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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 work-

shop, 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.

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 approx. 1.18 million km² (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

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

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 (Suškevičs 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

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

"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 experi-

ments, 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).

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

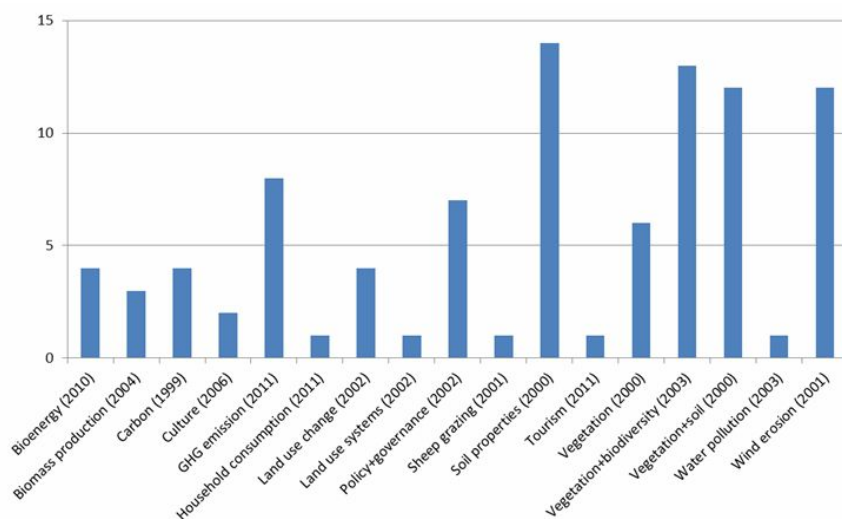


Fig. 1 - Primary land use topics covered by the international scientific literature and the year of emergence (n=94).

