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Chapter 20
Experiences with a Transdisciplinary Research Approach for Integrating Ecosystem Services into Water Management in Northwest China

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Abstract Consideration of the relatively new concept of ecosystem services (ESS) in management decisions calls for a transdisciplinary research (TR) approach that aims at integration of knowledge among scientists from multiple disciplines and stakeholders from multiple sectors. In this paper, we present our experiences with the implementation of a TR approach to support the integration of ESS into land and water management under climate change in the arid Tarim River Basin, Northwest China (SuMaRiO project). Our initial TR approach focused on the execution of a stakeholder dialogue (15–20 interviews and five workshops, including participatory modeling) to integrate stakeholder knowledge with research results from SuMaRiO scientists. In the first project phase, the approach was adapted by adding a stakeholder analysis, with explicit efforts to integrate knowledge among the multidisciplinary German scientists, and between German and Chinese scientists. Two key stakeholders from the water sector, together with other representatives of governmental organizations from the sector crop production, animal husbandry, environment, and forestry, were involved in the TR process. The applied TR approach resulted in an improved understanding on issues related to land and water management as well as ESS, and a joint problem perception of stakeholders and scientists. Based on the overall perception graph and discussion with stakeholders and scientists, gaps in the present knowledge related to water and ESS were identified. Chinese stakeholders and scientists appreciated that the TR process facilitated cross-sectoral and multi-disciplinary communication and knowledge exchange. TR (including methods of knowledge elicitation and integration) needs to be continually adapted in reaction

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to the challenges encountered in the socio-cultural and institutional setting in the study area. Explicit efforts of network and trust building are a prerequisite for TR, in particular in China.

Introduction

The concept of ecosystem services (ESS) is increasingly recognized as a useful policy tool that can help foster sustainable development. The concept connects environmental health to human well-being and shows the benefits of conservation of ecosystems (and their services) for the development of human society. ESS are goods and services (e.g. clean water or food) that people derive from nature (Millennium Ecosystem Assessment 2005). To help achieve a sustainable use of natural capital for the development of human welfare, ESS need to be integrated into policy making as well as business decisions (TEEB 2010). In China, the integration of ESS into decision-making processes is recommended to support ecosystem management (Chen et al. 2014). The interplay between ESS and land and water management (or integrated water resources management, IWRM) has been demonstrated in a number of studies (e.g. Jewitt 2002; Nakamura 2003; Le Maitre et al. 2007; Gordon et al. 2010; Wainger et al. 2010; Siew and Döll 2012). Coupling ESS and IWRM concepts could help to overcome the conflict between "development" and "environment", i.e. between "freshwater for humans" versus "freshwater for nature". The integrative concept facilitates the identification and negotiation of trade-offs between management options. It can also be used to develop policies to align private incentives with societal objectives (Engel and Schaefer 2013). The question is how to implement ESS into practical land and water management in light of the existing "implementation gaps" (Cook and Spray 2012).

The operationalization of ESS in strategic management decisions calls for the cooperation among multiple disciplinary scientists as well as the engagement of stakeholders in an iterative process of modeling and valuing ESS (Daily et al. 2009). In this process, scientific knowledge about coupled social-ecological systems is synthesized using modeling methods, while perceptions and needs of stakeholders are taken into account. Such approach of integrating knowledge from inside and outside of academia is termed transdisciplinary research (TR) approach (Thompson Klein et al. 2001; Hirsch Hadorn et al. 2006). TR has been applied in various problem fields in Europe, North America, South Africa, and Asia to support for instance sustainable agriculture development (Vandermeulen and van Huylenbroeck 2008), regional planning (Wiek and Walter 2009), conservation planning (Steventon 2008; Reyers et al. 2010), and water management (Cain et al. 2003). The potential contribution of TR to the development of sustainable socio-economic strategies in China is recognized (Jiang 2009).

A TR approach has been conceptualized to support the integration of ESS into land and water management under climate change and uncertainty in the Tarim

River Basin, Northwest China (Siew and Döll 2012). Competing uses of limited water resources for agriculture development and nature protection between upstream and downstream users is the major problem in the arid basin. Our TR project Sustainable Management of River Oases along the Tarim River (SuMaRiO) started in 2011. We are bringing scientists from multiple disciplines and stakeholders from multiple sectors together to develop knowledge-based management strategies through a recursive process. Scientific and stakeholder knowledge is integrated using participatory methods including actor modeling (Titz and Döll 2009), actor-based modeling (Döll et al. 2013), Bayesian Network (Düspohl et al. 2012), and participatory scenario development. The aim of this paper is to describe our experiences with the implementation of our TR approach, highlighting the challenges faced and adapted research strategies.

In the next section, the current situation in the Tarim River Basin is described. We then elaborate on the execution of the TR approach in the study area. Subsequently, outcomes and challenges to the implementation of the approach are presented, and finally conclusions are drawn.

