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Confronting international research topics with stakeholders on multifunctional land use: the case of Inner Mongolia, China

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The established pattern of land use in the Inner Mongolia autonomous region is being challenged by China's rapid overall economic transition. The provision of required land-related functions and services is subject to land management decision making. Scientific research can offer substantial support to decision making by providing evidence of the interaction between land management and land function services. The goal of this paper was to identify the most important land use functions and services from a local perspective and to compare these functions and services with the land-related research topics addressed in the scientific literature. For this purpose, we conducted a workshop with local stakeholders (land use decision makers) in the West Ujimqin Banner (Inner Mongolia) as a specific case study and performed a comprehensive survey of the Inner Mongolian land use research published in international scientific journals. Our analysis indicated that the stakeholders assigned particular importance to social land use functions, such as jobs, as well as environmental land use functions and ecosystem processes. In contrast, the research topics were primarily concerned with natural science. We discussed possible shortcomings in the research agenda by emphasising and contrasting local stakeholder perspectives with the research topics and concluded that without bottom-up stakeholder participation, there would be a mismatch between the research interests of land use scientists and the needs of stakeholders. Future research that can contribute to local policy making with the aim of meeting the objectives of a multifunctional land use concept is required.

Keywords: Interdisciplinary Research, Sustainable Development, Decision Making, Research Needs, Science-policy Interface

Introduction

Land use in the Inner Mongolia Autonomous Region ("Inner Mongolia") has a long tradition of nomadic pastoralism (Zhizhong & Wen 2008). With economic development, population growth, and increasing demand for natural resources globally and particularly in China, regional land use preferences have changed toward an increased preference for commodity production (Zhen et al. 2010, 2014). Thus, land use in Inner Mongolia is experiencing a period of transition, which affects natural resources and regional development in different ways. Because Inner Mongolia is increasingly facing severe land degradation problems, regional land use changes were triggered by the Chinese government with the introduction of several land conservation policies, such as the "Wind and sand source control around Beijing and Tianjin project" (2001 to 2010), which focused on afforestation and grassland maintenance (Xu et al. 2011); the "Sloping land conversion program" (SLCP - initiated 1999) to convert arable land to grassland or forests in the agro-pasture zone (Yin & Yin 2010, König et al. 2012b); and the "Grazing prohibition" policy (since 1987), which requires livestock fencing and bans livestock from degraded areas (Jun Li et al. 2007, Li & Huntsinger 2011). Simultaneously, the government has excluded herders from vast areas of land and has attempted to move them into "minority villages", where they are expected to survive by producing milk for the dairy industry using a limited and fixed area of grassland. These developments resulted in the abandonment of nomadic pastoralism in favor of individual farming, with fenced herding and increasing herd densities per unit of land (Zhizhong & Wen 2008).

With the increasing demand for land-based resources and ecosystem services, land use is no longer an issue that is of interest only to local land managers. Instead, society places a complex portfolio of demands on land utilization. Some of these demands are met by commodities for which farmers and land managers are paid, such as food, fiber, energy, and timber. Other demands exhibit the character of public goods, *e.g.*, habitats, biodiversity, clean water and air, greenhouse gas mitigation, the buffering of weather extremes, cooling, flood control, cultural assets, and recreational and human health assets, and they contribute to the social and environmental good (Costanza & Daly 1992, de Groot et al. 2010).

The concept of multifunctional land use was developed to encompass the multitude of services that land use provides (Wiggering et al. 2003). The underlying rationale for multifunctional land use is to simultaneously and interactively consider the social, economic, and environmental effects of any land use action including the effects of commodity production and those of uses for the public good. The multifunctionality of land use reflects the wide spectrum of land use options and their interaction with regard to sustainable development (Wiggering et al. 2006). Thus, scientific support requires the inclusion of results from various scientific disciplines in the decision-making process to fully reflect the individual and joint components of multifunctional land use, which leads to a central question: does the current

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provision of scientific information meet the interests and needs of the decision makers or are there areas of decision-making interest that are not adequately addressed in the research (Podhora et al. 2013)?