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

- Adelle C, Hertin J, Jordan A (2006). Sustainable development “outside” the European Union: what role for impact assessment? *European Environment* 16: 57-72. - doi: [10.1002/eet.405](https://doi.org/10.1002/eet.405)
- Ao M, Ito M, Ito K, Yun JF, Miura R, Tominaga T (2008). Floristic compositions of Inner Mongolian grasslands under different land-use conditions. *Grassland Science* 54: 173-178. - doi: [10.1111/j.1744-697X.2008.00121.x](https://doi.org/10.1111/j.1744-697X.2008.00121.x)
- Ao M, Miura R, Tominaga T (2009). Root and rhizome systems of perennial grasses grown in Inner Mongolian grassland, China. *Grassland Science* 55: 187-192. - doi: [10.1111/j.1744-697X.2009.00158.x](https://doi.org/10.1111/j.1744-697X.2009.00158.x)
- Bai Y, Han X, Wu J, Chen Z, Li L (2004). Ecosystem stability and compensatory effects in the Inner Mongolia grassland. *Nature* 431: 181-184. - doi: [10.1038/nature02850](https://doi.org/10.1038/nature02850)
- Bai Y, Wu J, Clark CM, Naemz S, Pan Q, Huang J, Hang L, Han X (2010). Tradeoffs and thresholds in the effects of nitrogen addition on biodiversity and ecosystem functioning: Evidence from inner Mongolia Grasslands. *Global Change Biology* 16: 358-372. - doi: [10.1111/j.1365-2486.2009.01950.x](https://doi.org/10.1111/j.1365-2486.2009.01950.x)
- Bennett MT, Mehta A, Xu J (2011). Incomplete property rights, exposure to markets and the provision of environmental services in China. *China Economic Review* 22: 485-498. - doi: [10.1016/j.chieco.2010.12.002](https://doi.org/10.1016/j.chieco.2010.12.002)
- Brogaard S, Li X (2005). Agricultural performance on marginal land in Eastern Inner Mongolia, China - Development in the pre- and post-1978 reform periods. *GeoJournal* 64: 163-175. - doi: [10.1007/s10708-005-5645-z](https://doi.org/10.1007/s10708-005-5645-z)
- Brogaard S, Runnström M, Seaquist JW (2005). Primary production of Inner Mongolia, China, between 1982 and 1999 estimated by a satellite data-driven light use efficiency model. *Global and Planetary Change* 45: 313-332. - doi: [10.1016/j.gloplacha.2004.09.012](https://doi.org/10.1016/j.gloplacha.2004.09.012)
- Brogaard S, Xueyong Z (2002). Rural reforms and changes in land management and attitudes: A case study from Inner Mongolia, China. *Ambio* 31: 219-225. - doi: [10.1579/0044-7447-31.3.219](https://doi.org/10.1579/0044-7447-31.3.219)
- Buckley R, Ollenburg C, Zhong L (2008). Cultural landscape in Mongolian tourism. *Annals of Tourism Research* 35: 47-61. - doi: [10.1016/j.annals.2007.06.007](https://doi.org/10.1016/j.annals.2007.06.007)
- Cao L, Tian W, Ni B, Zhang Y, Wang P (2002). Preliminary study of airborne particulate matter in a Beijing sampling station by instrumental neutron activation analysis. *Atmospheric Environment* 36: 1951-1956. - doi: [10.1016/S1352-2310\(02\)00178-4](https://doi.org/10.1016/S1352-2310(02)00178-4)
- Chang IS, Zhao J, Yin X, Wu J, Jia Z, Wang L (2011). Comprehensive utilizations of biogas in Inner Mongolia, China. *Renewable and Sustainable Energy Reviews* 15: 1442-1453. - doi: [10.1016/j.rser.2010.11.013](https://doi.org/10.1016/j.rser.2010.11.013)
- Chen J, Hori Y, Yamamura Y, Shiyomi M, Huang D (2008). Spatial heterogeneity and diversity analysis of macrovegetation in the Xilingol region, Inner Mongolia, China, using the beta distribution. *Journal of Arid Environments* 72: 1110-1119. - doi: [10.1016/j.jaridenv.2007.11.013](https://doi.org/10.1016/j.jaridenv.2007.11.013)
- Chen J, Huang D, Shiyomi M, Hori Y, Yamamura Y (2007a). Spatial heterogeneity and diversity of vegetation at the landscape level in Inner Mongolia, China, with special reference to water resources. *Landscape and Urban Planning* 82: 222-232. - doi: [10.1016/j.landurbplan.2007.02.011](https://doi.org/10.1016/j.landurbplan.2007.02.011)
- Chen S, Bai Y, Lin G, Han X (2005). Variations in life-form composition and foliar carbon isotope discrimination among eight plant communities under different soil moisture conditions in the Xilin River Basin, Inner Mongolia, China. *Ecological Research* 20: 167-176. - doi: [10.1007/s11284-004-0026-5](https://doi.org/10.1007/s11284-004-0026-5)
- Chen S, Bai Y, Lin G, Huang J, Han X (2007b). Isotopic carbon composition and related characteristics of dominant species along an environmental gradient in Inner Mongolia, China. *Journal of Arid Environments* 71: 12-28. - doi: [10.1016/j.jaridenv.2007.02.006](https://doi.org/10.1016/j.jaridenv.2007.02.006)
- Chen W, Wolf B, Brüggemann N, Butterbach-Bahl K, Zheng X (2011). Annual emissions of greenhouse gases from sheepfolds in Inner Mongolia. *Plant and Soil* 340: 291-301. - doi: [10.1007/s11104-010-0367-5](https://doi.org/10.1007/s11104-010-0367-5)
- Chen W, Zheng X, Chen Q, Wolf B, Butterbach-Bahl K, Brüggemann N, Lin S (2013). Effects of increasing precipitation and nitrogen deposition on CH₄ and N₂O fluxes and ecosystem respiration in a degraded steppe in Inner Mongolia, China. *Geoderma* 192: 335-340. - doi: [10.1016/j.geoderma.2012.08.018](https://doi.org/10.1016/j.geoderma.2012.08.018)
- Costanza R, Daly HE (1992). Natural capital and sustainable development. *Conservation Biology* 6: 37-46. - doi: [10.1046/j.1523-1739.1992.610037.x](https://doi.org/10.1046/j.1523-1739.1992.610037.x)
- Davies AR (1999). Where do we go from here? Environmental focus groups and planning policy formation. *Local Environment* 4: 295-316. - doi: [10.1080/13549839908725601](https://doi.org/10.1080/13549839908725601)
- de Groot RS, Alkemade R, Braat L, Hein L, Willemen L (2010). Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. *Ecological Complexity* 7: 260-272. - doi: [10.1016/j.ecocom.2009.10.006](https://doi.org/10.1016/j.ecocom.2009.10.006)
- Dickinson D, Webber M (2007). Environmental resettlement and development, on the Steppes of inner Mongolia, PRC. *Journal of Development Studies* 43: 537-561. - doi: [10.1080/00220380701204513](https://doi.org/10.1080/00220380701204513)
- Dong J, Liu J, Yan H, Tao F, Kuang W (2011a). Spatio-temporal pattern and rationality of land reclamation and cropland abandonment in Mid-eastern Inner Mongolia of China in 1990-2005. *Environmental Monitoring and Assessment* 179: 137-153. - doi: [10.1007/s10661-010-1724-9](https://doi.org/10.1007/s10661-010-1724-9)
- Dong J, Tao F, Zhang G (2011b). Trends and variation in vegetation greenness related to geographic controls in middle and eastern Inner Mongolia, China. *Environmental Earth Sciences* 62: 245-256. - doi: [10.1007/s12665-010-0518-2](https://doi.org/10.1007/s12665-010-0518-2)
- Dong J, Liu J, Zhang G, Basara JB, Greene S, Xiao X (2013). Climate change affecting temperature and aridity zones: a case study in Eastern Inner Mongolia, China from 1960-2008. *Theoretical and Applied Climatology* 113 (3-4): 561-572. - doi: [10.1007/s00704-012-0804-x](https://doi.org/10.1007/s00704-012-0804-x)
- ESPON (2012). EU-LUPA European land use patterns. Applied Research 2013/1/8, Annexes to Inception Report, v. 3 Dec 2010, European Union, Luxembourg, pp. 42. [online] URL: http://www.espon.eu/export/sites/default/Documents/Projects/AppliedResearch/EU-LUPA/Inception_report_EU-LUPA_Annexes.pdf
- Feng XM, Zhao YS (2011). Grazing intensity monitoring in Northern China steppe: integrating CENTURY model and MODIS data. *Ecological Indicators* 11: 175-182. - doi: [10.1016/j.ecolind.2009.07.002](https://doi.org/10.1016/j.ecolind.2009.07.002)
- Gao T, Su L, Ma Q, Li H, Li X, Yu X (2003). Climatic analyses on increasing dust storm frequen-

