How to set up a transdisciplinary research project in Central Asia: description and evaluation

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Abstract

While there has been significant progress regarding the research mode “transdisciplinary research” (TDR) on a theoretical level, case studies describing specific TDR processes and the applied methods are rare. The aim of this paper is to describe how the first phase (Phase A) of a TDR project can be carried out in practice and to evaluate its accomplishments and effectiveness. We describe and evaluate Phase A of a TDR project that is concerned with tipping points of riparian forests in Central Asia. We used a TDR framework with objectives for Phase A and selected a sequence of methods for transdisciplinary knowledge integration. Semi-structured expert interviews for eliciting problem perceptions prepared for two transdisciplinary workshops, in which perception graphs, interest-influence diagrams and stakeholder network analyses were applied in addition to discussions in the plenary and in break-out groups. Scientists and stakeholders achieved to jointly frame the real-world problem, formulate research objectives, design a framework for knowledge integration, build a TDR team and decide on specific research activities for the main project phase. TDR context, process and products were judged by workshop participants positively, with average ratings above 3 on a scale from 0 (worst) to 4 (best). Strengths of our particular TDR approach during Phase A were the direct contact (interviews and two workshops) with potential TDR participants and the ability to allocate sufficient time and money to Phase A due to the funded project pre-phase of 1 year. TDR in countries foreign to the scientists, as in our study, is hampered by language barriers as well as by a lack of familiarity with local conditions, in particular regarding stakeholder interrelations that cannot be simply overcome by a stakeholder analysis. We believe that the presented approach for setting up a TDR project can serve as a good basis for the design of other projects.

Keywords Transdisciplinary research · Project co-design · Riparian forests · Central Asia · Evaluation

Introduction

It is state-of the art that effective environmental research needs to take a transdisciplinary research (TDR) approach (Pohl 2011). TDR is a comprehensive, multi-perspective, problem- and solution-oriented approach to a societally

relevant issue that integrates scientists from a wide range of academic-disciplines as well as non-academic actors (Pohl 2011, Hoffmann et al. 2017). To stop the negative trends in worldwide environmental degradation, a TDR approach is needed to understand the structure and processes of the social-ecological system (*system knowledge*) as well as the perspectives, values and goals of the different actors within the problem field (*target/orientation knowledge*), and to identify ways and means of achieving common goals (*transformation knowledge*) (Conference of the Swiss Scientific Academies/ProClim 1997, Mehring et al. 2017). There has been a growing amount of research on how to best conduct TDR predominately on the non-empirical, theoretical and conceptual level (Zscheischler and Rogga 2015) with suggestions for frameworks how to best link different academic disciplines and non-academic actors (Díaz et al. 2011, Lang et al. 2012, Jahn et al. 2012, Scholz and Steiner 2015, Döll and Romero-Lankao 2017). However, TDR

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practice does not keep pace with the progress of the theoretical discourse. Publications about empirical research on TDR, with coherent analyses of case studies that describe and discuss the peculiarities of TDR processes are rare. A literature review of 167 research papers of TDR with focus on land-use science by Zscheischler and Rogga (2015) found that only a minority (12%) encompasses TDR methods (e.g. Durham et al. 2014). Thus, the implementation of TDR remains a substantial challenge.

To advance TDR, analysis and sharing of experiences with concrete TDR projects is required such that the design of future TDR projects can be optimized (Zscheischler and Rogga 2015, Döll and Romero-Lankao 2017). This includes a description of successful methods but also of problems and wrong turns in the TDR process (Bergmann et al. 2005). In practice, it is challenging to initialize, frame and design the TDR process, selecting appropriate methods for collaboration and knowledge integration among scientists from different disciplines and practitioners (Luthe 2017). Each TDR process needs to be adapted to the given context, the needs of scientists and non-academic actors, the desired outcomes as well as to available money and time (Durham et al. 2014, Tobias et al. 2018). Hence, there cannot be a TDR blueprint in terms of “one-size-fits-all” (Zscheischler and Rogga 2015).

According to Lang et al. (2012), a TDR process should comprise three phases. In Phase A, the transdisciplinary team is formed, the problem is framed and the research process is co-designed. In Phase B the TDR team co-produces solution-oriented and transferrable knowledge, while the produced knowledge is (re-)integrated into both scientific and societal practice in Phase C. Phase A is crucial as it orients and enables the further TDR process during Phase B and C. It consists in a collaborative process among researchers from different disciplines and non-academic actors that jointly (1) identify, describe and frame a real-world problem, (2) define the common research objective (relevant for science and society), (3) design a conceptual and methodological framework for knowledge integration, and (4) build a collaborative TDR team. In addition, in phase A it is also necessary to plan specific research and dissemination activities for the project main phase among all project partners (Fig. 1,

adapted from Lang et al. 2012). A particular challenge is the identification and involvement of non-academic actors and the generation of the joint problem understanding and research approach. Phase A costs time and effort and needs to be financed in some way (Luthe 2017).