In recent years, the discussion on the role of science in policy support has increasingly become important to both sides: policy makers and researchers. Scientific results should provide appropriate information to the various stages of the policy process (*e.g.*, policy design and *ex-ante* as well as *ex-post* evaluation) and enable policy makers to base their decisions on scientifically robust results (Adelle et al. 2006). The Chinese state is organized into administrative units of the central state, provinces and autonomous regions, cities, counties, towns/townships, and villages. Although the national and provincial levels provide a policy framework, the local governments enjoy a considerable degree of local autonomy (Zweig 1992).

The land use functions (LUFs) framework was developed to make the concept of multifunctional land use operational for land use decision making and land management (Pérez-Soba et al. 2008). The framework facilitates the assessment and governance of land use to promote sustainable development. First developed for scientific purposes (Helming et al. 2011), the LUFs approach was then implemented in a European typology for planning and decision-making purposes (ESPON 2012). The concept transcends the agricultural perspective in that it integrates other land use sectors and links them with the socio-economic and geophysical properties of the landscapes affected by land use. Thus, the multifunctionality of land use was defined as the degree to which the uses interactively affect the performance of the landscape in providing social, economic, and environmental functions, *i.e.*, the "goods and services" that satisfy societal needs or demands (Wiggering et al. 2006). This definition emphasizes the spatially explicit interaction between land use on the one hand and the condition, structures, and processes of landscape on the other hand. Consequently, the LUFs approach considers all rural land use sectors: agriculture, forestry, tourism, energy, water management, nature conservation, and transport.

What is missing is a holistic analysis of multifunctional land use in Inner Mongolia, as well as the matching of research topics with the needs and interests of local stakeholders. Commonly, stakeholders in land use include multiple players who could be divided into two main groups, namely into "decision makers" (*e.g.*, government level) and "decision takers" (*e.g.*, local farmers - Grimble & Wellard 1997, Reed et al. 2009). This study took place in China where land property is still state owned, implying that land management by local land users (*e.g.*, farmers) is very much influenced by political top-down decisions (Bennett et al. 2011, Xu 2004). In this study, we therefore considered a group of local land administration officers (decision makers), as well as village/town headman (decision takers at implementation level) to be the relevant stakeholder group. We therefore considered land use decision makers at the multi-level spectrum of governance to be the most important stakeholder target group.

This paper has the objective of analyzing the topics and themes of multifunctional land use in Inner Mongolia from two different perspectives, that is, by comparing the research topics with local stakeholder views. Through a review of the international scientific literature and a local stakeholder workshop, we investigated the themes behind land use issues from the research and local governance perspectives. A comparison of these themes resulted in an identification of the issues that are important for stakeholders but are not addressed in the research, and those topics that are important from the research perspective but are neglected in local decision making.

Tab. 1 - Land use functions conceptual framework (adapted from: Pérez-Soba et al. 2008 and König et al. 2012a).

Label	Land use function (LUF)	LUF definition
ECO1	Land-based production	Provision of land for economic production including agricultural and forest products
ECO2	Non-land based activities	Provision of space used for industry and service activities
ECO3	Infrastructure	Quantity/quality of roads as a means to connect rural regions with outer regions
SOC1	Provision of work	Employment opportunities for activities based on natural resources
SOC2	Culture	Landscape aesthetics and quality and values associated with the local culture
SOC3	Food security	Availability of a sufficient quantity and quality of food
ENV1	Provision of abiotic resources	The role of land in regulating the supply and quality of soil and water
ENV2	Provision of biotic resources	Provision of habitat and factors affecting the capacity of the land to support regional biodiversity
ENV3	Maintenance of ecosystem processes	The role of land in the regulation of natural processes and ecological supporting functions