- cy in the springs of 2000 and 2001 in inner Mongolia. *International Journal of Climatology* 23: 1743-1755. - doi: [10.1002/joc.970](https://doi.org/10.1002/joc.970)
- Gao YZ, Giese M, Lin S, Sattelmacher B, Zhao Y, Brueck H (2008). Belowground net primary productivity and biomass allocation of a grassland in Inner Mongolia is affected by grazing intensity. *Plant and Soil* 307: 41-50. - doi: [10.1007/s11104-008-9579-3](https://doi.org/10.1007/s11104-008-9579-3)
- Gao YZ, Chen Q, Lin S, Giese M, Brueck H (2011). Resource manipulation effects on net primary production, biomass allocation and rain-use efficiency of two semiarid grassland sites in Inner Mongolia, China. *Oecologia* 165: 855-864. - doi: [10.1007/s00442-010-1890-z](https://doi.org/10.1007/s00442-010-1890-z)
- Gao T, Jiang X, Hu Y (2013). Climate condition of the significant precipitation decrease over the middle-eastern region of Inner Mongolia, China in recent 10 years (2001-2010). *Theoretical and Applied Climatology* 111: 265-274. - doi: [10.1007/s00704-012-0645-7](https://doi.org/10.1007/s00704-012-0645-7)
- Gao T, Si Y, Yan W, Gao L, Yu X, Xiao S (2014). Typical synoptic types of spring effective precipitation in Inner Mongolia, China. *Meteorological Applications* 21 (2): 330-339. - doi: [10.1002/met.1338](https://doi.org/10.1002/met.1338)
- Grimble R, Wellard K (1997). Stakeholder methodologies in natural resource management: a review of principles, contexts, experiences and opportunities. *Agricultural Systems* 55: 173-193. - doi: [10.1016/S0308-521X\(97\)00006-1](https://doi.org/10.1016/S0308-521X(97)00006-1)
- Hansen MH (2006). In the footsteps of the communist party: dilemmas and strategies, In: "Doing fieldwork in China" (Heimer M, Thøgersen S eds). University of Hawai'i Press, Honolulu, USA, pp. 81-95.
- Hao Y, Wang Y, Huang X, Cui X, Zhou X, Wang S, Niu H, Jiang G (2007). Seasonal and interannual variation in water vapor and energy exchange over a typical steppe in Inner Mongolia, China. *Agricultural and Forest Meteorology* 146: 57-69. - doi: [10.1016/j.agrformet.2007.05.005](https://doi.org/10.1016/j.agrformet.2007.05.005)
- Hao Y, Wang Y, Mei X, Huang X, Cui X, Zhou X, Niu H (2008). CO₂, H₂O and energy exchange of an Inner Mongolia steppe ecosystem during a dry and wet year. *Acta Oecologica* 33: 133-143. - doi: [10.1016/j.actao.2007.07.002](https://doi.org/10.1016/j.actao.2007.07.002)
- He J, Kuhn NJ, Zhang XM, Zhang XR, Li HW (2009). Effects of 10 years of conservation tillage on soil properties and productivity in the farming-pastoral ecotone of Inner Mongolia, China. *Soil Use and Management* 25: 201-209. - doi: [10.1111/j.1475-2743.2009.00210.x](https://doi.org/10.1111/j.1475-2743.2009.00210.x)
- He JJ, Cai QG, Cao WQ (2013). Wind tunnel study of multiple factors affecting wind erosion from cropland in agro-pastoral area of Inner Mongolia, China. *Journal of Mountain Science* 10: 68-74. - doi: [10.1007/s11629-013-2433-y](https://doi.org/10.1007/s11629-013-2433-y)
- Helming K, Bach H, Dilly O, Hüttl R, König B, Kuhlmann T, Pérez-Soba M, Sieber S, Smeets P, Tabbush P, Tscherning K, Wascher D, Wiggering H (2008). Ex ante impact assessment of land use changes in European regions - the SEN-SOR approach. In: "Sustainability Impact Assessment of Land Use Changes" (Helming K, Pérez-Soba M, Tabbush P eds). Springer, Berlin Heidelberg, Germany, pp. 77-105. - doi: [10.1007/978-3-540-78648-1](https://doi.org/10.1007/978-3-540-78648-1)
- Helming K, Diehl K, Bach H, Dilly O, König B, Kuhlmann T, Pérez-Soba M, Sieber S, Tabbush P, Tscherning K, Wascher D, Wiggering H (2011). Ex ante impact assessment of policies affecting land use. Part A. Analytical framework. *Ecology and Society* 16 (1): 1-17. [online] URL: http://zbl.med.fiz-karlsruhe.de/pubman/item/escidoc:55032:4/component/escidoc:55029/Helming_2011b.pdf
- Hoffmann C, Funk R, Li Y, Sommer M (2008a). Effect of grazing on wind driven carbon and nitrogen ratios in the grasslands of Inner Mongolia. *Catena* 75: 182-190. - doi: [10.1016/j.catena.2008.06.003](https://doi.org/10.1016/j.catena.2008.06.003)
- Hoffmann C, Funk R, Sommer M, Li Y (2008b). Temporal variations in PM10 and particle size distribution during Asian dust storms in Inner Mongolia. *Atmospheric Environment* 42: 8422-8431. - doi: [10.1016/j.atmosenv.2008.08.014](https://doi.org/10.1016/j.atmosenv.2008.08.014)
- Hoffmann C, Funk R, Wieland R, Li Y, Sommer M (2008c). Effects of grazing and topography on dust flux and deposition in the Xilinge grassland, Inner Mongolia. *Journal of Arid Environments* 72: 792-807. - doi: [10.1016/j.jaridenv.2007.09.004](https://doi.org/10.1016/j.jaridenv.2007.09.004)
- Hoffmann C, Funk R, Reiche M, Li Y (2011). Assessment of extreme wind erosion and its impacts in Inner Mongolia, China. *Aeolian Research* 3: 343-351. - doi: [10.1016/j.aeolia.2011.07.007](https://doi.org/10.1016/j.aeolia.2011.07.007)
