of existing communication infrastructure, and know participants and what form of communication is best suited to them.

Application of the communication framework in SURUMER project

The framework of TDR communication was applied in a TDR project—Sustainable Rubber Cultivation in the Mekong Region (SURUMER)—funded by the German Federal Ministry of Education and Research (BMBF) under the Sustainable Land Management Program (SLM). As shown in Fig. 2, the German–Chinese consortium consists of nine subprojects focusing on ecological (e.g., soil, water, biodiversity) and socio-economic (e.g., contingent valuation, farmers' livelihood) themes. In addition to interdisciplinary collaboration, a broad range of Chinese practitioners—including key stakeholders from governmental bureaus and farmers—actively participated in the project. In SURUMER, as one subproject ("knowledge transfer management", Fig. 2), a group of which the authors are members was assigned to facilitate communication processes. Our local partner Naban River Watershed National Nature Reserve Bureau (NRWNNRB) acted as the bridge between German researchers and Chinese practitioners and effectively facilitated our activities on site.

The project site is located in Xishuangbanna, Southwest China. This region has experienced robust economic growth driven by the introduction and intensification of monoculture rubber plantations which has resulted in a dramatic loss in ecosystem function in recent years. The SURUMER project aimed specifically at developing an integrative, applicable, and stakeholder-validated concept for sustainable land-use strategy in this area and wider application in the Greater Mekong region. The development of the land-use strategy required intensive communication with various groups of stakeholders to integrate scientific and local knowledge. Here, we present the relationships and tasks within the SURUMER project in the group development process, paying specific attention to the challenges and how they were solved.

Forming: come together and get orientation

The scientific disciplines and researchers involved in SURUMER were pre-determined during the project development phase (i.e., proposal writing), which is a common practice in the majority of current TDR projects. After the project kick-off, the identification and involvement of

Table 1 Framework of communication in TDR project

Group development stages	Indicators for successful communication		
	Relationship development	Solution development	
Forming	<p>G Relevant actors to the general issue Rules and principles for teamwork Goal to achieve as a team</p> <p>T Key problem to be solved considering research and practice Stakeholders related to the key problem and its solution Interests or objectives for each actor joining the team</p> <p>C Cultural backgrounds of actors Form of power distances (hierarchical or flat group structure) suitable for teamwork</p>	<p>All relevant actors are initially identified (e.g., stakeholder list) Actors are willing and able to participate (e.g., contract regulating their participation and contribution) Actors have effective channels to get to know each other (e.g., informal and formal forms, realistic and virtual channels across knowledge boundaries and geographic distance) Group structure is roughly formed</p>	<p>Core problem is defined preliminarily with general agreement (e.g., documented in memorandum or protocol) Actors agree on the objective of the TDR project Actors attempt to identify the task that needs to be accomplished in the TDR project</p>
Storming	<p>G Status, rights, and power relationships of team members Obstacles preventing team members' participation and ways to improve the engagement Conflict points and the reasons behind them Possible solutions for mitigating conflicts and reaching consensus on the key issue</p> <p>T Conflicts between scientists and practitioners on the problem and its solution Similarities and differences in different stakeholders' perspectives and possible pathways mitigating the conflicts</p> <p>C Levels of tolerance of ambiguity of team members Similarities and differences in individual values and organizational values and possible ways to integrate them</p>	<p>Team members are further discovered with more individual information on their knowledge, values, cultural background and existing relationships (e.g., stakeholder list, social network matrix, stakeholder mapping) Team members are aware of the fact that different members have different opinions Team members accept that they need to work together to generate solutions to the problems</p>	<p>Team members' interests, problems, objectives, and social relationships are identified in relation to the solution that could be used to accomplish the task</p>
Norming	<p>G Common viewpoints concerning problems and objectives Evaluation criteria for teamwork Environment of psychological safety</p> <p>T Applicability of the objective, i.e., whether it is possible to reach within the scope of the research project Legitimacy of the objective, i.e., whether it reflects both the needs of both researchers and practitioners Relevant scientific and local knowledge regarding the identified problem and possible solutions Critical awareness of the strengths and weaknesses of one's own and other disciplines</p> <p>C Competitiveness and cooperativeness of team members Atmosphere for exchange (e.g., high-context communication or low-context communication)</p>	<p>Group routines (e.g., frequency of meetings) are stabilized Team members accept the membership and are willing to contribute to the teamwork Team members respect others' knowledge and opinions Team members are willing to express their ideas and communicate with each other Rights and responsibilities of team members are identified (preferably in written terms, e.g., contracts and protocols) Open atmosphere and communication channels are established for exchange Harmony is ensured</p>	<p>The focal problem, objective, and TDR evaluation criteria are defined with the agreement of team members The identified focal problem addresses the concerns of all team members Scientific and local knowledge on the problem are collected Shared language is created among researchers and practitioners in place of disciplinary jargon Information and knowledge are exchanged among all team members via multiple channels and documented</p>