Materials and method

Study area

We selected Inner Mongolia as a case study and the West Ujimqin Banner as a sub-region (the county level) to consider stakeholder perspectives from a local viewpoint. Inner Mongolia is third largest province of China in area and covers approximately 1.18 million km^2 (National Statistics Bureau 2011). Inner Mongolia's population amounted to 24 722 million individuals in 2010 (National Statistics Bureau 2010). The urbanization rate is 56.6% (Inner Mongolia Statistics Bureau 2012), which indicates the strong rural-urban transition character of the region. Grassland is the primary type of land use in this region (Zhang et al. 2007a). Agriculture, which remains the primary land use sector in Inner Mongolia, is characterized by small-scale mixed subsistence farming systems, which primarily features livestock production (Zhang et al. 2007b, Zhen et al. 2010). In addition to agriculture, mining and related industries are gaining economic importance in land use (Wu et al. 2011).

An analytical framework for the comparative analysis of stakeholder perspectives and research foci

We used a conceptual framework based on the Land Use Functions (LUFs) approach (Tab. 1). LUFs are defined as "goods and services" that reflect the most relevant sustainability issues related to land use at the regional level (Pérez-Soba et al. 2008). Thus, LUFs provide a structured platform on which multifunctional land use issues can be analyzed in a balanced way following a triple-bottom line approach (see United Nations 1987), while equally considering the social, economic, and environmental dimensions of sustainable development (Helming et al. 2008, Schösser et al. 2010). A previous study on regional land use in China (Guyuan, Ningxia Hui Autonomous Region) conducted by König et al. (2012b) has demonstrated that the LUFs conceptual framework is a practical way to compare local perspectives with research topics. Therefore, this method has been adopted in this study.

Stakeholder participation and local perspectives

A stakeholder workshop on local land use perspectives was conducted in summer 2012

in West Ujimqin Banner, Inner Mongolia. The workshop's aim was to obtain information on the relative importance of social, economic, and environmental land use functions from the local perspective including the current challenges in this banner. We based our invitation of local stakeholders to the workshop on the concept of multi-level governance (Suškevics 2012), thereby employing the nexus county (banner) as the local decision-making level and the villages as the local decision-taking level (gacha). Adapting to the characteristics of fieldwork in China, we relied on the contacts and recommendations of intermediaries and official representatives to reach the stakeholders (Hansen 2006). For the workshop, we followed a two-step approach. To invite the decision-making representatives, we followed the recommendations of the vice governor of West Ujimqin Banner, who was responsible for land use and grassland management issues and with whom the authors' organization had established contact. Second, during a household survey in West Ujimqin Banner that occurred shortly before the workshop, we asked the village headmen if they were interested in joining the workshop to represent the so-called gacha and, thus, the local implementation level.

The final group of invitees included a mixed group of ten participants from different decision levels (Tab. 2).

The workshop was conducted within the framework of a focus group discussion (see Davies 1999). Based on a predefined list of nine LUFs that was adapted from Pérez-Soba et al. (2008) and König et al. (2012a - Tab. 1), the stakeholder group was asked to propose relevant land use issues associated with the corresponding LUFs in the West Ujimqin Banner. In the second step, the stakeholders were asked to assign "weights" to the perceived importance of each LUF (very important, important, less important - Tab. 4).

The identification of scientific perspectives on multifunctional land use: the literature survey

Complementary to the stakeholder workshop, a survey of the scientific literature was conducted focusing on multifunctional land use at the Inner Mongolian provincial level. The survey's aim was to identify the primary scientific studies addressing land use topics and, in a later step, to compare the identified (provincial) research topics with the (local) perceptions of the stakeholders. We searched the ISI Web of Science® and SCOPUS® (1996 to present) and the references from the articles found therein. Although we were aware that much has been published in Chinese, we only considered publications in English. We considered journal articles referred to as "articles", "reviews", or articles "in press". The keyword search included "Inner Mongolia" as the first criterion to be included in the article title. The second criterion was that the article should address one of the nine LUFs.