- Holst J, Liu C, Brüggemann N, Butterbach-Bahl K, Zheng X, Wang Y, Han S, Yao Z, Yue J, Han X (2007a). Microbial N turnover and N-oxide (N₂O/NO/NO₂) fluxes in semi-arid grassland of Inner Mongolia. *Ecosystems* 10: 623-634. - doi: [10.1007/s10021-007-9043-x](https://doi.org/10.1007/s10021-007-9043-x)
- Holst J, Liu C, Yao Z, Brüggemann N, Zheng X, Han X, Butterbach-Bahl K (2007b). Importance of point sources on regional nitrous oxide fluxes in semi-arid steppe of Inner Mongolia, China. *Plant and Soil* 296: 209-226. - doi: [10.1007/s11104-007-9311-8](https://doi.org/10.1007/s11104-007-9311-8)
- Inner Mongolia Statistics Bureau (2012). Inner Mongolia Statistical Yearbook. China Statistics Press, Beijing, China, pp. 789. [in Chinese]
- Jiang G, Han X, Wu J (2006). Restoration and management of the Inner Mongolia grassland require a sustainable strategy. *Ambio* 35: 269-270. - doi: [10.1579/06-S-158.1](https://doi.org/10.1579/06-S-158.1)
- Jiang H (2005). Grassland management and views of nature in China since 1949: regional policies and local changes in Uxin Ju, inner Mongolia. *Geoforum* 36: 641-653. - doi: [10.1016/j.geoforum.2004.10.006](https://doi.org/10.1016/j.geoforum.2004.10.006)
- Jiang H (2006). Decentralization, ecological construction, and the environment in post-reform China: case study from Uxin Banner, Inner Mongolia. *World Development* 34: 1907-1921. - doi: [10.1016/j.worlddev.2005.11.022](https://doi.org/10.1016/j.worlddev.2005.11.022)
- Jun Li W, Ali SH, Zhang Q (2007). Property rights and grassland degradation: a study of the Xilingol Pasture, Inner Mongolia, China. *Journal of Environmental Management* 85: 461-470. - doi: [10.1016/j.jenvman.2006.10.010](https://doi.org/10.1016/j.jenvman.2006.10.010)
- Kang X, Hao Y, Li C, Cui X, Wang J, Rui Y, Niu H, Wang Y (2011). Modeling impacts of climate change on carbon dynamics in a steppe ecosystem in Inner Mongolia, China. *Journal of Soils and Sediments* 11: 562-576. - doi: [10.1007/s11368-011-0339-2](https://doi.org/10.1007/s11368-011-0339-2)
- König HJ, Uthes S, Schuler J, Zhen L, Purushothaman S, Suarma U, Sghaier M, Makokha S, Helming K, Sieber S, Chen L, Brouwer F, Morris J, Wiggering H (2012a). Regional impact assessment of land use scenarios in developing countries using the FoPIA approach: findings from five case studies. *Journal of Environmental Management* 127: S56-S64. - doi: [10.1016/j.jenvman.2012.10.021](https://doi.org/10.1016/j.jenvman.2012.10.021)
- König HJ, Zhen L, Helming K, Uthes S, Yang L, Cao X, Wiggering H (2012b). Assessing the impact of the sloping land conversion programme on rural sustainability in Guyuan, western China. *Land Degradation and Development* (early view). - doi: [10.1002/ldr.2164](https://doi.org/10.1002/ldr.2164)
- Lee Kwan C (2010). The Inner Mongolia autonomous region: a major role in China's renewable energy future. *Utilities Policy* 18: 46-52. - doi: [10.1016/j.jup.2009.07.002](https://doi.org/10.1016/j.jup.2009.07.002)
- Li FR, Zhang H, Zhao LY, Shirato Y, Wang XZ (2003). Pedoecological effects of a sand-fixing poplar (*Populus simonii* Carr.) forest in a desertified sandy land of Inner Mongolia, China. *Plant and Soil* 256: 431-442. - doi: [10.1023/A:1026124915454](https://doi.org/10.1023/A:1026124915454)
- Li FR, Zhao LY, Zhang H, Zhang TH, Shirato Y (2004). Wind erosion and airborne dust deposition in farmland during spring in the Horqin Sandy Land of eastern Inner Mongolia, China. *Soil and Tillage Research* 75: 121-130. - doi: [10.1016/j.still.2003.08.001](https://doi.org/10.1016/j.still.2003.08.001)
- Li FR, Kang LF, Zhang H, Zhao LY, Shirato Y, Taniyama I (2005). Changes in intensity of wind erosion at different stages of degradation development in grasslands of Inner Mongolia, China. *Journal of Arid Environments* 62: 567-585. - doi: [10.1016/j.jaridenv.2005.01.014](https://doi.org/10.1016/j.jaridenv.2005.01.014)
- Li C, Hao X, Zhao M, Han G, Willms WD (2008a). Influence of historic sheep grazing on vegetation and soil properties of a Desert Steppe in Inner Mongolia. *Agriculture, Ecosystems and Environment* 128: 109-116. - doi: [10.1016/j.agee.2008.05.008](https://doi.org/10.1016/j.agee.2008.05.008)
- Li YH, Wang W, Liu ZL, Jiang S (2008b). Grazing gradient versus restoration succession of *Leymus chinensis* (Trin.) Tzvel. grassland in inner Mongolia. *Restoration Ecology* 16: 572-583. - doi: [10.1111/j.1526-100X.2007.00332.x](https://doi.org/10.1111/j.1526-100X.2007.00332.x)
- Li W, Huntsinger L (2011). China's grassland contract policy and its impacts on herder ability to benefit in Inner Mongolia: tragic feedbacks. *Ecology and Society* 16 (2): 1-14.
- Li Y, Zhao H, Zhao X, Zhang T, Li Y, Cui J (2011). Effects of grazing and livestock exclusion on soil physical and chemical properties in desertified sandy grassland, Inner Mongolia, northern China. *Environmental Earth Sciences* 63: 771-783. - doi: [10.1007/s12665-010-0748-3](https://doi.org/10.1007/s12665-010-0748-3)
- Li A, Wu J, Huang J (2012). Distinguishing between human-induced and climate-driven vegeta-