Still, most current research funding schemes require researchers to present a detailed research proposal with a societally relevant research problem before the start of the project, with already identified stakeholders that are foreseen to participate in the research project (Luthe 2017). This may lead to a problem framing and research design that is not co-designed by both researchers and stakeholders, i.e. the non-academic actors in the TDR, which probably prevents successful TDR with optimal research results. To warrant co-design of TDR in the projects within the research program “Tipping points, dynamics and interactions between social and ecological systems (Bio-Tip)”, the German Federal Ministry of Education and Research (BMBF) has funded a project pre-phase of 1 year. This year serves as Phase A before a potential start of a 3-year main project (Phases B and C).

The aim of this paper is to describe how the first phase of a TDR project can be carried out in practice and to evaluate its accomplishments and effectiveness. This paper consists of two parts, using a TDR project on tipping points of riparian forests in Central Asia as a case study (Sect. 2). In part 1, we describe how Phase A of the TDR case study was executed within 8 months and we present research results of Phase A (Sect. 3). Then, we evaluate the applied TDR approach based on feedback of the participants of two workshops (Sect. 4). We discuss positive and negative aspects of the selected design for Phase A (Sect. 5). Finally, conclusions are drawn. By describing and evaluating the initial phase of our TDR project, we wish to support those who plan to set up TDR projects in the future.

Case study

We participate in the project “Riparian forests in arid regions of Central Asia under pressure by use and limited water resources: definition of tipping points to ensure

Fig. 1 Five objectives of Phase A of an ideal TDR process (after Lang et al. 2012, modified)

sustainable management—ForeCeA”. In the arid regions of Kazakhstan, Kyrgyzstan and Uzbekistan riparian forests are severely threatened by intensive human use of land and water resources, with negative consequences for biodiversity and human well-being. Lack of water negatively affects rejuvenation of the trees from seeds and, eventually, the vegetative regeneration from root suckers. Further stressors are wood harvesting, grazing and browsing. This may shift ecosystem functions and services towards a tipping point, whose transgression will result in irreversible changes of the ecosystem and, finally, in degradation of the forests and related socio-economic impacts. Basic knowledge about tipping points is lacking, including which indicators can be used and their value. These tipping points need to be defined, identified and quantified to have thorough knowledge for the development of schemes for a sustainable forest management. To achieve an improved understanding of the social-ecological system riparian forest is a complex task that has to be done in an integrative manner in a TDR approach by a broad group of local and international scientists from different disciplines and non-academic actors (i.e. local and regional administration, non-governmental organizations, etc.) (Pohl and Hirsch Hadorn 2006).

Description of Phase A of the TDR process

In the following, we first describe the methods applied in each of the five steps of Phase A (Fig. 1) of the ForeCeA project. We then present the results obtained in each step and discuss them.

Methods

In Phase A of our TDR project, we wanted to achieve the four objectives by Lang et al. (2012). In addition, we wanted to plan specific research and dissemination activities so that we could write a joint proposal for the main

project phase (Fig. 1). We became directly engaged with stakeholders and local scientists as presented in Table 1.

We use the term “local scientists” for scientists working at universities in the three Central Asian Countries (CA), the term “stakeholders” for representatives of non-academic organizations (administration and non-governmental organizations) in CA and the term “project partners” for scientists of six research organizations that had been involved in preparing the proposal for the project pre-phase (five from Germany and one from Central Asia). In the following section, the methods applied for achieving the five objectives of Phase A of ForeCeA are described and the results are presented.

Identify, describe and frame the real-world problem

When writing the proposal for the pre-phase of ForeCeA, the project coordinator framed the problem to be investigated in a preliminary manner based on his previous research experience in the area, information from the project partner based in CA and a literature review. During the project kick-off meeting, the interdisciplinary project partners further framed the problem through discussions. Then, individual semi-structured interviews were conducted with representatives from governmental, non-governmental and development organizations engaged with forestry to elicit their problem perspective, goals, major research needs and constraints for a sustainable management of riparian forests. Interviews were done with the help of a student translator, information was recorded with notes, without voice recording nor transcriptions. The information was visualized by creating perception graphs (Döll et al. 2013) (Fig. 2). Perception graphs are directed graphs and a type of causal map that visualize the relationships between the actor’s goals, the factors affecting the achievement of the goals and actions that impact the factors, and thus the goal achievement (Döll et al. 2013). Perception graphs are suitable for eliciting and visualizing an actor’s perception of a particular problem field and

Table 1 Direct engagement with stakeholders and local scientists

Method	Amount of participants being:			Location	Duration	Date
	Local scientists	Stakeholders	Project partners			
Individual interviews	5	16	/	Kazakhstan, Kyrgyzstan	3 weeks	September 2017
Transdisciplinary workshop I	12 (day 1) 15 (day 2)	14	10	Bishkek/Kyrgyzstan	2 days	October 2017
Transdisciplinary workshop II	4	3	11	Frankfurt/Germany	1 day	January 2018

idea how the factor will change. Measures and actors responsible to change the factors (rectangles). An arrow with a plus indicates a positive interrelationship (an increase in factor A will cause an increase in factor B), an arrow with a minus indicates a negative interrelationship (an increase in factor A will cause a decrease in factor B)

Define the common research objective

During the interviews each stakeholder and local scientist was asked about the most important research questions and required research activities regarding tipping points of the riparian forests in CA. Then, in the World Café of workshop I research needs of stakeholders and local scientists were discussed. In the plenary, the research needs relevant for the project main phase were jointly prioritized based on the list developed in the World Café. Each stakeholder and local scientist was asked to assign a total of two points to their most important research needs. This resulted in a ranked list of the most important research needs from the local perspective. Then, the project partners assembled the ranked research needs and translated them into research objectives. These were presented to all workshop participants on the next day, and then discussed and agreed upon

in the plenary. Research objectives were later somewhat adjusted by the participants of workshop II.