The identified research topics were thematically clustered into groups covering major natural science topics (*e.g.*, soil science, vegetation science, and ecosystem processes) and socio-economic topics (*e.g.*, income, food security, culture and tourism, and governance). In addition to the identified topics, we surveyed the primary methods and materials used in the identified studies. These methods and materials were also thematically clustered into groups, distinguishing, for example, between empirical studies, spatial studies using Geographic Information Systems (GIS), modeling studies, reviews, and theoretical studies. Similarly, clustering was performed for the materials and data used, distinguishing, for example, between natural science-based field experiments, socio-economic focused household surveys, statistics and spatio-temporal data sources. In a final step, based on the topics addressed and the methods applied, the identified studies were assigned to the single or multiple sustainability dimensions of economic, social, and environmental land use issues. The purpose of this task was to relate the research topics to multifunctional land use while covering multiple sustainability dimensions (Tab. 5).

Tab. 2 - Participation of decision makers and takers in the regional stakeholder workshop. (N): Number of representatives.

Decision level	Affiliation	Key responsibilities	N
Local	Balagaergaole principle town government	Implementation, monitoring and reporting	1
Local	Shutu Gacha (village), Balagaergaole town	Implementation, monitoring and reporting	1
Local	Yilide Gacha (village), Balagaergaole town	Implementation, monitoring and reporting	1
Regional	Agriculture and Animal Husbandry Bureau of West Ujimqin Banner	Knowledge provision, extension service	1
Regional	Climate and Meteorological Bureau of West Ujimqin Banner	Monitoring, forecast and disaster defense-response planning	1
Regional	Grassland Supervision Bureau of West Ujimqin Banner	Monitoring and implementation of grassland management policies	2
Regional	Government Office of West Ujimqin Banner	Monitoring and control of policy implementation	1
Regional	State-run grassland monitoring station of West Ujimqin Banner	Monitoring, analysis and planning support	1
Regional	Water Conservancy and Forestry Bureau of West Ujimqin Banner	Resource management, flood and drought control, forest and wildlife management and protection	1

Results

Multifunctional land use in Inner Mongolia: the scientific perspective

The survey of the scientific literature on land use issues in Inner Mongolia resulted in a list of 94 research articles (Fig. 1, Appendix 1). An analysis of the primary land use topics addressed indicated that these topics are primarily related to natural science, in particular soil issues (first emergence in

Tab. 3 - Primary methods and materials used by international scientific studies (n=94) addressing land use in Inner Mongolia.

Materials	Methods					
	Theory	Review +statistics	Review	Modelling	GIS +statistics	Empirical analysis
Field experiment	-	-	-	2	5	61
Household survey	-	-	-	-	-	5
Literature	2	-	3	-	-	-
Literature+household survey	-	2	-	-	-	-
Spatial data	-	-	-	-	3	-
Spatio-temporal data	-	-	-	-	-	3
Statistics	-	-	2	2	-	1