- tion changes: a critical application of RE-STREND in inner Mongolia. *Landscape Ecology* 27: 969-982. - doi: [10.1007/s10980-012-9751-2](https://doi.org/10.1007/s10980-012-9751-2)
- Lichtfouse E, Hamelin M, Navarrete M, Debaeke P, Henri A (2010). Emerging agrosience. *Agronomy for Sustainable Development* 30: 1-10. - doi: [10.1051/agro/2009055](https://doi.org/10.1051/agro/2009055)
- Lin L, Dickhoefer U, Müller K, Wang C, Glindemann T, Hao J, Wan H, Schönbach P, Gierus M, Taube F, Susenbeth A (2012). Growth of sheep as affected by grazing system and grazing intensity in the steppe of Inner Mongolia, China. *Livestock Science* 144: 140-147. - doi: [10.1016/j.livsci.2011.11.008](https://doi.org/10.1016/j.livsci.2011.11.008)
- Lin Y, Han G, Zhao M, Chang SX (2010). Spatial vegetation patterns as early signs of desertification: a case study of a desert steppe in Inner Mongolia, China. *Landscape Ecology* 25: 1519-1527. - doi: [10.1007/s10980-010-9520-z](https://doi.org/10.1007/s10980-010-9520-z)
- Liu C, Holst J, Brüggemann N, Butterbach-Bahl K, Yao Z, Yue J, Han S, Han X, Krümmelbein J, Horn R, Zheng X (2007). Winter-grazing reduces methane uptake by soils of a typical semi-arid steppe in Inner Mongolia, China. *Atmospheric Environment* 41: 5948-5958. - doi: [10.1016/j.atmosenv.2007.03.017](https://doi.org/10.1016/j.atmosenv.2007.03.017)
- Liu J, Wu J, Liu F, Han X (2012). Quantitative assessment of bioenergy from crop stalk resources in Inner Mongolia, China. *Applied Energy* 93: 305-318. - doi: [10.1016/j.apenergy.2011.12.059](https://doi.org/10.1016/j.apenergy.2011.12.059)
- Liu X, Wang Y, Peng J, Braimoh AK, Yin H (2013). Assessing vulnerability to drought based on exposure, sensitivity and adaptive capacity: a case study in middle Inner Mongolia of China. *Chinese Geographical Science* 23: 13-25. - doi: [10.1007/s11769-012-0583-4](https://doi.org/10.1007/s11769-012-0583-4)
- Lu N, Chen S, Wilske B, Sun G, Chen J (2011). Evapotranspiration and soil water relationships in a range of disturbed and undisturbed ecosystems in the semi-arid Inner Mongolia, China. *Journal of Plant Ecology* 4: 49-60. - doi: [10.1093/jpe/rtq035](https://doi.org/10.1093/jpe/rtq035)
- Lü XT, Han XG (2010). Nutrient resorption responses to water and nitrogen amendment in semi-arid grassland of Inner Mongolia, China. *Plant and Soil* 327: 481-491. - doi: [10.1007/s11104-009-0078-y](https://doi.org/10.1007/s11104-009-0078-y)
- Miao H, Chen S, Chen J, Zhang W, Zhang P, Wei L, Han X, Lin G (2009). Cultivation and grazing altered evapotranspiration and dynamics in Inner Mongolia steppes. *Agricultural and Forest Meteorology* 149: 1810-1819. - doi: [10.1016/j.agrformet.2009.06.011](https://doi.org/10.1016/j.agrformet.2009.06.011)
- Nan Z (2005). The grassland farming system and sustainable agricultural development in China. *Grassland Science* 51: 15-19. - doi: [10.1111/j.1744-697X.2005.00003.x](https://doi.org/10.1111/j.1744-697X.2005.00003.x)
- National Development and Reform Commission (2011). National plan of priority ecological functional zones. National Development and Reform Commission, Beijing, China, pp. 132. [in Chinese]
- National Statistics Bureau (2010). China Statistical Yearbook. China Statistics Press, Beijing, China, pp. 1032. [in Chinese]
- National Statistics Bureau (2011). China Statistical Yearbook. China Statistics Press, Beijing, China, pp. 1058.
- Nederhof AJ (2005). Bibliometric monitoring of research performance in the social sciences and the humanities: a review. *Scientometrics* 66: 81-100. - doi: [10.1007/s11192-006-0007-2](https://doi.org/10.1007/s11192-006-0007-2)
- Peng Q, Dong Y, Qi Y, Xiao S, He Y, Ma T (2011a). Effects of nitrogen fertilization on soil respiration in temperate grassland in Inner Mongolia, China. *Environmental Earth Sciences* 62: 1163-1171. - doi: [10.1007/s12665-010-0605-4](https://doi.org/10.1007/s12665-010-0605-4)
- Peng Q, Qi Y, Dong Y, Xiao S, He Y (2011b). Soil nitrous oxide emissions from a typical semi-arid temperate steppe in inner Mongolia: effects of mineral nitrogen fertilizer levels and forms. *Plant and Soil* 342: 345-357. - doi: [10.1007/s11104-010-0699-1](https://doi.org/10.1007/s11104-010-0699-1)
- Pérez-Soba M, Petit S, Jones L, Bertrand N, Briquel V, Omodei-Zorini L, Contini C, Helming K, Farrington JH, Mossello MT, Wascher D, Kienast F, Groot R (2008). Land use functions - a multifunctionality approach to assess the impact of land use changes on land use sustainability. Springer, Berlin-Heidelberg, Germany, pp. 375-404.
- Podhora A, Helming K, Adenauer L, Heckelet T, Kautto P, Reidsma P, Rennings K, Turnpenny J, Jansen J (2013). The policy-relevancy of impact assessment tools: Evaluating nine years of European research funding. *Environmental Science and Policy* 31: 85-95. - doi: [10.1016/j.envsci.2013.03.002](https://doi.org/10.1016/j.envsci.2013.03.002)