Design a conceptual and methodological framework for knowledge integration

The joint production and integration of knowledge was first discussed during workshop I in the plenary and then in break-out groups divided by working packages. Here each partner discussed its contributions to the relevant working package and how collaboration with the other partners and participants in the TDR process could take place. The results of the discussions per working package were then presented and discussed in the plenary with all workshop participants. Then, based on these results, a conceptual and methodological framework for transdisciplinary knowledge production and integration was elaborated among the project partners, based on theoretic frameworks by Mehring et al. (2017) and Díaz et al. (2011) as starting points (Fig. 3).

Build a collaborative TDR team

The preliminary interdisciplinary research team in Phase A of the project consisted of plant ecologists, biogeographers, remote sensing specialists, hydrologists and scientists working on transdisciplinary methods from five German universities and one CA research organization. Five of the six principle investigators had already collaborated in a TDR project in northwestern China (Siew and Döll 2012,

Siew et al. 2016). To determine which stakeholders and local scientists to involve in the main project phase or “who is in and why” (Reed et al. 2009), a systematic stakeholder analysis was performed. According to the early definition by Grimble and Wellard (1997) a stakeholder analysis is a holistic procedure for gaining an understanding of a system by identifying the key actors and assessing their respective interests in the system. Preferably, a broad range of diverse actors with different interests, influences and perspective should be represented (Durham et al. 2014). From the wide range of possible approaches and methods for stakeholder analyses (Reed et al. 2009), we chose a three-step approach as described by Reed et al. (2009).

Step 1: identifying stakeholders and local scientists We used snow-ball sampling and semi-structured interviews (Reed et al. 2009). First, the German scientist responsible for TDR in the project developed categories for a stakeholder list according to Durham et al. (2014): Name and category of institution (governmental, non-governmental organization, development agency, research organization), key research partner or key stakeholder, role in project, reasons for the involvement of stakeholder, benefits for stakeholder to be involved and the contact person with its function and address. Then the key scientific partner in Kazakhstan and Kyrgyzstan filled out the list with the most important contacts in their country from their point of view, and the Kyrgyz key scientific partner informed

Fig. 3 Conceptual framework for interdisciplinary and transdisciplinary knowledge integration: knowledge elements from the various work packages (WP) and blocks (WB) to be integrated by Bayesian network modelling (CA: Kazakhstan, Kyrgyzstan, Uzbekistan. KazNU: Kazakh National University, UniSam: University of

Samarkand, KyrNAS: Kyrgyz National Academy of Science, KAZCoF: Kazakh Committee of Forestry and Wildlife, UZBCoF: Uzbek State Committee on Forestry, ICRAF: The World Agroforestry Centre, Uni: UNiversity, TU: Technical University, KU: Catholic University, NGO: Non-governmental organization)

himself locally which contacts are most important in Uzbekistan. During the semi-structured interviews, stakeholders were asked to name other stakeholders who are important for the project. This list was then presented at workshop I and local participants were asked to complement this list with further stakeholders who they think are important for the project.

Step 2: categorizing stakeholders and local scientists We used a reconstructive categorization (bottom-up) with a participatory stakeholder-led stakeholder categorization with the help of an interest-influence matrix (Reed et al. 2009, Durham et al. 2014). Due to time constraints the parameters of the categorization (influence and interest) were defined by the researcher, while the categorization was done by the stakeholders during workshop I. Each stakeholder ranked his own organization in the interest-influence matrix, according to his perception which interest (high to low) his organization has regarding the project and which influence (high to low) his organization has in the arena of riparian forests in its country. The matrix with the result was visualized for all workshop participants and discussed and adjusted in the plenary. Then, stakeholders in the interest-influence matrix were categorized (see Fig. 4) according to their position as suggested in Durham et al. (2014) into stakeholders that the project should inform (low interest, low influence), consult (high interest, low influence), involve (low interest, high influence) and collaborate with (high interest, high influence).

Step 3: investigating relationships between stakeholders and local scientists We performed a social network analysis with network mapping (Lienert et al. 2013, Hauck

et al. 2015), in this paper referred to as stakeholder network analysis. As we wanted the stakeholders to map their own network of current interaction, during workshop I, we decided to use a simple form and limit the network map to two essential steps. During workshop I, stakeholders and local scientists were grouped by country around a table with a big piece of paper and pencil and were asked to draw a network of the current arena relevant for riparian forests in their country. This included first to name the most influencing actors regarding riparian forests and second to link the actors with arrows (Hauck et al. 2015). Then, all three network maps were visually presented to all workshop participants, discussed and adjusted where necessary. In addition, benefits for stakeholders and local scientists of participation in the project were discussed during the World Café in workshop I. This was done such that each stakeholder and local scientist could develop a well-founded rationale for his or her decision to participate or not in the main project phase.