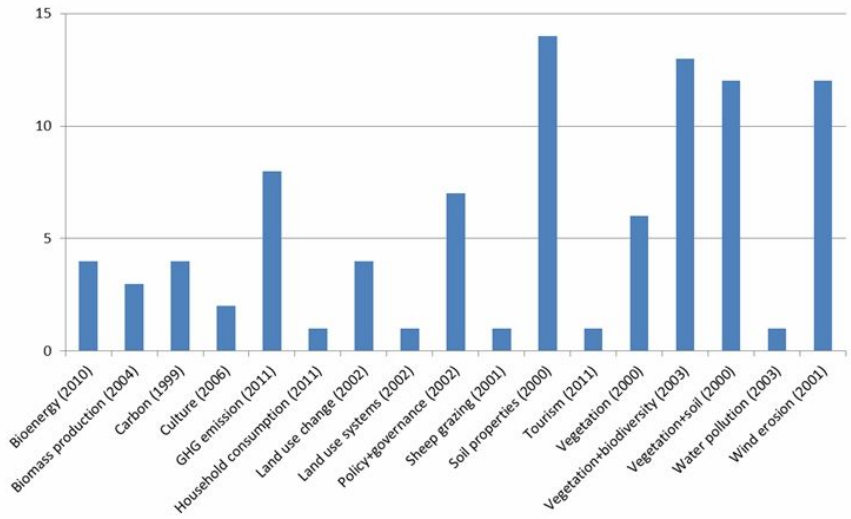

Fig. 1 - Primary land use topics covered by the international scientific literature and the year of emergence (n=94).

1999), vegetation science (emergence in 2000), biodiversity (primarily plant diversity - emergence in 2003), and greenhouse gas (GHG) studies (emergence in 2011). In contrast, social and economic topics have been less investigated. Only a few studies were available on policy and governance issues (emergence in 2002), household consumption patterns (emergence in 2010), and culture and tourism (emergence in 2011).

Regarding the materials and methods used in the research reported in the analyzed literature on Inner Mongolia, our analysis indicated that most natural-science land use studies were conducted using field experiments in combination with empirical analysis (n=61), followed by GIS and statistical analysis (n=5 - Tab. 3). In social and economic land use science, the primary methods used were household surveys in combination with statistical analysis (n=5). Here, a few studies also employed theory (n=2) or literature reviews (n=2).

Tab. 4 - Stakeholder associations with multifunctional land use: a local perspective from West Ujimqin Banner.

LUF	Description	Perceived importance	Specific associations	Relevance
ECO1	Land-based production	important	Grassland (livestock production)	Grassland is the primary land use type
			Forests (fuel wood, wild animals, herbal plants)	Forests provide important sources to rural households
ECO2	Non-land based activities	not listed	-	-
ECO3	Infrastructure	important	Transport (roads and railway)	Use of roads and railway to connect regions
			Fences for animals	Fencing is important to keep livestock on the farm
			Communication infrastructure	Telecommunications connects all regions, even distant ones
			Energy facilities	More inhabitants require electricity and energy facilities
			Water treatment facilities	Water treatment is necessary for cleaning polluted water
SOC1	Provision of work	very important	On-farm work (herding activities and harvesting)	Most rural residents work in the livestock sector
			Local factories	Factories provide additional job opportunities for rural people
			Mining industry	Mining is the most important industrial land use sector in Inner Mongolia
			Tourism and hotel services	Tourism is becoming an important employment sector as more individuals are interested in visiting Inner Mongolia
SOC2	Culture	less important	Traditional landscapes for cultural events	Inner Mongolia has a long history of traditions related to the regional landscapes
SOC3	Food security	important	Meat and crops	Inner Mongolians primarily consume meat (mainly lamb), wheat, and dairy products (cheese, butter)
			Wild animals and edible wild herbs	Wild animals and wild plants are traditionally important in rural household consumption
ENV1	Provision of abiotic resources	important	Water	Water is a fundamental resource for life
			Minerals (coal)	Inner Mongolia is rich in minerals
			Sun (solar energy)	Solar energy is becoming an important source of independent energy in rural areas
ENV2	Provision of biotic resources	important	Herbal plants	Widely used traditional Chinese medicine requires herbal plants
			Wild animals	Rural residents formerly hunted and consumed wild animals
			Maintenance of grassland habitats	Protection of grassland is important as more individuals demand land resources
ENV3	Maintenance of ecosystem processes	very important	Control of soil erosion	Wind erosion is one of the largest land use problems
			Management of water resources	Water is a scarce and important resource
			Maintenance of valuable grassland	Quality of grass determines livestock production

Tab. 5 - Comparison of stakeholder perspectives with (international) research themes addressing multifunctional land use in Inner Mongolia. "x": LUF addressed by research topic; "(x)": LUF only partly addressed by research topic; (N): appearance in scientific articles (see Appendix 1).