- Qi YC, Dong YS, Liu JY, Domroes M, Geng YB, Liu LX, Liu XR, Yang X (2007). Effect of the conversion of grassland to spring wheat field on the CO2 emission characteristics in Inner Mongolia, China. *Soil and Tillage Research* 94: 310-320. - doi: [10.1016/j.still.2006.08.008](https://doi.org/10.1016/j.still.2006.08.008)
- Qi YC, Dong YS, Jin Z, Peng Q, Xiao SS, He YT (2010). Spatial heterogeneity of soil nutrients and respiration in the desertified grasslands of inner mongolia, China. *Pedosphere* 20: 655-665. - doi: [10.1016/S1002-0160\(10\)60055-0](https://doi.org/10.1016/S1002-0160(10)60055-0)
- Qi Y, Dong Y, Peng Q, Xiao S, He Y, Liu X, Sun L, Jia J, Yang Z (2012). Effects of a conversion from grassland to cropland on the different soil organic carbon fractions in Inner Mongolia, China. *Journal of Geographical Sciences* 22: 315-328. - doi: [10.1007/s11442-012-0929-y](https://doi.org/10.1007/s11442-012-0929-y)
- Qiao G, Zhao L, Klein KK (2009). Water user associations in Inner Mongolia: factors that influence farmers to join. *Agricultural Water Management* 96: 822-830. - doi: [10.1016/j.agwat.2008.11.001](https://doi.org/10.1016/j.agwat.2008.11.001)
- Reed MS, Graves A, Dandy N, Posthumus H, Hubacek K, Morris J, Prell C, Quinn CH, Stringer LC (2009). Who's in and why? A typology of stakeholder analysis methods for natural resource management. *Journal of Environmental Management* 90: 1933-1949. - doi: [10.1016/j.jenvman.2009.01.001](https://doi.org/10.1016/j.jenvman.2009.01.001)
- Reiche M, Funk R, Zhang Z, Hoffmann C, Reiche J, Wehrhan M, Li Y, Sommer M (2012). Application of satellite remote sensing for mapping wind erosion risk and dust emission-deposition in Inner Mongolia grassland, China. *Grassland Science* 58: 8-19. - doi: [10.1111/j.1744-697X.2011.00235.x](https://doi.org/10.1111/j.1744-697X.2011.00235.x)
- Reszkowska A, Krümmelbein J, Peth S, Horn R, Zhao Y, Gan L (2011). Influence of grazing on hydraulic and mechanical properties of semiarid steppe soils under different vegetation type in Inner Mongolia, China. *Plant and Soil* 340: 59-72. - doi: [10.1007/s11104-010-0405-3](https://doi.org/10.1007/s11104-010-0405-3)
- Rounsevell MDA, Pedroli B, Erb KH, Gramberger M, Busck AG, Haberl H, Kristensen S, Kuemmerle T, Lavorel S, Lindner M, Lotze-Campen H, Metzger MJ, Murray-Rust D, Popp A, Pérez-Soba M, Reenberg A, Vadineanu A, Verburg PH, Wolfslehner B (2012). Challenges for land system science. *Land Use Policy* 29: 899-910. - doi: [10.1016/j.landusepol.2012.01.007](https://doi.org/10.1016/j.landusepol.2012.01.007)
- Schösser B, Helming K, Wiggering H (2010). Assessing land use change impacts - a comparison of the SENSOR land use function approach with other frameworks. *Journal of Land Use Science* 5: 159-178. - doi: [10.1080/1747423X.2010.485727](https://doi.org/10.1080/1747423X.2010.485727)
- State Council (2011). Recommendations of the State Council on sound and fast development of the economy and society of Inner Mongolia. Chinese State Council, Beijing, China, pp. 1-26.
- Suškevics M (2012). Legitimacy analysis of multi-level governance of biodiversity: evidence from 11 case studies across the EU. *Environmental Policy and Governance* 22: 217-237. - doi: [10.1002/eet.1588](https://doi.org/10.1002/eet.1588)
- Schönbach P, Wan H, Schiborra A, Gierus M, Bai Y, Müller K, Glindemann T, Wang C, Susenbeth A, Taube F (2009). Short-term management and stocking rate effects of grazing sheep on herbage quality and productivity of Inner Mongolia steppe. *Crop and Pasture Science* 60: 963-974. - doi: [10.1071/CP09048](https://doi.org/10.1071/CP09048)
- Shao C, Chen J, Li L, Xu W, Chen S, Gwen T, Xu J, Zhang W (2008). Spatial variability in soil heat flux at three Inner Mongolia steppe ecosystems. *Agricultural and Forest Meteorology* 148: 1433-1443. - doi: [10.1016/j.agrformet.2008.04.008](https://doi.org/10.1016/j.agrformet.2008.04.008)
- Shiyomi M, Akiyama T, Wang S, Yiruhan Ailikon Hori Y, Chen Z, Yasuda T, Kawamura K, Yamamura Y (2011). A grassland ecosystem model of the Xilingol steppe, Inner Mongolia, China. *Ecological Modelling* 222: 2073-2083. - doi: [10.1016/j.ecolmodel.2011.03.028](https://doi.org/10.1016/j.ecolmodel.2011.03.028)
- Su YZ, Li YL, Zhao HL (2006). Soil properties and their spatial pattern in a degraded sandy grassland under post-grazing restoration, Inner Mongolia, northern China. *Biogeochemistry* 79: 297-314. - doi: [10.1007/s10533-005-5273-1](https://doi.org/10.1007/s10533-005-5273-1)
- Taylor JL (2006). Negotiating the grassland: the policy of pasture enclosures and contested resource use in Inner Mongolia. *Human Organization* 65: 374-386.
- Turner BL, Lambin EF, Reenberg A (2007). The emergence of land change science for global environmental change and sustainability. *Proceedings of the National Academy of Sciences USA* 104: 20666-20671. - doi: [10.1073/pnas.0704119104](https://doi.org/10.1073/pnas.0704119104)
- United Nations (1987). Our common future