Plan specific research and dissemination activities for the main project phase

The concept for the project main phase (Phase B, C) was developed interdisciplinary in an iterative manner between the project partners during several meetings and exchanges. Stakeholders and local scientists were included in workshop I and II, where we jointly planned activities, defined the level of engagement of each stakeholder and discussed data availability and provisioning. In addition, the selection of research areas in CA was prepared in workshop I and II. A pre-selection of possible study plots had taken place before. In a first step, the remote sensing specialist among the project

Fig. 4 Influence-interest matrix developed by stakeholders and local scientists. (KAZ: Kazakhstan, KYR: Kyrgyzstan, UZB: Uzbekistan, KRASS: Khorezm Rural Advisory Support Service, KazNU: Kazakh National University, KazNAU: Kazakh National Agrarian University, AGOCA: Alliance of Central Asian Mountain Communities, CAREC: Regional Environmental Center for Central Asia, GIZ: German Development Cooperation, GEF-SGP: Global Environment Facility—Small Grants Programme, Dept.: Department, Lab.: Laboratory)

partners analyzed satellite data to detect stands of riparian forest along the main rivers within the three countries. A field trip was organized to visit some of these stands to make sure that they are suitable for future research.

Results and discussion

Identify, describe and frame the real-world problem

Before the beginning of Phase A of ForeCeA, project partners framed riparian forest degradation in CA as being due to overuse of the forest resources as well as reduced streamflow (leading to lowering ground water table and diminishing inundation frequency). Stakeholders and local scientists identified three key problems of riparian forests in all three countries alike: (1) overgrazing in riparian forests by sheep, horses and cows of local farmers, (2) overcutting of trees by the local population for heating or by local administration for income generation as well as (3) forest fires. These problems were described to have a higher impact than diminishing groundwater tables and inundation frequency. The main goal of all interviewed stakeholders and local scientists was the protection of the existing riparian forests. This is represented in the combined perception graph by the orange box in the middle (Fig. 2). Constraints and factors for a sustainable management of riparian forests (Fig. 2) were mostly seen on the policy level and the current management system, i.e. lack of financial support by the government, weak control of the state and lack of transparency in forest management, questions of property rights, lacking recommendations and guidelines for reforestation (including its irrigation) and lack of a general strategy or a vision for riparian forest management and conservation. Financial constraints and lacking expertise in administration have an impact on implementing regulations, buying the necessary technical supply and installing nurseries. Concerning science, financial constraints and lacking expertise were stated to limit the creation of new know-how. Stakeholders and local scientists stated that there is a general lack of research on fauna and flora of riparian forests, related ecosystem services, the impacts of climate change on ecosystem functions of riparian forests, parasitic trees and shrubs. As a result, necessary data are missing (e.g. maps, water volume). Concerning the local population, problems are low information as well as financial constraints that lead to over-grazing and over-cutting and lacking knowledge on alternative income sources. In addition, there is a loss of traditional knowledge that is transmitted from the old to the new generation due to migration from rural to urban areas. Another important problem area is the scarcely regulated water sector, in particular high water consumption by irrigated agriculture which has been claimed to lead to

lowering of the groundwater table, soil salinity, soil drying and changes of riverbed.

Define the common research objective

The stakeholders and local scientists identified their research demands concerning riparian forests to be mainly (1) preliminary data, (2) research of ecosystem services and their (e.g. economic) importance for local people, (3) identify current challenges such as driving forces in riparian forests and (4) develop forest conservation strategies. Therefore, the research needs were quite similar to the initially envisaged project objectives by the project partners including the existing expertise in the research team. Finally, our defined research objective was: (1) to quantify “metrics of vulnerability” for the social-ecological system riparian forests, (2) to identify and quantitatively and qualitatively assess ecological tipping points and their relation with socio-economic changes, and (3) to develop science and stakeholder-based recommendations for a sustainable management and governance strategy.

Develop a conceptual and methodological framework for knowledge integration

The developed conceptual and methodological framework shows how knowledge (natural and social sciences, local, informal and practical knowledge) will be integrated in the project (Fig. 3). For knowledge integration, we will use participatory modelling with Bayesian networks. The concept of ecosystem services will serve to link the ecological and the social system to identify ecologic and related socio-economic tipping points of the socio-ecological system riparian forests in CA.

Build a collaborative TDR team

Following reviewers' suggestions of the pre-proposal and of participants of workshop I, the initial project team was extended by two principle investigators from cultural anthropology and institutional and resource economics from Germany. Both have extensive research experience in the project region and on the topic of the linkage of societies to natural resources. With this addition, the social part of the social-ecological system riparian forests with its linkages to the ecological part is to be investigated in more detail. Regarding stakeholders and local scientists relevant for understanding tipping points in riparian forests, the following results were obtained.