Table 1 (continued)

Group development stages	Indicators for successful communication	
	Relationship development	Solution development
Performing	<p>G Generating new knowledge by integrating existing knowledge</p> <p>T Possible solutions to the problem which could be accepted by both scientific and social bodies</p> <p>Synergies, priorities and trade-offs</p> <p>Implementation strategies for application in both science and practice</p> <p>Activities and measures should be carried out by different stakeholders towards implementation</p> <p>C Persistence of team members (e.g., long-term orientation or short-term goal)</p>	<p>Topics discussed are common interests of team members</p> <p>Issues investigated in the project are important for local stakeholders</p> <p>Hybrid new insights are produced with contributions from both science and practice</p> <p>Co-created knowledge contributes to the solutions</p> <p>The solution is defined, and the measures are clarified as instruction for implementation</p>

Own processing based on Bagnol et al. (2016), Balsiger (2004), Bracken et al. (2014), Brandt et al. (2013), Hall (1976), Hall et al. (2012), Harris and Lyon (2013), Hadorf et al. (2006), Hofstede (1984, 1990), Jahn et al. (2012), Jahn and Keil (2015), Klein (2004), Lang et al. (2012), Mitchell et al. (2015), Pohl (2011), Popa et al. (2015), Russell et al. (2008), Schauppenlehner-Kloyber and Penker (2015), Scholz and Steiner (2015a,b), Tuckman (1965), Wickson et al. (2006), Wiek and Walter (2009)

Chinese practitioners were initiated to build the team. After continuous discussion with SURUMER researchers as well as local project partners and key informants, a consensus was reached that the team would include as representatives researchers, village heads/innovative farmers, prefectural decision makers, and provincial decision makers. All relevant stakeholders were invited to the first stakeholder workshop and confirmed the name list for the TDR group after a round of self-introduction. SURUMER researchers became familiar with the local context and reached key practitioners, and local stakeholders showed interest in SURUMER. The preliminary sustainability problem was identified as monoculture rubber cultivation and its negative consequences on the environment in the study area. With the common orientation towards a regional sustainable development goal, there seemed to be a good basis for TDR cooperation.

The main challenge at this stage was that Chinese practitioners were suspicious and passive at the very beginning, and they were hesitant to participate in SURUMER activities. This was mainly due to the different perceptions of power distance between academic professionals and social groups as well as between the Germans (as foreigners) and local Chinese. German researchers are used to working in a low-power distance environment with flat organizational arrangements, where they get together and express their ideas openly. In contrast, Chinese practitioners, especially those working in administrative bureaus, are used to communicating in a high-power distance environment characterized by hierarchical structures. To overcome this challenge, we formed two strategies: first, we obtained access to these stakeholders via personal networks and met with them on informal occasions, to present SURUMER and raise their interest. Second, we authorized our workshop by sending stakeholders formal invitation letters in the name of our local partner NRWNNRB. These strategies succeed in bringing together relevant stakeholders in the first workshop and setting up the common orientation for later cooperation.