"Development" and "Environment" Trade-Offs in the Tarim River Basin

With an approximately one million km^2 and eight million inhabitants, the Tarim River Basin is the largest inland basin in China (Fig. 20.1a). The lowland part of the basin is characterized by low annual precipitation (less than 50 mm per year) and high potential evapotranspiration (more than 2,000 mm/year). The Tarim River Basin consists of four tributaries (Aksu, Hotan, Yarkant, and Kaidu-Kenqi Rivers) and the mainstem (Tarim River) which flows eastwards to the end lake Taitema (Fig. 20.1a). Glacier and snow melt feeds the tributaries. The Kenqi River is connected to the Tarim River by a constructed channel that transfers water from Bosten Lake to the lower reaches of the Tarim River. Long-term average annual river discharge flowing from the four tributaries into the mainstem Tarim is 4.7 km^3/year (Deng 2009). Three quarters of the annual discharge occurs in July and August (Thevs 2011).

Agriculture production, which depends completely on irrigation, is the key driver for socio-economic development in the water scarce river basin (Zhuang et al. 2010). Major products are cotton, grain crops and horticultural products such as pears, apricots, and walnuts. Along the tributaries, 15,000–22,500 m^3 of water is used per year for irrigating one hectare of cultivated land (Jiang et al. 2005), including the water required for leaching salt before the growing season. In the Aksu river subbasin, 5.2 km^3 of 8.4 km^3 of discharge is used for agriculture. The amount of water use in the upstream tributary basins has increased strongly over the last decades; while river discharge upstream of the Aksu oasis has significantly increased, most likely because of glacier mass losses due to anthropogenic climate change, river discharge downstream at the confluence of the Aksu into the Tarim

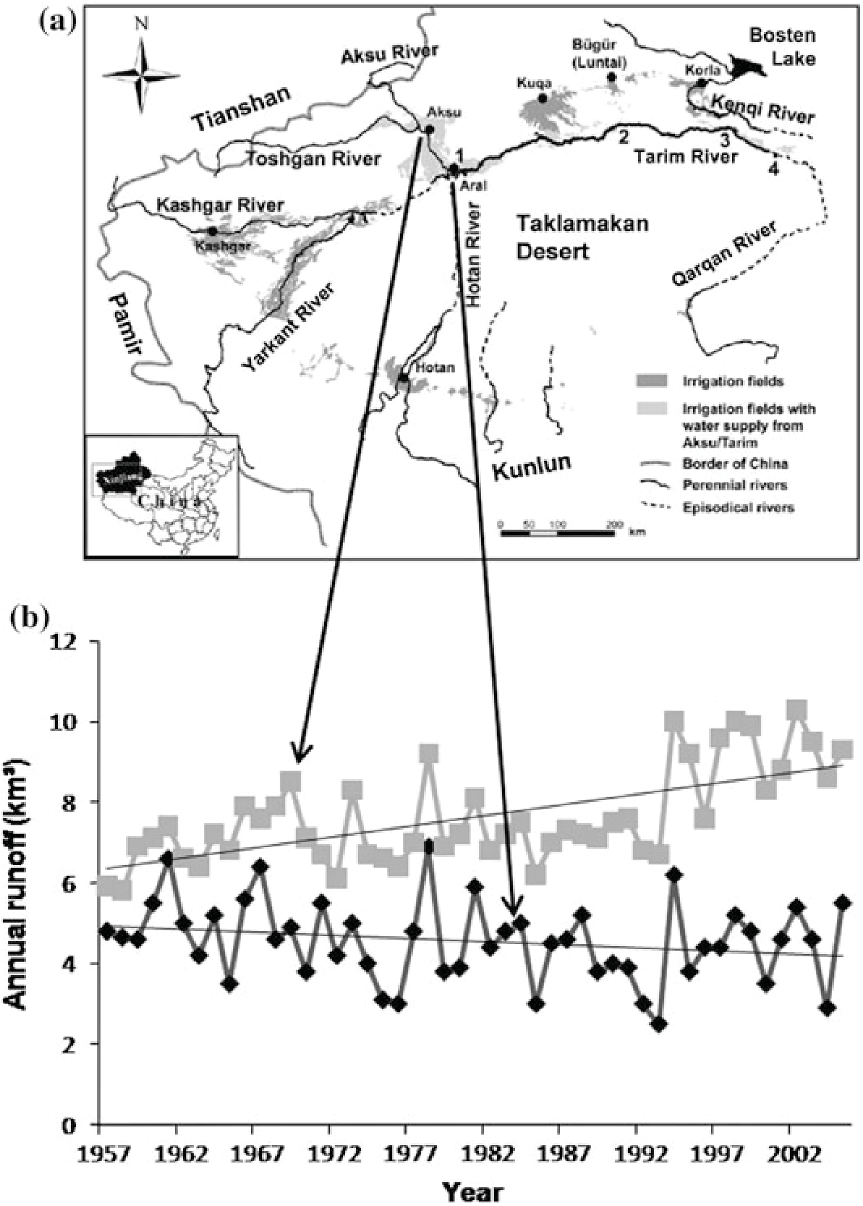

Fig. 20.1 **a** Location of the Tarim River Basin. **b** Annual runoff at the confluence of Toshgan and Aksu River ( ) and at the Station Aral ( ), 1957–2005 (modified from Thevs 2011)

has significantly decreased (Tang and Deng 2010; Fig. 20.1b). In the mainstem Tarim basin, approximately one fourth of river discharge is used for agriculture and the rest by the riparian vegetation (Deng 2009).