Step 1: identifying stakeholders and local scientists Filling out the stakeholders' list, the local scientific partners identified 7 stakeholders and local scientists in

Kazakhstan, 9 in Kyrgyzstan and 4 in Uzbekistan evenly distributed over all institutions types. During workshop I, the list was presented and further institutions were proposed by the participating stakeholders and added to the list.

Step 2: categorizing stakeholders The influence-interest matrix revealed the stakeholders and local scientists with whom to ideally collaborate (e.g. as project partners), whom to involve and consult (e.g. in future project workshops) and whom to merely inform about project activities and results (Fig. 4). Representative of two national Kazakh governmental bodies were not present at workshop I and other participants estimated their position in the matrix.

Step 3: investigating relationships between stakeholders Developing the stakeholder network analysis (Fig. 5) evoked vivid discussions among the participants of each round table, with most discussions taking place at the table of Kazakhstan having the highest number of participants (around 10). In contrast, the three participants from Uzbekistan easily agreed on a clear structure. The networks shown are not meant to be representative or complete but show the perception of the participating stakeholders and local scientists regarding their current interaction in each country. Therefore, it is clear that the networks are conditioned by the participants of each table. For instance, the network for Kazakhstan is much more detailed than the others, as it contains all stakeholders that were present at workshop I. The networks for Kyrgyzstan and Uzbekistan contain the participants of the round table and the most important other ones not present.

Identified benefits for local scientists to be involved in the project are better data availability (e.g. remote sensing maps) as a basis for their own research and education,

training and learning of new methods. Benefits for the population would be: conservation of traditional knowledge, identification of ecosystem services of riparian forests, improvement of their quality of life if the forests are preserved, improvement of pastures, improved environmental education, social protection of the population, adaptation to climate change. Benefits for administration are regional and international cooperation, preservation of forests and extension of the forest area in the long term, management strategy, methodological learning for forestry experts, recommendation for guidelines, and inventory of the state of riparian forests. Benefits for non-governmental organizations include additional work with local population, management strategy on the local scale, collection of data and monitoring, practical pilot projects, regional cooperation on the local scale.

Plan specific research and dissemination activities for the main project phase

The work on the co-design of the TDR concept resulted in the document proposal for the project main phase which was submitted to the German funding agency 9 months after funding started for the pre-phase.

Evaluation

Methods

We evaluated the effectiveness of Phase A of the ForeCeA project, focusing on suitability of the applied methods. For this, we constructed an evaluation framework based on suggestions for framework main features, aspects and

Fig. 5 Visualization of the stakeholder network analysis developed by stakeholders and local scientists for (1) Kazakhstan, (2) Kyrgyzstan and (3) Uzbekistan. (UNDP: United Nations Development

Programme, GEF-SGP: Global Environment Facility—Small Grants Programme, NGOs: Non-governmental organizations, GIZ: German Development Cooperation, Dept.: Department)

criteria found in the literature (Carew and Wickson 2010, Bergmann et al. 2005, Walter et al. 2007, Frank 2015, Siew et al. 2016) as shown in Sect. 4.2. For evaluation, a questionnaire was filled out by 31 participants of workshop I (8 project partners, 7 stakeholders, 12 (day 1) and 15 (day 2) local scientists) and 17 of workshop II (9 project partners, 3 stakeholders, 4 local scientists).

Results and discussion

Our evaluation framework (Table 2) is structured into three main features of TDR according to Carew and Wickson

(2010), TDR context, process and product. For each main feature and its aspects (Carew and Wickson 2010) we developed criteria based on suggestions by Bergmann et al. (2005), Walter et al. (2007), Frank (2015) and Siew et al. (2016) and we identified targets for each criterion. From these targets we derived evaluation questions. Participants of workshop I and II answered these questions on a Likert scale by filling out an anonymous questionnaire. They were also asked open questions. One limitation of the evaluation is that all questionnaire respondents were either project partners and/or interested in further collaboration and

Table 2 Evaluation framework for Phase A of ForeCeA TDR

Main features of TDR	Aspects of the main feature	Criteria to evaluate the aspects	Target for criteria
Context	Problem context	Appropriateness of research problem for the social and environmental setting	High societal and environmental relevance of research objective
	Research context	Favorable situation of associated research institutes	Achieving the research objective within the 3 years main project phase together with (funded) partners in CA
	Researcher's context	Appropriate skills, experiences and intentions of researchers in project	Researchers have appropriate skills, experiences and intentions
Process	Interdisciplinary collaboration	Satisfaction with interdisciplinary collaboration	Scientists are satisfied with interdisciplinary collaboration
	Transdisciplinary collaboration	Motivation for and satisfaction with the involvement in the TDR process	Participant's motivation to be involved in the project is clear High interest of stakeholders to be involved in the project main phase Satisfaction with joint planning of the project main phase
	Supportive project management	Communication for invitation to interview and TD workshops	Communication with local stakeholders and scientists is appropriate
	Application of appropriate methods	Usefulness of methods to integrate participants' knowledge and perspective	Participants feel their knowledge and perspective was sufficiently accounted for
Product	Peer approval (scientific product)	Scientific output	Each scientist is satisfied with its own scientific output achieved
	Mutual learning (scientific and societal product)	Reflection and learning	Improved awareness of different goals and perspectives of each stakeholder
		Production and distribution of new ideas and opinions	Sharing of own knowledge with other actors
	Societal effects (societal product)	Professional social network building	Workshops allowed to gain new professional contacts
		Build of trust	Higher likeliness to share information with participants
	Joint problem framing	Identification of stakeholder demand and defining scientific and societally relevant problem	Satisfaction with problem formulation
	Formation of consortium for and co-design of main project phase	Integration of relevant stakeholders and scientific disciplines Integration of stakeholders' and local scientists perspective into proposal for main phase	Satisfaction with consortium and common research questions, problem formulation and concept

funding of the project and might, therefore, avoid a strongly negative evaluation.