Storming: power struggling and resolving conflicts

As the project went on and the interaction intensified, conflicting situations emerged. In addition to fundamental disagreements among disciplines on ontological, epistemological, and methodological issues, poor communication between German researchers and Chinese practitioners was the main obstacle. Chinese practitioners doubted the purpose of the SURUMER project because they felt they were mistreated as an information source, as information was collected from them mainly through open discussions on the workshops and semi-structured interviews. They expected researchers to deliver information that could be beneficial to their work. However, such expectations were not met at the beginning. The difference in the perception

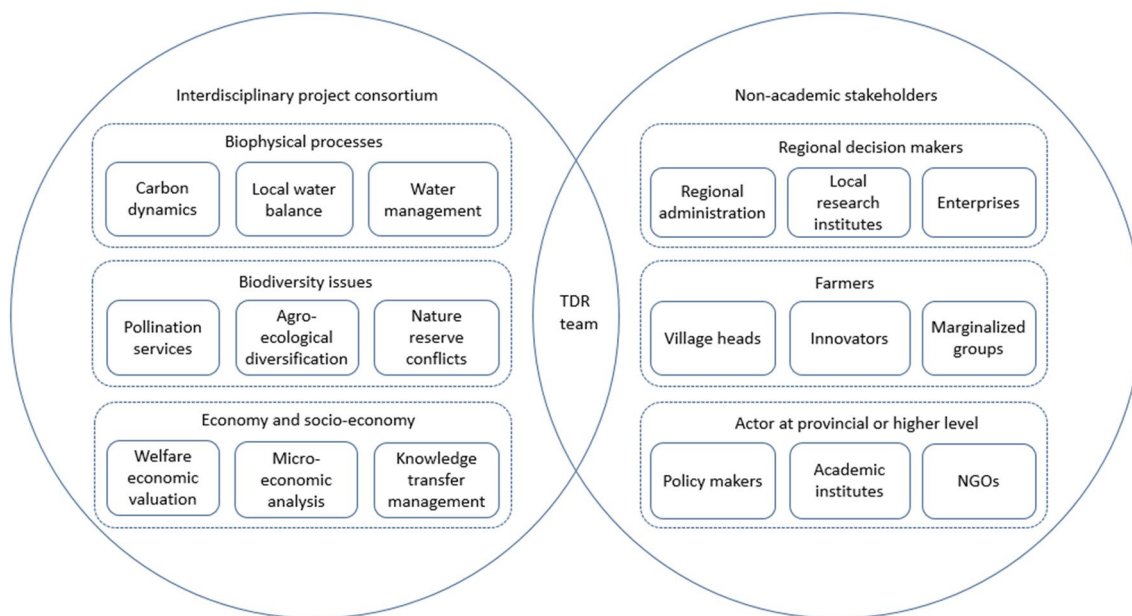


Fig. 2 Group communication in SURUMER project. Note: Authors' illustration

of collaboration could be traced to the different working dynamics between Eastern and Western cultures—Chinese are used to top-down working relationships instead of the open discussions or brainstorming that characterize Western working environments. Kim and Lee (1995) similarly observed the cultural disposition that Koreans are, in comparison to Westerners, more accepting of hierarchical arrangements and less comfortable with autonomy. To encourage the active participation of Chinese practitioners, we enhanced the information flow from researchers to practitioners with additional communication channels such as flyers, newsletters, and presentations of preliminary research results on workshops. We used the Chinese language, in addition to German and English, on the project website, in protocols, etc. These measures proved effective in improving communication among researchers and practitioners, but they cost much more time and human labor than planned.