The exploitation of land and water resources for irrigation agriculture has serious impacts on the environmental conditions in the Tarim River Basin (Shen and Lein 2005). The most prominent problem, which caught international and national attention, is the deterioration of riparian vegetation ("Green Corridor") in the lower reaches of the Tarim River and the drying up of Taitema Lake. The 436-km long "Green Corridor", which mainly consists of poplar trees (*Populus euphratica*), is the shelterbelt on both sides of the Tarim Desert Highway. It protects the road from wind and sand and therefore safeguards “the lifeline for oil and gas exploitation, traffic, and economy in Southern Xinjiang” (Zhuang et al. 2010).

To restore the “Green Corridor”, the central government of China invested 10.7 billion RMB Yuan (1.29 billion USD) for a water conveyance project since 2001, under the Integrated Environment Restoration Plan (Lu et al. 2010). Water is channeled from upstream Tarim River through the diked midstream as well as from Bosten Lake via Kenqi River to the lower reaches of the Tarim River. The water diversion project has successfully recharged groundwater in the floodplain and therefore improved the quantity and quality of the riparian vegetation (Tao et al. 2008). However, it had a negative impact on Bosten Lake and the upstream water users. Water use conflicts arose between Kenqi river basin and the “Green Corridor” in 2004–2005, when the basin experienced a dry period (Tao et al. 2008).

Development, use, and management of water resources in the Tarim River Basin are guided by the principle of “four tributaries and one mainstem”. Formulated based on a water quota system, an annual water allocation plan is agreed upon by the Tarim Basin Water Resources Commission (TBWRC) each year to regulate the distribution of water to different regions, different users (irrigation, industry, households, environment), and different types of farm operations (local and state farms) (Thevs 2011). TBRWC consists of a number of governmental organizations from the water, agricultural, forestry, and environmental sectors. In practice, actual water abstraction may significantly differ from the agreed upon water allocation plan. The central argument is how much water should be allocated to irrigation agriculture and to riparian vegetation,[1] which is regarded as a trade-off between “development” and “environment”.

Integrating ESS concept into land and water management has been considered as a new approach to overcome the conflict between development and environment brought on by water scarcity in the Tarim River Basin (Siew and Döll 2012). River discharge generated in the upstream mountain areas should be allocated such that multiple ESS (e.g. crop production, dust retention, climate regulation, etc.) are maximized. By determining ESS, preferably in terms of monetary unit per unit of land or water used, awareness about the relative importance of ESS to policy makers can be raised (de Groot et al. 2012), decisions about allocating resources between competing uses can be better supported (Farley 2008), and the efficient use of funds for nature protection and restoration can be improved (Crossman et al. 2011).

Implementation of a Transdisciplinary Research Approach

The TR approach of SuMaRiO is illustrated in Fig. 20.2. The initial approach focused on the execution of a stakeholder dialogue comprising interviews and

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[1] For the Tugai vegetation along the river, its regeneration and growth depend not only on the ‘sufficient’ amount of water received but also the right timing of water release from summer flood (Thevs 2011).