In the following section, results of the evaluation during workshop I are presented in detail, as it comprised more questions and more respondents from CA than the evaluation during workshop II. Both evaluations were very similar, and evaluation results from workshop II are only presented if they differ considerably from workshop I. Generally, the TDR approach was evaluated positively, with a similar result during workshop I (3.5 ± 0.6) and workshop II (3.4 ± 0.6) (mean result and standard deviation on a four-level Likert scale, range 1–4, optimum 4).

TDR context

Respondents strongly agreed (3.6 ± 0.6) that the TDR context, composed of problem context, research context and researchers' context is favorable. Concerning the problem context, respondents strongly agreed that the formulated research questions and objective are relevant for the own organization (3.7 ± 0.5) and for societies in the three Central Asian countries (3.8 ± 0.4) (Fig. 6). Regarding the research context, respondents only slightly agreed (3.3 ± 0.6) that the formulated research objective could be achieved within 3 years. The possibility for Central Asian organizations to obtain German funding in the main project phase was perceived to be very useful for collaboration (3.8 ± 0.5), especially so by the project partners (4.0 ± 0.0). Regarding the researchers' context, there was a slight to strong agreement (3.4 ± 0.7) that the foreseen participants of the main project phase include the most important stakeholders and scientific disciplines to successfully conduct the research. It was mainly suggested to add social scientists and some other stakeholders.

TDR process

Respondents slightly to strongly agreed (3.4 ± 0.5) that the TDR process is effective, inducing interdisciplinary and transdisciplinary collaboration, supportive project management and application of appropriate methods. Until workshop I, interdisciplinary collaboration among project partners was judged by all to be good (4.0 ± 0.0), while after workshop II the agreement was lower (2.9 ± 0.8). This was due to the more intense proposal preparation phase after workshop I until workshop II where interdisciplinary exchange became more necessary and differing perspectives across disciplines became more apparent than before. Transdisciplinary collaboration, joint planning of stakeholder activities and participation in the main project phase was evaluated to have been useful and appropriate (3.5 ± 0.6); with large differences among the different participant groups: strong agreement by stakeholders (3.7 ± 0.5) and only slight agreement by the German cooperation partners (3.3 ± 0.7). The motivation of stakeholders and local scientists (Fig. 7) to participate in interviews and workshop I was mainly of practical nature (number of respondents); to explore the opportunity to participate in the project (18 out of 19), to strengthen or form new professional contacts (14 out of 19) and to learn about the perspective of other participants (13 out of 19). In addition to these reasons, project partners were also motivated by bringing in knowledge and ideas (6 out of 9). Stakeholders and local scientists, in contrast, were not so much motivated by bringing in their knowledge and ideas (9 out of 19) or to learn more about riparian forests (5 out of 19).

According to the evaluation, all stakeholders and local scientists would like to be further involved in the project: either as a cooperation partner (6 out of 7 stakeholders, 11 out of 15 local scientists) or/and as a funded project partner

Fig. 6 Evaluation of the TDR context during Phase A. Level of agreement: 1: strongly disagree, 2: slightly disagree, 3: slightly agree, 4: strongly agree, with mean responses and standard deviation

Fig. 7 Evaluation of the motivation of participants for taking part in the interview and/or workshop I, showing share of respondents marking the respective motivation

(5 and 9), the stakeholder interest being the highest. Local scientists strongly agreed (4.0 ± 0.7) while stakeholders only slightly agreed (3 ± 0.8) that the communication with the project regarding the invitation to the interview and the workshop was appropriate. Suggestions for improvements were mainly to better communicate in advance how workshop participation costs will be reimbursed to workshop participants. A further remark was that more stakeholders from forestry administration should be invited. Among the participatory methods used, the World Café (3.6 ± 0.4), the guided discussion during workshop I (3.6 ± 0.5) and the interviews (3.5 ± 0.7) received the best evaluation (Fig. 8). Perception graphs (3.1 ± 0.6) and the interest-influence matrix (2.9 ± 0.9) received medium ratings. Stakeholders evaluated the *World Café* to be a good for allowing them to actively express their opinion. The authors of this study also share this evaluation, as

during the World Café format there was a very vivid discussion among stakeholders and local scientists (in Russian). A further benefit was the outcome of a tangible product at the end, in form of jointly developed list or chart on a piece of paper. The respondents of the questionnaires evaluated the *guided discussions* very positively, as they thought it was a good mean to actively express their opinion and engage in discussions with other participants. Also the authors of this study had the impression that there were vivid discussion going on among most participants alike, even though to a lesser extent than during the World Café. While the discussions had no direct tangible product they were precious for preparing the World Café and for facilitating the exchange among all participants. Respondents slightly agreed that *perception graphs* developed during the interviews before workshop I are a useful method to convey stakeholder knowledge and perspectives.