- (chapt. 2). Towards sustainable development. [online] URL: <http://www.un-documents.net/ocf-02.htm>
- Wan H, Bai Y, Schönbach P, Gierus M, Taube F (2011). Effects of grazing management system on plant community structure and functioning in a semiarid steppe: scaling from species to community. *Plant and Soil* 340: 215-226. - doi: [10.1007/s11104-010-0661-2](https://doi.org/10.1007/s11104-010-0661-2)
- Wang S, Wang Y, Schnug E, Haneklaus S, Fleckenstein J (2002). Effects of nitrogen and sulphur fertilization on oats yield, quality and digestibility and nitrogen and sulphur metabolism of sheep in the Inner Mongolia steppes of China. *Nutrient Cycling in Agroecosystems* 62: 195-202. - doi: [10.1023/A:1015592423948](https://doi.org/10.1023/A:1015592423948)
- Wang ZP, Han XG (2005). Diurnal variation in methane emissions in relation to plants and environmental variables in the Inner Mongolia marshes. *Atmospheric Environment* 39: 6295-6305. - doi: [10.1016/j.atmosenv.2005.07.010](https://doi.org/10.1016/j.atmosenv.2005.07.010)
- Wang ZP, Han XG, Wang GG, Song Y, Gullede J (2008). Aerobic methane emission from plants in the Inner Mongolia steppe. *Environmental Science and Technology* 42: 62-68. - doi: [10.1021/es071224l](https://doi.org/10.1021/es071224l)
- Wang YF, Cui XY, Hao YB, Mei XR, Yu GR, Huang XZ, Kang XM, Zhou XQ (2011). The fluxes of CO₂ from grazed and fenced temperate steppe during two drought years on the Inner Mongolia Plateau, China. *Science of the Total Environment* 410 (411): 182-190.
- Wei Y, Chen D, Hu K, Willett IR, Langford J (2009). Policy incentives for reducing nitrate leaching from intensive agriculture in desert oases of Alxa, Inner Mongolia, China. *Agricultural Water Management* 96: 1114-1119. - doi: [10.1016/j.agwat.2009.02.001](https://doi.org/10.1016/j.agwat.2009.02.001)
- Wiggering H, Müller K, Werner A, Helming K (2003). The concept of multifunctionality in sustainable land development. In: "Sustainable Development of Multifunctional Landscapes" (Helming K, Wiggering H eds). Springer, Berlin, Germany, pp. 3-18.
- Wiggering H, Dalchow C, Glemnitz M, Helming K, Müller K, Schultz A, Stachow U, Zander P (2006). Indicators for multifunctional land use - linking socio-economic requirements with landscape potentials. *Ecological Indicators* 6: 238-249. - doi: [10.1016/j.ecolind.2005.08.014](https://doi.org/10.1016/j.ecolind.2005.08.014)
- Wilske B, Lu N, Wei L, Chen S, Zha T, Liu C, Xu W, Noormets A, Huang J, Wei Y, Chen J, Zhang Z, Ni J, Sun G, Guo K, McNulty S, John R, Han X, Lin G, Chen J (2009). Poplar plantation has the potential to alter the water balance in semiarid Inner Mongolia. *Journal of Environmental Management* 90: 2762-2770. - doi: [10.1016/j.jenvman.2009.03.004](https://doi.org/10.1016/j.jenvman.2009.03.004)
- Wu D, Dai F, Yan Y, Liu X, Fu X (2011). The environmental and economic influence of coal-electricity integration exploitation in the Xilingol League. *Shengtai Xuebao/ Acta Ecologica Sinica* 31: 5055-5060.
- Xiao LB, Fang XQ, Ye Y (2013). Reclamation and revolt: social responses in eastern Inner Mongolia to flood/drought-induced refugees from the north China plain 1644-1911. *Journal of Arid Environments* 88: 9-16. - doi: [10.1016/j.jaridenv.2012.07.022](https://doi.org/10.1016/j.jaridenv.2012.07.022)
- Xu W (2004). The changing dynamics of land-use change in rural China: a case study of Yuhang, Zhejiang Province. *Environment and Planning A* 36: 1595-1615. - doi: [10.1068/a36185](https://doi.org/10.1068/a36185)
- Xu X, Duan X, Sun H, Sun Q (2011). Green space changes and planning in the capital region of China. *Environmental Management* 47: 456-467. - doi: [10.1007/s00267-011-9626-3](https://doi.org/10.1007/s00267-011-9626-3)
- Yin RS, Yin GP (2010). China's primary programs of terrestrial ecosystem restoration: initiation, implementation, and challenges. *Environmental Management* 45: 429-441. - doi: [10.1007/s00267-009-9373-x](https://doi.org/10.1007/s00267-009-9373-x)
- Zhang W, Skarpe C (1996). Small-scale vegetation dynamics in semi-arid steppe in inner Mongolia. *Journal of Arid Environments* 34: 421-439. - doi: [10.1006/jare.1996.0122](https://doi.org/10.1006/jare.1996.0122)
- Zhang W (1998). Changes in species diversity and canopy cover in steppe vegetation in Inner Mongolia under protection from grazing. *Biodiversity and Conservation* 7: 1365-1381. - doi: [10.1023/A:1008852017493](https://doi.org/10.1023/A:1008852017493)
- Zhang TH, Zhao HL, Li SG, Li FR, Shirato Y, Ohkuro T, Taniyama I (2004). A comparison of different measures for stabilizing moving sand dunes in the Horqin Sandy Land of Inner Mongolia, China. *Journal of Arid Environments* 58: 203-214. - doi: [10.1016/j.jaridenv.2003.08.003](https://doi.org/10.1016/j.jaridenv.2003.08.003)
- Zhang LX, Yang ZF, Chen GQ (2007a). Emergy analysis of cropping-grazing system in Inner Mongolia autonomous region, China. *Energy Policy* 35: 3843-3855. - doi: [10.1016/j.enpol.2007.01.022](https://doi.org/10.1016/j.enpol.2007.01.022)
- Zhang MA, Borjigin E, Zhang H (2007b). Mongolian nomadic culture and ecological culture: On the ecological reconstruction in the agro-pastoral mosaic zone in northern China. *Ecological Economics* 62: 19-26. - doi: [10.1016/j.ecolecon.2006.11.005](https://doi.org/10.1016/j.ecolecon.2006.11.005)