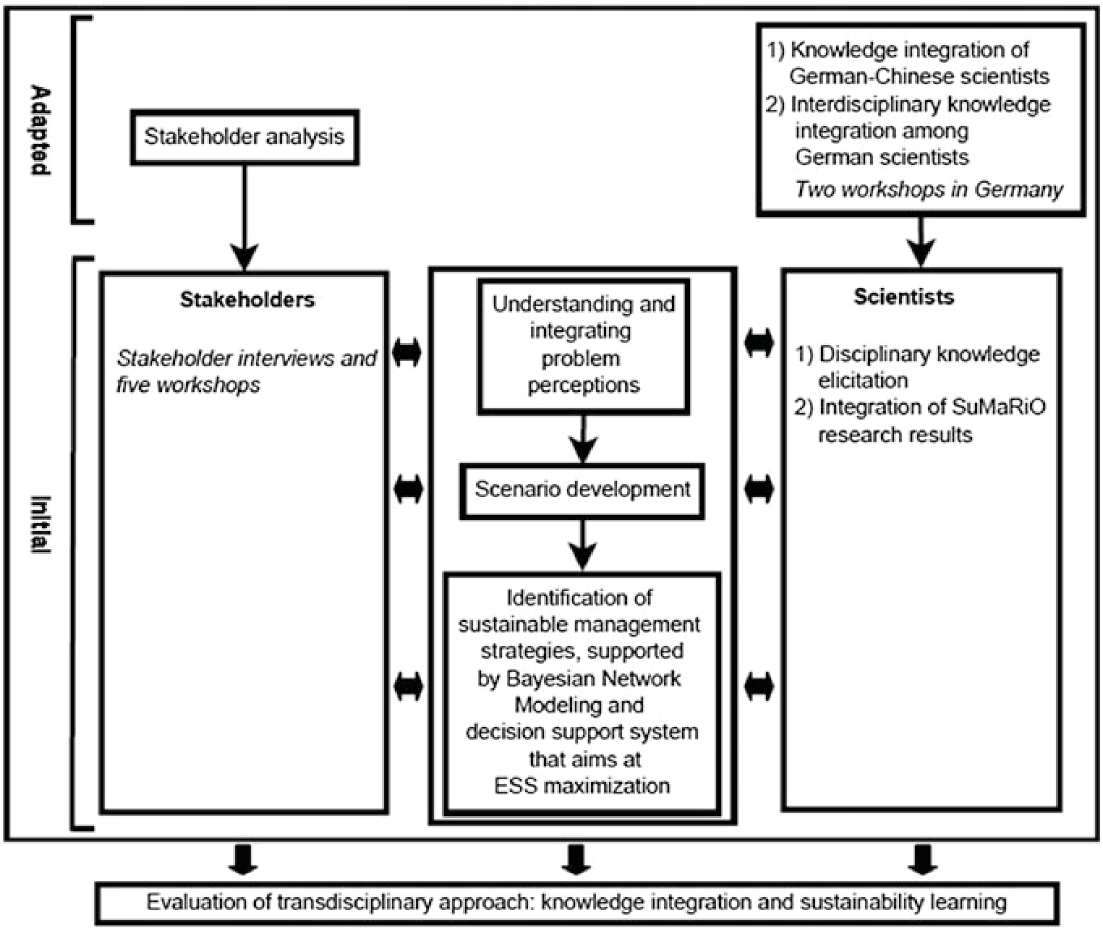

Fig. 20.2 Initial and adapted transdisciplinary approach for the support of integrating ecosystem services (ESS) into land and water management strategies in the Tarim River Basin, Northwest China. Chinese stakeholders are represented in the *box on the left* and scientists in the *box on the right*. The *box in the middle* depicts the process of integrating scientists and stakeholder knowledge on land, water, and ESS leading to the identification of sustainable management strategies. Tarim DSS (decision support system) is a software tool to be developed in the project SuMaRiO to support ESS maximization by stakeholders. The success of sustainability learning in terms of knowledge integration will be evaluated upon completion of the project

workshops. After eliciting problem perceptions of stakeholders and integration of SuMaRiO research results, scenarios under future climate and socio-economic change should then be developed. The identification of sustainable land and water management strategies is to be supported by a decision support system (Tarim DSS) that aims at maximizing identified ESS. Bayesian Networks (BNs) modeling method[2] is incorporated in the software system to account for uncertain knowledge about ESS.

The initial approach has been adapted during the first phase of the project. A stakeholder analysis was performed in addition to elicitation of problem

[2] BNs modeling method has become a core method in transdisciplinary research (Düspohl et al. 2012).