Most of the researchers preferred to conduct their disciplinary scientific research without many interactive activities, such as workshops with practitioners. Some of the researchers hesitated to interact or to communicate in the intensive way that a TDR context demands. During the initial phase, the researchers did not reach a consensus about the importance of interacting with practitioners. Because of the continuous efforts made by the project management and communication work group and the pressure exerted by external project evaluators who strongly emphasized the need for science–practice interaction, the researchers then changed their attitude and engaged in interactive discussions, for example, in workshops and focus groups.

Norming: development of cohesiveness and open exchange

Conflicts that emerged during the storming stage were mitigated with enhanced communication. The relationship between the researchers and practitioners was improved by formalized cooperation through written contracts and stable personal linkages. Information and knowledge on issues to be addressed were regularly exchanged via multiple channels, including reports, newsletters, protocols, workshop discussions and informal meetings. The team started to work together towards mutual objectives with clearly defined responsibilities. The biggest challenge at this stage was that members of the team looked at the current land management situation from different angles that were clearly related to the dynamic social context, complex power relations and the vested interests of the respective actor groups. For instance, researchers focused more on ecosystem services and land-use modeling, government officers focused on the regional development policy scheme, and farmers often cared more about the on-site applicability and the impacts on income generation. Such differences show that intercultural communication occur not only across national cultures but also across professional cultures.

Stakeholder analysis and social network analysis have been shown to be useful in identifying the interests and influences of relevant actors (Lienert et al. 2013; Reed et al. 2009). Various means are dispensible to facilitating this process. For instance, people were found to express different opinions in an interview than in a workshop discussion. In the collectivism culture in China, people tend to follow the

group decision instead of opening up and expressing their ideas that might go against the group. Participants say things that are “politically correct” in an official setting such as a workshop, whereas interviews seem more private and personal. Under such circumstances triangulation of information is important (Wang et al. 2018). The regular facilitated discussions between researchers and practitioners proved to be a strong tool that allowed both sides to fully express their opinions and promoted exchange, thereby enhancing mutual understanding and learning.

Performing: functional team and highly productive cooperation towards common goals

At this stage, the main focus of the project should be on integrating the knowledge of the TDR team members using the scenario development method (see Kok et al. 2015). However, researchers focused more on developing scientific models, including multiple indicators and variable systems, to project the future of sustainable land management. Practitioners, on the other hand, considered scenarios to be merely an exercise that allowed them to imagine future possibilities. There was clearly a difference in the way that researchers and practitioners perceived scenario development. To bridge this gap, we first started to discuss with practitioners their expectations of the future, and we quantified such information into scientific modeling; later, we translated the scientific scenario into qualitative storylines to communicate with practitioners. Such processes were iterated for several rounds. After intensive exchange and discussion, the team identified a priority scenario that showed the consequences on local policies and cultivation measures. For instance, as one of the elements of the jointly developed scenario, a consensus on prioritized ecosystem services such as water quality and soil erosion emerged, and concrete solutions were discussed (e.g., a plan for water protection). It was expected at the end of the project that the jointly prioritized future land-use options could lead to implementation and that practitioners would continue executing the implementation plan even after the project was completed.

Discussion and conclusion

The focus on group processes provides closer insights into how team members interact and react to the task, and it provides an entry point for team managers and facilitators to better address communication issues in TDR. While conflicts are inevitable, the distinctions between relationship development and task accomplishment help trace the source of the problem—that is, to determine whether it is attributable to problematic relationships among individuals or tasks—and to address it effectively with more focused

solutions. We identified certain aspects that must be given attention.