Fig. 8 Evaluation of the methods used in the TDR approach with mean responses and standard deviation (Level of agreement: 1: strongly disagree, 2: slightly disagree, 3: slightly agree, 4: strongly agree)

Unfortunately, only 3 out of the 10 individuals that constructed a perception graphs during the interviews attended workshop I. Therefore, 16 out of 19 respondents only assisted in the presentation of combined perception graphs. The three respondents who also generated a perception graphs rated its usefulness very differently with 2, 3 and 4. One respondent stated that perception graphs are generally a useful tool but that its presentation would have needed a more detailed explanation. This view is also shared by the authors of this study. More time would have been necessary to explain the perception graphs (Fig. 2) in more detail. The *influence-interest matrix* was evaluated very differently by the participants of workshop I. The authors of this study perceived the participatory construction of the influence-interest matrix as a rather approximate categorization of stakeholders which would have needed more discussion in the plenary in the end. Unfortunately, after each actor categorized their own institution in comparison to the others in the matrix there was no further discussion. In general, the workshop and the interview were seen to be a good (3.6 ± 0.8) basis for developing the proposal for the main project phase.

TDR products

Aspects influencing the quality of the TDR products are scientific output, mutual learning, societal effect, joint problem framing, co-design of the main project phase and composition of the project consortium. All project partners strongly agreed (4.0 ± 0.0) to be satisfied with their own scientific output. Good ratings were also given for mutual learning, as there was a strong agreement (3.8 ± 0.4) that the own awareness of the different goals and perspectives of other participants has improved through the participation in the workshop (and interview). To a lesser extent, the participants felt that the workshop gave them the opportunity to share their knowledge with the other participants (3.5 ± 0.6). Stakeholders and local scientists perceived the most important outcome of the workshop to be a better problem understanding around the topic riparian forests (5 out of 7 stakeholders and 8 out of 12 local scientists), followed by new or intensified contacts to other participants (3 stakeholders and 6 local scientists) a reflection on the actor's arena (3 stakeholders and 4 local scientists). For project partners, these three outcomes were equally achieved, with somewhat more importance on the contacts to other participants. Therefore, the outcome of the workshop matched the motivation of workshop participants. Regarding potential societal effects, there was a particular strong agreement that it was useful to gain new professional contacts or intensify relevant professional contacts (3.8 ± 0.4). Participants even strongly agreed (3.6 ± 0.6) that through their participation in the workshop they are

more likely to share information with other stakeholders participating in the ForeCeA project. Regarding joint problem framing, the workshop was evaluated to have been successful in identifying the research and knowledge demand of stakeholders (3.6 ± 0.6), and, to a lesser extent, the workshop was successful in reaching a joint problem understanding of riparian forests that is also reflected in the formulated problem (3.4 ± 0.7). Regarding the co-design of main phase we evaluated whether problem perspectives of stakeholders and local scientists was sufficiently considered. Participants mostly strongly agreed that their perspective was considered regarding the formulation of the research questions (3.5 ± 0.7), and to a lesser extent for the concept for the ForeCeA main phase and the societal problem (3.4 ± 0.6 and 3.3 ± 0.7). For formation of the future project consortium, participants slightly to strongly agreed (3.4 ± 0.7) that the most important stakeholders and scientific disciplines are included and suggested to include more stakeholders from forestry administration and social scientists.

Encountered difficulties and strengths

Difficulties during Phase A of ForeCeA can be summarized as follows.

1. It was challenging for all participants to fully understand each other's concepts within the short time available for interaction until the proposal for the main project phase (B and C) had to be handed in 9 months after the start of Phase A. This is in line with experiences of many previous studies (e.g. MacLeod 2018).
2. As also reported by Durham et al. (2014) and Tobias et al. (2018) we found it quite challenging to initialize the TDR project in terms of getting the right stakeholders on board. Initially stakeholders were difficult to reach by email or phone, emails asking for an interview were rarely considered and our local assistants were only successful in fixing a few interviews appointments in advance by phone. Therefore, the personal visit in the stakeholder's office and the one-to-one conversation presenting our project in person were crucial for initiating the contact and evoking interest in the project. For instance, out of 16 stakeholders that were individually interviewed, 14 came to workshop I, while the ones that could not be interviewed did not participate in workshop I. This was different for the local scientists, where only five were interviewed, but eleven came to workshop I. The personal visit, in addition, allowed us to respect hierarchies, i.e. to first meet the director who then

directed us to the appropriate expert with whom to conduct the interview.