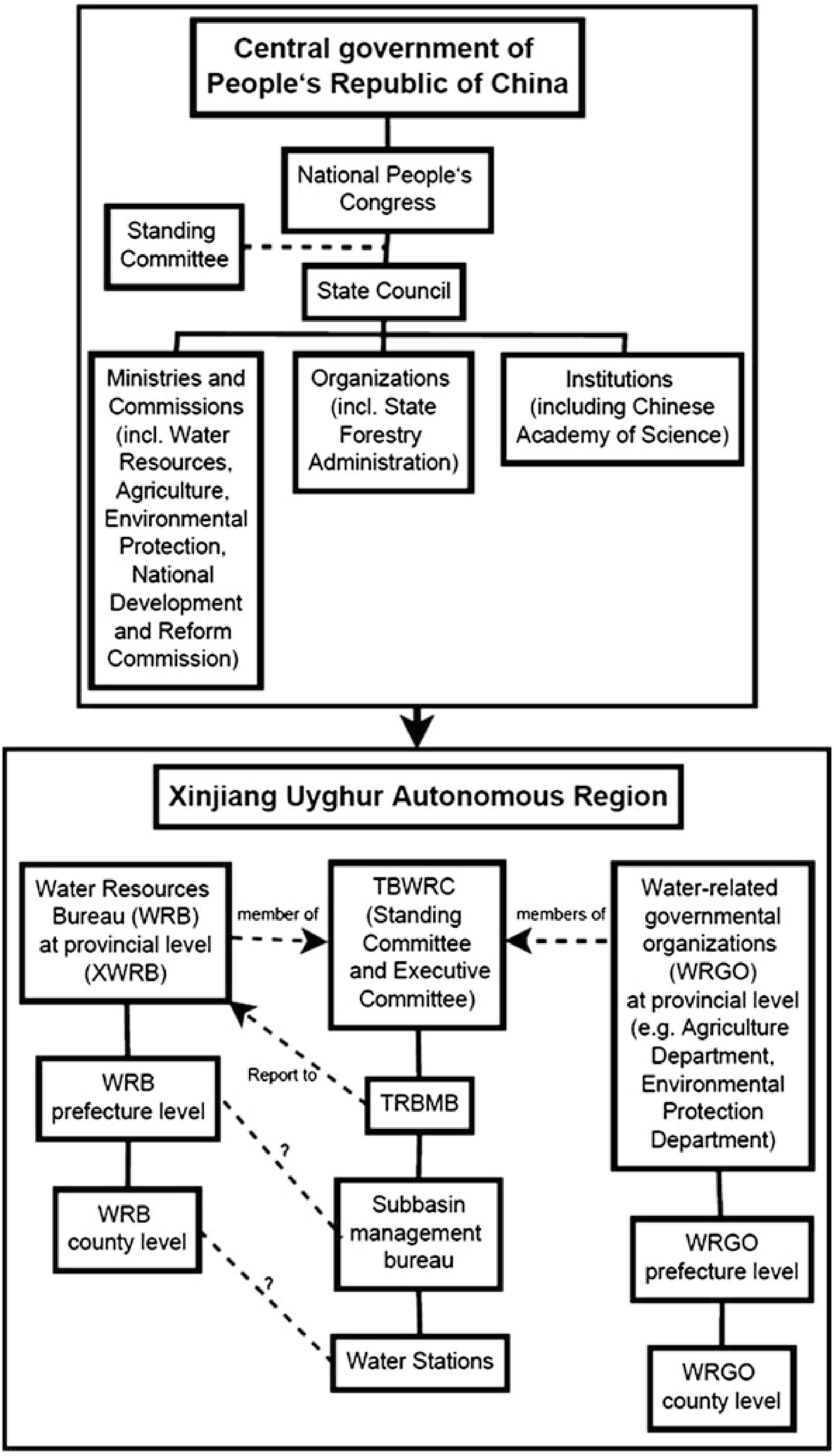

Fig. 20.3 Hierarchical structure of water management related governmental organizations in Xinjiang and China. "?" depicts unclear horizontal administrative interrelationships. (*TBWRC* Tarim Basin Water Resources Commission, *TRBMB* Tarim River Basin Management Bureau)

perceptions of German and Chinese scientists. Integration of knowledge of Chinese scientists with that of German scientists is as important as integration of stakeholder knowledge. In addition, we emphasized the integration of interdisciplinary knowledge of German scientists in our adapted approach (Fig. 20.2).

Stakeholder Analysis

Stakeholder analysis aims at identifying relevant stakeholders, their interests and agenda, and the interrelationships among the stakeholders (Grimble 1998). Stakeholders in land and water management can be governmental organizations, water user associations, farmer associations, environmental and other non-governmental organizations, and citizen groups. In our TR process, we can only involve governmental organizations from provincial, prefecture, county, or basin levels as stakeholders. Governmental organizations include those from the sector water, crop production, animal husbandry, environment, and forestry (including fruit trees). Our key stakeholders are the Xinjiang Water Resources Bureau (XWRB) at the provincial level and the Tarim River Basin Management Bureau (TRBMB). TRBMB is a basin organization who is in charge of preparing and implementing decisions made by TBWRC, in particular water allocation plans (Fig. 20.3).

TRBMB coordinates the operations of subbasin organizations as well as the execution of engineering projects. Together with other governmental organizations such as agriculture and environmental protection departments, XWRB is a member of the Standing Committee of TBWRC. Since the institutional reform in 2011, TRBMB has been empowered and has the same hierarchical status as XWRB. In reality, however, TRBMB still reports to XWRB. The responsibilities and mandates between TRBMB and administrative water resources bureaus at lower governance levels are not clear to us. Likewise, institutional functions related to water management across different sectors are also overlapping (c.f. Yan et al. 2006). Both sectoral and cross-sectoral cooperation and coordination need to be improved.

TR Process

Altogether 13 interviews were conducted in Xinjiang (9 in November 2011 and 4 in November 2012) with Chinese scientists coming from different institutions (academy and research institutes) in Xinjiang and various disciplines (hydrology, agricultural economy, ecology, and climate specialist). A causal network (perception graph) was constructed together with each interview partner during the interview which took about 2–3 h. The perception graph depicts the perspectives of interview partner with regard to the goals of land and water management, factors affecting the goal factors, possible action options that can lead to the