Research topics and coverage	N	Land use functions and perceived importance as specified by stakeholders								
		ECO1 Land-based production	ECO2 Non-land based activities	ECO3 Infra-structure	SOC1 Provision of work	SOC2 Culture	SOC3 Food security	ENV1 Provision of abiotic resources	ENV2 Provision of biotic resources	ENV3 Maintenance of ecosystem processes
		Important	Not listed	Important	Very important	Less important	Important	Important	Important	Very important
Bioenergy	4	x	-	x	-	-	-	-	-	-
Biomass production	3	x	-	-	-	-	-	-	-	-
Carbon	4	-	-	-	-	-	-	-	-	(x)
Culture	2	-	-	-	-	x	-	-	-	-
GHG emission	8	-	-	-	-	-	-	-	-	(x)
Household consumption	1	x	-	x	x	x	x	x	x	x
Land use change	4	x	-	-	-	-	-	-	-	-
Land use systems	1	x	-	-	-	-	-	-	-	-
Policy+governance	7	x	-	(x)	(x)	-	x	x	(x)	x
Sheep grazing	1	-	-	-	-	-	x	-	-	-
Soil properties	14	-	-	-	-	-	-	-	-	x
Tourism	1	-	-	-	-	x	-	-	-	-
Vegetation	6	-	-	-	-	-	-	-	x	x
Vegetation+bio-diversity	13	-	-	-	-	-	-	-	x	-
Vegetation+soil	12	-	-	-	-	-	-	-	-	x
Water pollution	1	-	-	-	-	-	-	x	-	-
Wind erosion	12	-	-	-	-	-	-	-	x	
Sum of corresponding LUF articles	x	20	-	12	8	4	9	9	27	64

Multifunctional land use in Inner Mongolia: the stakeholder perspective

The participating stakeholders group identified eight (Tab. 4) out of nine LUFs as applicable to the case of West Ujimqin Banner in Inner Mongolia. The economic LUF "Non-land based activities" (ECO2) was neglected for several reasons. First, non-land based activities were partly considered in other LUFs, for example, as industrial activities, such as mining, in the "Provisioning of work" (SOC1). Second, there might also be a methodological and cultural misinterpretation as to why "non-land based" land use issues should be considered at all.

Weighing the perceived importance of the identified LUFs demonstrated that the "Provisioning of work" (SOC1) and the "Maintenance of ecosystem processes" (ENV3) were perceived to be of high relevance (very important) compared with all of the other LUFs (Tab. 4). This result reflected that land-based job opportunities (primarily on-farm jobs) are highly important from the local decision-making perspective in West Ujimqin Banner and that the stakeholders were aware of the vast land degradation problems, particularly grasslands degradation and the need for soil and water conservation. Issues of medium importance included land use issues, including the "Provision of biotic resources" (ENV2), "Infrastructure" (ECO3), "Food security" (SOC3), the "Provision of abiotic resources" (ENV1), and "Land-based production" (ECO1). In contrast to these priorities, "Culture" (SOC2) was perceived to be of less importance. Notably, traditional landscapes are often used for cultural events and were perceived to be very important for the study area. However, the stakeholders considered these traditional landscapes to be less important because few cultural events have been organized. Frequently, these events are difficult to organize because of their high cost and because the population is scattered.

Comparison between stakeholder perspectives and research topics

A cross-tabulation analysis between stakeholder perspectives and research topics was performed on the LUFs and the corresponding research topics (Tab. 5).

Environmental LUFs were perceived to be important (ENV1 and ENV2) or very important (ENV3) by stakeholders, and the corresponding LUF research topics were well covered in the considered research articles with a total of 94 articles (Tab. 4 and Tab. 5). In particular, the LUF "Maintenance of ecosystem processes" (ENV3), which was perceived to be very important by stakeholders, was also given high priority in the research (this topic has been addressed in as many as 64 research articles).