3. Due to organizational difficulties not all stakeholders that were interviewed could take part in workshop I, such as the Kazakh Committee of Forestry and Wildlife who could not cover travel costs to the workshop from own funds before being reimbursed by the project.
4. Ties to certain stakeholders were developed less easy than others, also as a consequence of point (2) and (3). For example, the tie to one important Kyrgyz stakeholder, the Kyrgyz State Agency of Forestry, was not so well developed at first. They took part in the interview and construction of a perception graph as well as participated (partly) in workshop I. However, at the start of the project main-phase this relationship would need further development. In addition, a good tie could be built with a Kyrgyz non-governmental organization, who will also be part of the project main-phase, and will assume the tasks for the project that were meant to be taken by the Kyrgyz State Agency (i.e. the identification of past Kyrgyz measures in riparian forests).
5. For a successful TDR, Luthe (2017) suggests the TDR projects to ideally originate from society as opposed to with or for society. As Luthe (2017) states himself, this is difficult as the research topic and activities within the TDR project have to comply with the funding agency's requirements of the call (e.g. tipping points). In addition, the research agenda will always be already in part at least set by the initial project consortium and their research interests (e.g. poplars in riparian forests, socio-ecological systems, ecosystem services, remote sensing, etc.). The true involvement of stakeholders in the agenda setting also remains difficult due to time constraints. Consequently, in our TDR the problem framing has been mostly done by project partners, with only minor adjustments by stakeholders and local scientists. Nonetheless, in spite of this initial setting, we think that our numerous activities have best possibly engaged stakeholders into project co-design and they contributed to frame the problem with their local scientific and societal view before the start of Phase B and C. This is in any case better than without such an intense participatory process, however, not a research agenda that truly originates from local society.
6. In spite of the stakeholder analysis, it remains a challenge to understand the dynamics among stakeholders with its hierarchies and power relations (e.g., among administration units and non-governmental organizations). As also suggested by Siew et al. (2016), this is particularly true if scientists are foreign

to the countries where TDR takes place. In addition, past conflicts among stakeholders were transferred into current project. Direct communication of German researchers with local researchers and stakeholders was often not possible due to language barriers such that English-Russian translation was needed. The need for translation makes knowledge exchange and integration more difficult. However, participants of the three Central Asian countries easily and willingly communicated among themselves in Russian.

7. As also expressed by Luthe (2017), we found it challenging to build a methodological framework for knowledge integration. All researchers needed to agree and understand sufficiently the other disciplines' concepts and methods, which was quite challenging given the limited amount of possible meetings and exchanges. In addition, such frameworks with their underlying scientific concepts (e.g. social-ecological systems, ecosystem services) are quite difficult to understand for stakeholders. We believe that such a framework needs to be set up by scientists first and later discussed with stakeholders; a true co-design seems extremely challenging. For building our framework, we found the (generic) framework proposed by Mehring et al. (2017) and by Díaz et al. (2011) very inspiring as a starting point. The framework was then adapted iteratively, as also suggested by Siew et al. (2016) and Zscheischler and Rogga (2015), to the given project context, the particular transdisciplinary team and the underlying concept of ecosystem services.

We identify the following strengths of the chosen design for phase A.

1. Interdisciplinary collaboration and communication worked efficiently on the bilateral level among two partners collaborating closely in the project main phase.
2. We experienced that interviews with potential TDR participants (stakeholders and local scientists) were a very good means for starting the participatory process, by eliciting problem perceptions and supporting the selection of suitable participants.
3. Phase A was successful in involving stakeholders with diverse perspectives to participate in a constructive manner, which is often highlighted to be important in TDR (Durham et al. 2014).
4. At the end of phase A, stakeholders with diverse perspectives showed a high interest in participating in the planned main phase of the project, either as a financed partner or as workshop participants.
5. As a consequence of Phase A, it is planned to finance two national administrative bodies from Kazakhstan

and from Uzbekistan as well as a non-governmental organization from Kyrgyzstan by subcontracts. In addition, other stakeholders that will participate in knowledge integration workshops could be identified in phase A. Finally, local scientist from three universities, one in each country, will participate with some remuneration in the main project phase.

6. Recent TDR literature (Gaziulusoy et al. 2016, Luthe 2017) often express the need to allocate sufficient time and money for Phase A of a TDR project to set objectives, team members and activities in a transdisciplinary way before the actual start of Phase B. Our funding agency accounted for this by financing Phase A during 1 year. As a consequence, we had enough resources available in Phase A to best prepare TDR in Phase B and C. We think that this funding of a project pre-phase (Phase A) focusing on ensuring stakeholder engagement for the project main-phase (Phase B and C) has been very beneficial, which is in line with findings by Gaziulusoy et al. (2016) and Luthe (2017). Without such funding, co-design of the main project phase with stakeholder engagement would not have been possible.

Conclusion

We have shown how a TDR project about tipping points of riparian forests in Central Asia was set up in less than a year, presenting in detail the specific TDR methods we applied for achieving the goals of such an initial phase that were formulated by Lang et al. (2012). Our structured evaluation of design and methods of the initial phase of a TDR indicated that initial projects partners (German scientists) as well as local scientists and stakeholders were satisfied with TDR context, process and products. While difficulties were encountered, we conclude that the initial phase successfully prepared the main TDR project phase, by achieving a joint problem definition and identification of research goals and activities. The described structure and methods can serve as a helpful starting point for designing the first phase of other TDR projects around the world. However, adaptation to the specific TDR context is paramount.

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