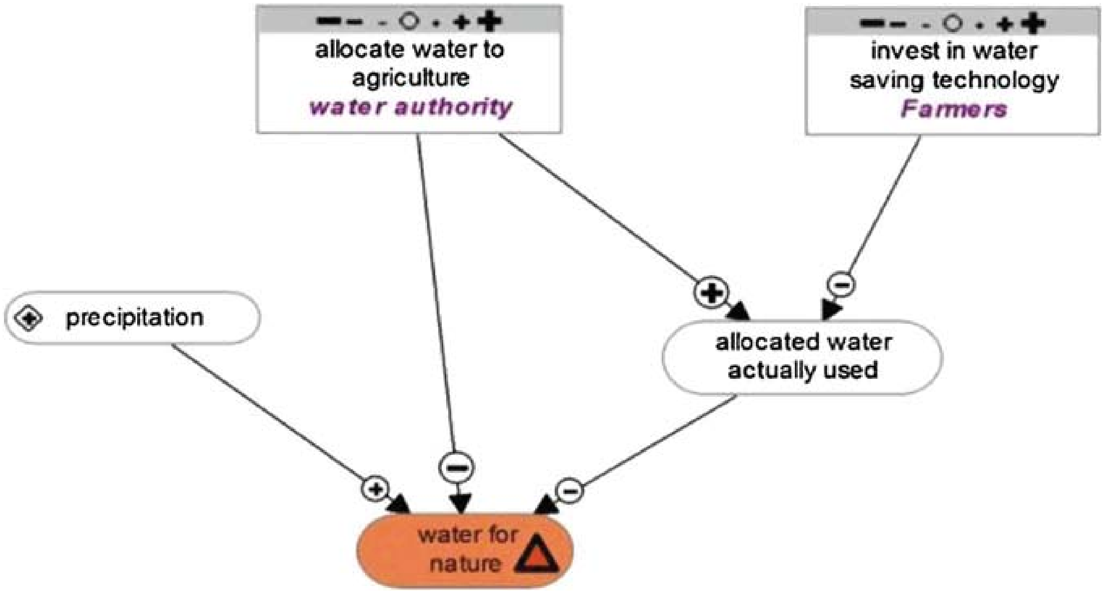

Fig. 20.4 An example of a simple perception graph depicting the problem perspective of an environmental protection organization in a fictive case of the problem field water management in arid regions. The *arrows* qualified with ⊕ or ⊖ sign in different sizes depict the intensity of the correlation between each element of the goal factor, influence factor, actions, and prospect. The perception graph expresses the perception that water allocation to agriculture by the water authority decreases strongly water for nature, and that farmers can increase water for nature somewhat by investing in water saving technology. Increasing precipitation will also lead to somewhat more water for nature (Siew and Döll 2012)

achievement of the goals, and the causal links between all these elements. After the interview, the paper-format perception graph was converted into a digital version using DANA software (http://dana.actoranalysis.com, Bots et al. 2007; Döll et al. 2013). An example of a perception graph is illustrated in Fig. 20.4.

Individual perception graphs generated from interviews in November 2011 were combined after all interviews were done, as first basis for a joint problem perception. The overall perception graph, which comprises all actions and factor mentioned in the individual graphs, was updated by integrating results gained from the four interviews conducted in November 2012. In between November 2011 and November 2012, we also constructed an overall graph representing the perspectives of German scientists within SuMaRiO project. The German overall perception graph was discussed in a SuMaRiO researcher workshop conducted in Germany in February 2012. Both German and Chinese overall perception graphs provide a basis for the development of the Tarim DSS.

The first version of German and Chinese overall perception graphs were presented at the first workshop organized in Urumqi (the capital city of Xinjiang) in March 2012. The workshop was attended by eight Chinese scientists who were interviewed and four Chinese scientists who were interviewed later in November 2012. Additionally, two representatives from TRBMB and two representatives from other governmental organizations were present at the workshop (Table 20.1). A World Café format (Welp et al. 2006) was used to encourage interactive small

Table 20.1 Chinese stakeholders and scientists involved in the transdisciplinary research

Institutions	No. of interviews with generation of perception graph	Total no. of persons participated in half-day workshops (workshop participated)
Governmental organizations		
Xinjiang Water Resources Bureau (XWRB)/provincial level	1 Informal interview (no perception graph)	1 (Workshop 2 and 3)
Tarim River Basin Management Bureau (TRBMB)/basin level	0	8 (Workshop 1, 2 and 3)
Forestry Administration/provincial level	1 Informal interview (no perception graph)	0
Agriculture Bureau/prefecture level	0	1 (Workshop 3)
Animal Husbandry Bureau/ prefecture level	0	1 (Workshop 3)
Wild Plants and Animals and Nature Reserve Management Office (under Forestry Administration)/prefecture level	0	1 (Workshop 2 and 3)
Water Conservancy Bureau Water Management Station/county level	0	1 (Workshop 1, 2 and 3)
Academy and research institutes		
Chinese Academy of Science	2	3 (Workshop 1 and 2)
Xinjiang Normal University	2	2 (Workshop 1 and 2)
Xinjiang University	4	5 (Workshop 1 and 2)
Xinjiang Academy of Forestry	1	1 (Workshop1 and 2)
Xinjiang Agricultural University	1	2 (Workshop 1 and 2)
Xinjiang Academy of Agriculture	1	1 (Workshop 2)
Xinjiang Water Resources Research Institute	1	1 (Workshop 1 and 2)
Research unit of Xinjiang Bureau of Meteorology	1	1 (Workshop 1 and 2)

group discussion among all participants. During the discussion, workshop participants were asked to formulate the most pertinent questions that need to be answered by German scientists (i.e. SuMaRiO researchers) as well as the requirements for a decision support system for land and water management. Both types of information were also collected using questionnaires, which was formulated in Chinese. Additionally, information pertaining to the current problems faced in the Tarim River Basin was also captured. Discussion in small groups was found to be an effective way of encouraging intensive interaction and exchange of ideas and information among workshop participants. In a plenary session, participants may feel reluctant to express their opinions as a sign of showing respect for high-level officials or as a way to avoid "losing face". The questionnaire was used in particular to gather information from workshop participants who did not voice their views at all in plenary or small group discussion.