In contrast, the perception of economic and social LUFs by stakeholders was more differentiated: not important at all (*i.e.*, not listed, ECO2), only less important (SOC2), important (ECO1, ECO3, and SOC3), or very important (SOC1). Economic LUFs were addressed in 32 articles, and social LUFs were addressed in 21 articles. Notably, the LUF "Provision of work" (SOC1), which was perceived as very important by stakeholders, was addressed in as many as eight articles. This result clearly indicated a research gap in the field of social issues in land use science in Inner Mongolia.

Discussion

Multifunctional land use

More than 50% of the land in Inner Mongolia is grassland (Zhang et al. 2007c). This area in northern China is considered to represent the richest grassland biodiversity worldwide (Nan 2005). However, land degradation is one of the most important sustainability problems in Inner Mongolia (Jiang et al. 2006). In economic terms, Chinese grassland has low productivity compared with other industrialized countries (Nan 2005). Both aspects - social (compare SOC1 "Provision of work") and environmental (compare ENV3 "Maintenance of ecosystem processes", ENV2 "Biotic resources") - were ranked highest by stakeholders in terms of local relevancy. With respect to the literature review, this ranking of local interests and general grassland aspects is consistent with ecosystem aspects but stands in contrast to the results of the social research related to jobs. Therefore, future research should address how to manage potential conflicts that may arise from intensified land use in the Inner Mongolian grasslands and related job opportunities while simultaneously protecting grassland biodiversity and ecosystem services functions.

The minimal focus on economic and social aspects within the international scientific literature is also reflected in the case of mining, which was perceived to be very important by the local stakeholders in terms of the provision of work (compare SOC2). However, the mining industry is one relevant example of a current development with a strong impact on land use. This industry is expected to grow dramatically within the next decades because of Inner Mongolia's large reserves of energetic, metallic, and non-metallic minerals (Inner Mongolia Statistics Bureau 2012). The mining industry is the primary driving force behind the spurious economic growth in Inner Mongolia. One consequence of the rapid development of the mining sector has been indirect land use changes, such as large investments in the railway infrastructure necessary to facilitate the increasing exports (State Council 2011). Thus, researchers should pay careful attention to local developments when targeting research to provide specific policy support.

Scientific focus and research needs

The clear dominance of natural science methods and topics compared with the methods and topics of social science in the scientific literature may have two primary causes. The first relates to the methods used in this paper: exclusively ISI-listed, English-language journal articles were analyzed. Whereas publication habits in the natural science fields clearly focus on ISI journals, this is not necessarily the case for social sciences, where book publications and other formats are widespread (Nederhof 2005). Consequently, there might be a methodological bias towards natural science literature in this paper. Second, land use is *per se* a topic primarily analyzed from the perspective of engineering (management) science or natural science in regards to its interaction with geophysical processes. Recently, the socio-economic aspects of land use have gained increasing importance, leading toward an increasingly interdisciplinary coverage of land use issues in the scientific literature (Lichtfouse et al. 2010). Today, it is commonly accepted that inter- or trans-disciplinary research is required to fully address the complexity of land use challenges and the human-nature interactions behind this complexity (Rounsevell et al. 2012, Turner et al. 2007).

Among the literature analyzed, articles most frequently addressed soil properties, soil erosion, vegetation, and the interaction between vegetation changes and soil degradation. Soil degradation and water and wind erosion were perceived to be the most pressing problems for land use in Inner Mongolia. Three reasons for these problems could be identified: first, increasing herd densities have increased grassland utilization beyond its threshold of natural resilience, resulting in grassland degradation, the appearance of uncovered land surface, and a respective increase in soil erosion (Feng & Zhao 2011, Li et al. 2011). Second, the initial impacts of climate change have increased the vulnerability of the grassland ecosystem because of more severe droughts (Liu et al. 2013, Xiao et al. 2013). Additionally, the identified focus of scientific articles on the issues of climate change, soil, GHG emissions, and carbon budgets is consistent with the increasing prominence of climate change topics in research worldwide. Third, wind erosion was identified as a major cause of the severe dust storms east of Inner Mongolia, including Beijing, which are adversely affecting the health of the metropolitan population (Cao et al. 2002, Hoffmann et al. 2011, Li & Huntsinger 2011). Consequently, the observed focus on soil-, climate- and vegetation-related natural science topics reflects a global and local trend in research on land use: climate change interactions.