First, the power relations among actors on a transdisciplinary team should not be ignored. In TDR, researchers often consider themselves to be the group that has higher power and leads transdisciplinary processes. Such power asymmetries can jeopardize the relationship between researchers and practitioners. Power asymmetries are often behind negative communication. People with higher power tend to have a lack of respect, openness and attention in relation to people with lower power. Meanwhile, lower power people tend to please their counterparties with modified information. Such negative communication often reinforces the existing asymmetric power hierarchy (Long and Vaughan 2006). To address this issue, we consider both researchers and practitioners to be equally important in our framework rather than regarding researchers as the core group of the research project who get local stakeholders involved by asking them to participate. However, this is not easy in practice because TDR projects are often initiated and planned by groups of researchers, and practitioners’ voice is lacking in the project application phase. Therefore, more attention should be paid to balancing power relations among TDR group members as early as possible to create the basis for interaction and information exchange. It is also important to define rules of communication as well as the rights and responsibilities of team members formally (in the written terms, e.g., contracts and protocols) at the group formation stage, with incentives to encourage effective communication.

Second, more attention should be paid to the role of “translators” (Belli 2010; Ginsburg and Gorostiaga 2001; Hirschhorn and Geelan 2008). In TDR, translators act as bridges that connect various cultures, languages, knowledge types and professions. The major task of translators is to translate research findings into a form that is comprehensible, plausible, and potentially useful in practice as well as to convey the interests and concerns of practitioners to researchers. Who could take the role of translator in TDR? Some suggest external professional facilitators or trained translators (e.g., Ginsburg and Gorostiaga 2001; Schuppenlehner-Kloyber and Penker 2015), while others suggest that social scientists within the project could take this role (e.g., Bagnol et al. 2016). Social scientists could provide illuminating insights into human behaviors and communicate more efficiently (Bagnol et al. 2016), but there are risks for role conflicts or multiple role ascriptions (Truffer 2007). External professionals can provide a neutral corner (Schuppenlehner-Kloyber and Penker 2015), but they might fail to do a good job because they are unfamiliar with both scientific and societal groups as well as topics to be discussed. We argue that project managers should choose translators according to the specific condition of each project. The translator is not necessarily one person or one group; rather it could be

a flow of roles. Actors who are most suitable at that time and place could take this role. Nevertheless, it is everyone's responsibility to contribute to science translate, negotiate, debate, triangulate and simplify to work together (Star and Griesemer 1989).

Third, the mindset change of researchers should be highlighted. Researchers often perceive transdisciplinary communication as an extra demand apart from their disciplinary research and may need several years to develop the respect and skills that it requires (Pohl 2005). Researchers must change their perspective from the traditional science-driven research paradigm, raise awareness of the importance of transdisciplinary communication, and enhance their communication skills. At the beginning of the SURUMER project, many researchers were strongly against intensive and regular interactions with practitioners. They were more interested in research than in communication, and some of them were not convinced about the need to interact with practitioners. This problem was overcome after project management initiated various measures to facilitate communication, encouraging active exchange between researchers and practitioners. External project evaluators who strongly emphasized the importance of interaction also helped improve communication. Improvement happens gradually rather than through a revolutionary process. Therefore, sustainable interventions and investments of time and resources are needed to build trust and establish an open working atmosphere (Aenis and Wang 2014). In the long run, an institutional arrangement is required to ensure active interactions.

To conclude, the development of sustainability solutions requires intensive and effective communication with various groups of stakeholders to integrate scientific and local knowledge into TDR projects. Effective interaction among stakeholders is based on understanding and empathy, which requires stakeholders' willingness to communicate, to work across disciplines and cultures, and to contribute enough time for participation. In this respect, it is necessary to assign more space and time for team building in TDR projects, ideally initiating contacts before starting to build trust and networks among actors. An approach that focuses on increasing the amount and quality of communication should be considered so that both researchers and practitioners are more likely to identify sustainability problems, take ownership of them, and become more engaged in producing solutions (Johnson 2012; Lynam et al. 2007). Looking closely at the group process and dynamics will help actors in a transdisciplinary team understand their interrelationships and thus facilitate and enhance the performance of the group in executing various tasks. Further research is needed for a more dynamic understanding of TDR group processes, and more attention should be paid to improving the supporting systems and institutional arrangements for transdisciplinary communication.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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