Based on the results of the first workshop and the interviews with Chinese scientists before the second workshop in November 2012, the Chinese overall perception graph was modified. The updated version of the overall perception graph was presented in the second workshop and intensively discussed by workshop participants. The participants included representatives of our two key stakeholders (deputy director of TRBMB who had also participated in the first workshop, and the vice president of XWRB). Two representatives, who are in charge of nature protection at prefecture level and water management at county level, respectively, were also present. On top of that, eight Chinese scientists of the first workshop were also present. The goal of the second workshop was to come up with a final joint problem perception of stakeholders and scientists. Besides, a list of ESS relevant to the Tarim River Basin was identified by workshop participants.

In February 2013, a second German SuMaRiO researcher workshop was organized to discuss the system description of the Tarim DSS, develop storylines of two scenarios, and identify possible land and water management measures from the perspective of German scientists. The outcome of this internal workshop was presented at the third workshop in Xinjiang in March 2013. The third workshop was attended by 12 representatives of institutional stakeholders (including vice president of XWRB, deputy director and chief engineer of TRBMB, deputy director and chief engineer of Tarim Mainstem Management Bureau, and representatives from agriculture, animal husbandry, and nature protection departments). The participants provided feedback to the system description and storylines. Additionally, they identified possible land and water management measures from their perspectives, each of them individually filling out a table. These were combined with the management measures identified by German and Chinese scientists. Together with climate and socio-economic scenarios, the impacts of a combination of management measures on ESS are to be analyzed in SuMaRiO. Issues pertaining to data needs for Tarim DSS were also discussed in the third workshop.

Two more workshops are planned to be conducted in Xinjiang with participation of all selected stakeholders by 2015. As depicted in Fig. 20.2, the overall TR process with regard to sustainability learning and knowledge integration will be evaluated upon completion of the project. Throughout the process, TR activities and their outcomes are continually documented and reflected on.

Outcomes of the TR Process

Our TR process as described in the previous section is on-going. At this stage, we are able to offer an insight about the following outcomes of our TR process, which can contribute to the integration of ESS into land and water management: an improved understanding on issues at hand, a joint problem perception of stakeholder and scientists, identified knowledge gaps, and improved communication and knowledge exchange among stakeholders and scientists.

An understanding on issues related to land and water management in the Tarim River Basin from the perspectives of Chinese stakeholders and scientists was gained at the beginning of our TR process. The issues of their concerned, including socio-economic, environmental, and institutional issues, were articulated through informal exchange and formal interviews as well as by means of group discussion and questionnaires at workshops. According to Chinese stakeholders and scientists, the deficiency of the institutional arrangement is a major obstacle that prevents integrated land and water management in the Tarim River Basin. Institutional functions across different sectors are overlapping, while there is a lack of cross-sectoral communication among government institutions. On the other hand, it was perceived that downstream reaches are mostly affected by environmental and socio-economic problems such as land desertification, loss of riparian vegetation, and poverty. The understanding of the diverse issues belongs to the first step in our TR process that focuses on defining the problem taking into account different perceptions of scientists and stakeholders as well as the interests and goals of relevant stakeholders (Siew and Döll 2012).

A joint problem perception of scientists and stakeholders was obtained by integrating the knowledge of stakeholders into the overall perception graph of Chinese scientists. The graph depicts the cause-effect relationships between socio-economic and environmental factors, which are impacted by possible action options and which have impacts on achieving goals of land and water management. The graph as a causal network was used to facilitate the discussion, among others, about prevailing issues related to the allocation of water for agriculture irrigation use and water for nature use (i.e. for the restoration and protection of natural vegetation along the Tarim River, especially in the lower reaches). Causal networks visualize the structure of the present knowledge of the involved stakeholders and scientists about the complex human-environment systems and thus can be used to come up with an accepted problem definition (Welp et al. 2006).

By generating the overall perception graph and discussing it with stakeholders and scientists, gaps in the present knowledge were revealed. It was found that the issue of water allocation receives more attention as compared to, for example, water quality issues in the Tarim River Basin. The discussion also pointed out that there is a lack of investigation on the trade-off of the bundle of ESS provided by different ecosystems in the entire Tarim River Basin. Most studies in the Tarim River Basin focus on the valuation of the effect of water transfer on crop production and to a lesser extent on the growth of natural vegetation in the lower reaches of the Tarim River (e.g. Xu et al. 2008). A total of seven ESS is currently considered in the system description of SuMaRiO integrated model (Tarim DSS). A detailed description of the DSS is out of the scope of this paper.

Based on the feedback from interview partners and workshop participants, the applied TR approach contributed to improving cross-sectoral and multi-disciplinary communication and knowledge exchange. By sharing divergent perspectives on land and water management issues as well as the current development in the field of ESS, mutual understanding and learning among stakeholders and scientists have been strengthened. Nevertheless, knowledge on land and water management as well as ESS that exists at different institutions in Xinjiang (inside and outside of academia) has so far only been partially integrated in light of the challenges experienced in the implementation of our TR approach.

Challenges to Implementation of the TR Approach

The implementation of the TR approach in the Tarim River Basin has been very challenging due to several reasons. We only had access to representatives of governmental organizations. They were selected in a somewhat biased way, as most of them belong to a close network. In addition, except for the deputy director of TRBMB and the vice president of XWRB, the participating representatives of stakeholders do not have strong decision power regarding land and water management issues in the Tarim River Basin.