- Zhang WL, Chen SP, Chen J, Wei L, Han XG, Lin GH (2007c). Biophysical regulations of carbon fluxes of a steppe and a cultivated cropland in semiarid Inner Mongolia. *Agricultural and Forest Meteorology* 146: 216-229. - doi: [10.1016/j.agrformet.2007.06.002](https://doi.org/10.1016/j.agrformet.2007.06.002)
- Zhang X, Gu S, Liu W, Gan L (2001). Wind energy technology development and diffusion: a case study of Inner Mongolia, China. *Natural Resources Forum* 25: 33-42. - doi: [10.1111/j.1477-8947.2001.tb00744.x](https://doi.org/10.1111/j.1477-8947.2001.tb00744.x)
- Zhang X, Sun T, Zhang J (2009). The role of land management in shaping arid/semi-arid landscapes: the case of the Catholic church (CICM) in western Inner Mongolia from the 1870s (late Qing Dynasty) to the 1940s (Republic of China). *Geographical Research* 47: 24-33. - doi: [10.1111/j.1745-5871.2008.00558.x](https://doi.org/10.1111/j.1745-5871.2008.00558.x)
- Zhao HL, Li SG, Zhang TH, Ohkuro T, Zhou RL (2004). Sheep gain and species diversity in sandy grassland, Inner Mongolia. *Journal of Range Management* 57: 187-190. - doi: [10.2307/4003917](https://doi.org/10.2307/4003917)
- Zhao HL, Zhao XY, Zhou RL, Zhang TH, Drake S (2005a). Desertification processes due to heavy grazing in sandy rangeland, Inner Mongolia. *Journal of Arid Environments* 62: 309-319. - doi: [10.1016/j.jaridenv.2004.11.009](https://doi.org/10.1016/j.jaridenv.2004.11.009)
- Zhao WZ, Xiao HL, Liu ZM, Li J (2005b). Soil degradation and restoration as affected by land use change in the semiarid Bashang area, northern China. *Catena* 59: 173-186. - doi: [10.1016/j.catena.2004.06.004](https://doi.org/10.1016/j.catena.2004.06.004)
- Zhao HL, Yi XY, Zhou RL, Zhao XY, Zhang TH, Drake S (2006a). Wind erosion and sand accumulation effects on soil properties in Horqin sandy farmland, Inner Mongolia. *Catena* 65: 71-79. - doi: [10.1016/j.catena.2005.10.001](https://doi.org/10.1016/j.catena.2005.10.001)
- Zhao HL, Zhou RL, Zhang TH, Zhao XY (2006b). Effects of desertification on soil and crop growth properties in Horqin sandy cropland of Inner Mongolia, north China. *Soil and Tillage Research* 87: 175-185. - doi: [10.1016/j.still.2005.03.009](https://doi.org/10.1016/j.still.2005.03.009)
- Zhao HL, Cui JY, Zhou RL, Zhang TH, Zhao XY, Drake S (2007a). Soil properties, crop productivity and irrigation effects on five croplands of Inner Mongolia. *Soil and Tillage Research* 93: 346-355. - doi: [10.1016/j.still.2006.05.009](https://doi.org/10.1016/j.still.2006.05.009)
- Zhao HL, Zhou RL, Su YZ, Zhang H, Zhao LY, Drake S (2007b). Shrub facilitation of desert land restoration in the Horqin Sand Land of Inner Mongolia. *Ecological Engineering* 31: 1-8. - doi: [10.1016/j.ecoleng.2007.04.010](https://doi.org/10.1016/j.ecoleng.2007.04.010)
- Zhao Y, Peth S, Krümmelbein J, Horn R, Wang Z, Steffens M, Hoffmann C, Peng X (2007c). Spatial variability of soil properties affected by grazing intensity in Inner Mongolia grassland. *Ecological Modelling* 205: 241-254. - doi: [10.1016/j.ecolmodel.2007.02.019](https://doi.org/10.1016/j.ecolmodel.2007.02.019)
- Zhao HL, He YH, Zhou RL, Su YZ, Li YQ, Drake S (2009a). Effects of desertification on soil organic C and N content in sandy farmland and grassland of Inner Mongolia. *Catena* 77: 187-191. - doi: [10.1016/j.catena.2008.12.007](https://doi.org/10.1016/j.catena.2008.12.007)
- Zhao W, Chen SP, Han XG, Lin GH (2009b). Effects of long-term grazing on the morphological and functional traits of *Leymus chinensis* in the semiarid grassland of Inner Mongolia, China. *Ecological Research* 24: 99-108. - doi: [10.1007/s11284-008-0486-0](https://doi.org/10.1007/s11284-008-0486-0)
- Zhao Y, Peth S, Horn R, Krümmelbein J, Ketzner B, Gao Y, Doerner J, Bernhofer C, Peng X (2010). Modeling grazing effects on coupled water and heat fluxes in Inner Mongolia grassland. *Soil and Tillage Research* 109: 75-86. - doi: [10.1016/j.still.2010.04.005](https://doi.org/10.1016/j.still.2010.04.005)
- Zhao Y, Wu P, Hu YG, Zhang ZS (2011). Plant species diversity in farmland drainage ditches in hetao irrigation region, Inner Mongolia. *Chinese Journal of Ecology* 30: 2797-2802.
- Zhao HL, Liu RT (2013). The "bug island" effect of shrubs and its formation mechanism in Horqin Sand Land, Inner Mongolia. *Catena* 105: 69-74. - doi: [10.1016/j.catena.2013.01.009](https://doi.org/10.1016/j.catena.2013.01.009)
- Zhen L, Ochirbat B, Lv Y, Wei YJ, Liu XL, Chen JQ, Yao ZJ, Li F (2010). Comparing patterns of ecosystem service consumption and perceptions of range management between ethnic herders in Inner Mongolia and Mongolia. *Environmental*

Research Letters 5: 015001. - doi: [10.1088/1748-9326/5/1/015001](https://doi.org/10.1088/1748-9326/5/1/015001)

Zhen L, Deng X, Wei Y, Jiang O, Lin Y, Helming K, Wang C, König HJ (2014). Future land use and food security scenarios for the Guyuan district of remote western China. *iForest* 7: 372-384. - doi: [10.3832/ifor1170-007](https://doi.org/10.3832/ifor1170-007)

Zhizhong W, Wen D (2008). Pastoral nomad

rights in Inner Mongolia. *Nomadic Peoples* 12: 13-33. - doi: [10.3167/np.2008.120202](https://doi.org/10.3167/np.2008.120202)

Zweig D (1992). Urbanizing rural China: bureaucratic authority and local autonomy, In: "Bureaucracy, Politics, and Decision Making in Post-Mao China" (Lieberthal KG, Lampton DM eds). University of California Press, Berkeley, Los Angeles, USA, pp. 334-363.

Supplementary Material

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

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