Biodiversity is another natural science topic that was addressed in the analyzed scientific literature. Biodiversity reflects both the role of Inner Mongolia as China's largest grassland area and the region's particular importance to the biodiversity of grassland ecosystems (Bai et al. 2010, Zhao et al. 2011).

The comparatively minimal focus of the analyzed scientific literature on (agricultural) production issues related to grassland utilization may reflect the fact that animal grazing and meat production only recently have gained a market-oriented focus in Inner Mongolia. In the past, Inner Mongolia was not perceived as an economic priority area, *e.g.*, a focus for agricultural production or mining; rather, it was classified as a "priority ecological zone" with the major goal of sand storm prevention and soil erosion mitigation to rehabilitate grassland ecosystems (National Development and Reform Commission 2011). With regard to agriculture, Inner Mongolia was understood to possess predominantly subsistence production systems that were not subject to productivity research. The increasing focus on market-oriented meat production may be reflected in the respective literature in the years to come.

Stakeholder participation

The main objective of our study was to identify research gaps by contrasting local sustainability issues (*i.e.*, needs/constraints) against internationally available research topics (*i.e.*, priorities). The primary focus was on the decision makers' side and mainly considered the administrative level in order to gather information from "key players" who were actually responsible for land use decisions and its implementation (see Xu 2004). We regarded this approach as specifically relevant for China, since the state - and thus political decisions - even today have a strong influence on land properties and land management.

When including participatory aspects in a research approach, it is essential to understand the strengths and limitations of the stakeholders involved (Reed et al. 2009). The role of stakeholders in Inner Mongolian grassland management has yet been poorly discussed in the international research. Taylor (2006) indicates the need to concentrate on the role of humans in grassland management: "Grassland science should be partnered with sound local pastoral knowledge, where herders are active subjects in the landscape inscribing meanings on it through day-to-day practices" (p. 383). Therefore, our research approach specifically addressed the nexus of banner-gacha in the workshop, thereby involving stakeholders at multiple levels of governance (*i.e.*, banner officials, grassland management officials, and village/gacha headmen) and reflecting the local interests and needs.

Our objective could be achieved by conducting a regional stakeholder workshop in which we considered both decision makers (at regional administrative level) as well as decision takers (at local village/town levels). We argue that based on our methodology the selected stakeholders group enabled us to obtain a "good picture" of the specific region of West Ujimqin Banner that helped to identify the relevant land use problems and to better understand important regional sustainability constraints. Our results could serve as a starting point for understanding the sci-

ence-policy-interface between local scientific needs and international scientific results, thereby enabling a transfer to other regions in Inner Mongolia in the next research phases.

Conclusions

The aim of our study was to compare local perspectives on multifunctional land use with international research topics. Our study revealed that the stakeholders in a selected sub-region in Inner Mongolia (West Ujimqin Banner) perceived not only environmental and social but also economic land use functions to be important, whereas international research has been primarily focused on natural science aspects. If research aims to support governmental decision making regarding sustainable development, then it must balance economic, social, and environmental aspects and narrow the gap between the knowledge requirements of the local perspective and the research topics established by the scientific community. The concept of multifunctional land use, operationalized by the "land use functions" (LUFs) concept, is a practical way to identify such gaps. We conclude that without stakeholder participation, research will likely fail to generate useful results for decision making while simply addressing the most popular research topics.

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Supplementary Material

Appendix 1 - Regional land use studies in Inner Mongolia: topics, methods, materials, and sustainability dimensions.

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