We planned to conduct 15–20 interviews before conducting workshops with representatives of different governmental organizations to elicit their problem perceptions. The resulted perception graph should include their goals pertaining to land and water management, factors that affect the goal factors, and possible action options that can lead to the achievement of the goals. However, formal interviews with stakeholder representatives were not possible until now. We only managed so far to exchange information with representatives from water and forest sectors informally. The main reason given was that SuMaRiO was not officially endorsed by the Chinese central government. The official recognition from a ministry in Xinjiang has, up to now, not been able to encourage the representatives to get involved in our TR process. On the other hand, stakeholder representatives did show their interest in our TR approach and the Tarim DSS. However, collaborating with foreign scientists without authorized approval from the powerful central government might probably be seen as a risk to their professional positions.

We initially intended to provide scientific support to land and water management in the Tarim River Basin, including the Aksu river basin which is subbasin of the overall Tarim basin. The Aksu contributes most of the river discharge into the Tarim mainstem. However, stakeholders in Xinjiang/China do not wish to be supported by German researchers regarding water management in the Aksu subbasin because it is a transboundary basin (Kyrgyzstan/China). Therefore, they want to restrict analysis, modeling (DSS), and the definition of management strategies to the Tarim mainstem (Fig. 20.1a). This is problematic because irrigation water in the Aksu subbasin is four times larger than in the mainstem basin and has significantly reduced river discharge into the Tarim mainstem (Fig. 20.1b).

In general, data sharing has been a sensitive issue for Chinese stakeholders and scientists, but especially problematic for transboundary basins. It seems to be impossible to provide daily discharge data for transboundary rivers to foreign researchers. A solution has been suggested by the representative of XWRB, but no official authorization can be done by XWRB alone. Some data can be obtained through alternative channels. Nevertheless, without discharge data in a temporal resolution that is required for hydrological modeling, the progress of the project has been substantially delayed.

In our research, most of the tasks could not be carried out within the planned time frame. On the one hand, our research activities (interviews and workshops) were given low priority by stakeholder representatives. On the other hand, it was not uncommon that potential workshop participants received short notices by their superiors that prevented them from participation in our workshops. As a result, workshop plans needed to be changed ad hoc, and additional time and resources were required. This poses a challenge to the design of a participatory process which should avoid the emergence of "stakeholder fatigue" (Reed 2008; Lamers et al. 2010). Flexibility is essential for doing research in China generally (van den Hoek et al. 2012).

Chinese language was used during interviews and workshops. Two German scientists involved in the TR process are native speakers of Chinese, and translation was only required for short presentation and intervention by German senior researchers. Technical terms and concepts related to land and water were well comprehended by Chinese stakeholder and scientists with whom we communicated. Misunderstandings and arguments arose as the terms "transdisciplinary research" and "ecosystem services" were introduced. The term "transdisciplinary research" was not recognized by the Chinese although it was directly adopted from a Chinese reference (Jiang 2009). In Chinese literature, "ecosystem service functions" is commonly used, deviating from the English usage. Although consensus was not achieved with regard to the use of these two core terms, the underlying concepts and applied methods were well accepted as innovative by both Chinese stakeholders and scientists.

Conclusion and Outlook

Transdisciplinary research has the potential to support the implementation of ecosystem services concept in land and water management. By getting scientists and stakeholders involved in the research process, divergent interests and perceptions on the balance of economic development, nature conservation, and human welfare can be shared. The joint generation and integration of knowledge using a transdisciplinary research approach can subsequently help derive ecosystem services-based strategies to resolve human-environment conflicts, especially in such a water-scarce and fragile environment as in the Tarim River Basin.

Some outcomes that contribute to the integration of ESS into land and water management could be obtained during the implementation of the TR approach in the Tarim River Basin. At the same time, a number of challenges were encountered. TR processes need to be adapted as new knowledge and surprises emerge. We have adapted our initial approach by adding a stakeholder analysis, and by concentrating our effort on knowledge integration between German and Chinese scientists. We have also intensified interdisciplinary knowledge integration within SuMaRiO that focuses on integration of SuMaRiO results and on the development of a decision support system. In this TR process that involves individuals from two culturally different countries, we have tailored the TR methods to suit ways of communication in the local socio-cultural and institutional setting. We have experienced that small group discussions in the form of World Café help to overcome the reluctance of Chinese workshop participants to voice their views in a large group. Making workshop participants fill out questionnaires during the workshop allows collecting specific information even from those who did not participate in the discussion. Workshops with Chinese scientists and stakeholder representatives are best conducted in Chinese language, including the materials provided.

Transdisciplinary research (including methods of knowledge elicitation and integration) needs to be continually adapted responding to the challenges encountered. For TR in China, it is a prerequisite to have a committed and eminent scientist as project partner. He/she should have influence, authority and good connections ("guanxi") to initiate network and trust building with Chinese stakeholders and scientists.

Our transdisciplinary approach is on-going. By 2015, we plan to have conducted interviews with representatives of all selected stakeholders, in addition to two more workshops in Xinjiang.

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