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Effects of Government Grassland Conservation Policy on Household Livelihoods and Dependence on Local Grasslands: Evidence from Inner Mongolia, China

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Abstract: Grassland degradation intensifies human-environment conflicts and adversely affects local residents' livelihoods. To reduce grassland degradation in Inner Mongolia, China, the government has enforced (since 1998) a series of grassland conservation and management policies that restrict the use of grasslands. To ease the impact on the residents' livelihoods, the national and regional governments have offered a series of top-down arrangements to stimulate sustainable use of the grasslands. Simultaneously, local households spontaneously developed bottom-up countermeasures. To determine the effects of these processes, we interviewed members of 135 households using a mix of qualitative and quantitative methods. We analyzed the effects on household dependence on local grasslands and on perceptions of the future of grassland use. Our findings show that the implementation of the grassland conservation policies significantly affected household livelihoods, which in turn affected household use of natural assets (primarily the land), their agricultural assets (farming and grazing activities) and their financial assets (income and consumption), resulting in fundamental transformation of their lifestyles. The households developed adaptation measures to account for the dependence of their livelihood on local ecosystems by initializing strategies, such as seeking off-farm work, leasing pasture land, increasing purchases of fodder for stall-fed animals and altering their diet and fuel consumption to compensate for their changing livelihoods.

Keywords: livelihood analysis; dependence; conservation policy; grassland management

1. Introduction

Grasslands are among the largest and most important ecosystems in the world, and human populations derive a variety of crucial benefits from the goods and services that grasslands provide. The livelihoods of pastoral communities are strongly linked to the health of the grasslands on which the majority of these communities rely [1]. However, grasslands in many regions of the world are showing alarming signs of degradation [2,3]. Increasing demand on pasture resources, especially in arid and semi-arid regions, has led to extensive and sometimes irreversible damage to the grassland environment, while simultaneously compromising the livelihoods of residents [4,5].

For the purposes of this paper, livelihood refers to a person's "means of securing the basic necessities—food, water, shelter, fuel, and clothing—of life" [6]. This definition comprises the set of activities required to obtain these necessities by working either individually or in groups to sustainably meet individual and household requirements. In practice, the definition of "livelihood" differs

among countries based on differences in their economic levels, social relationships and environmental conditions [7,8]. In China, there is no standard definition, but for rural residents, the term generally refers to income-generating activities both on and off their farm [9]. The concept of livelihood has gained wide acceptance as a valuable means to analyze the factors that influence human living, well-being and impacts on the ecosystems that sustain them, particularly in the most impoverished and ecologically fragile areas in the developing world [10], such as Inner Mongolia, in northern China.

The analysis of livelihoods normally links the micro-level of individual livelihoods with macro-level policy development and implementation and thereby provides support for policy development and poverty alleviation [11,12]. This is especially useful when policies are examined from the perspective of the sustainable use of human, natural, financial, social and physical capital to reveal the influence of the policy on these important aspects of livelihoods [13]. Most current research has focused on the construction of a conceptual framework for livelihood and the application of the framework in different contexts, as well as on identifying policy intervention mechanisms in natural resource management to reveal the effects of local ecosystems [14–16]. Several studies for adaptive management have investigated the vulnerability of ecosystems and of communities and nations that depend on the exploitation of natural resources against the background of global climatic change [8,14]. In previous research, the analysis of the household dependence on natural resources simply referred to the economic aspect, such as the actual household income or its proportional change over time. However, until recently, the implications of interventions (e.g., government policy, urbanization) on the livelihoods of resource users and changes in household dependence on natural resources at local scales have been less well explored [17,18]. In addition, there has been insufficient attention to the changing background of ecological management and the adoption of new livelihoods in response to changes in government policy, especially in regions with a vulnerable environment (e.g., Inner Mongolia), where policies to balance regional socio-economic development with ecological conservation have had important effects on household livelihoods [19].

The grasslands of Inner Mongolia have been experiencing degradation for decades, resulting in decreased primary production and frequent forage shortages, especially in the spring [20]. The degradation appears to have been caused by unsustainable use of the natural resources provided by these grasslands [21]. However, Inner Mongolia is inherently an ecologically-vulnerable area, and this degradation directly threatens both the environment and the sustainability of regional socioeconomic development. To solve the problem, national and local governments have implemented a series of grassland management policies. The implementation of these policies began in limited parts of Inner Mongolia in 1998, and the policies were expanded to all of Inner Mongolia after several years' experience. The overall policy included five main measures [22]:

(1) Seasonal grazing, in which pastures could only be grazed throughout the period of grass growth from April to November, was broadly implemented in the slightly degraded grassland, and pastoralists received an annual compensation payment of 22.5 CNY/ha (US$3.46/ha based on the exchange rate of 6.50 CNY/US$ on 10 January 2016).

(2) Rotational grazing, in which the grassland was divided into paddocks that could only be used at 25- to 50-day intervals, depending on the type of grassland: 25 to 30 days for meadow, 30 to 35 days for steppes and 40 to 45 days for desert steppes. This policy was implemented in slightly to moderately degraded grassland, and pastoralists received an annual compensation payment of 22.5 CNY/ha (US$3.46/ha).

(3) Grazing prohibition, which was mainly carried out in severely-degraded grassland, eliminated all grazing in an area until it recovered to near its original condition, and pastoralists received an annual compensation of 90 CNY/ha (US$13.85/ha).

(4) Control of livestock rearing, in which the number of livestock was limited according to the carrying capacity of the local grassland, and nomadism was prohibited and replaced by indoor rearing. To implement this measure, fences were constructed throughout the grassland, and pastoralists received a single compensation payment of 300 CNY/ha (US$46.15/ha).

(5) Offering jobs in the cities let residents change their employment from animal husbandry or farming to urban employment, thereby reducing household dependence on local grasslands. This policy was mainly implemented in severely-degraded grassland. The government provided assistance for job training, employment opportunities and social benefits, such as medical insurance and education for their children.

Unfortunately, these policies created great stresses on households by fundamentally changing their lifestyles [23,24] and drastically reshaping the patterns of grassland use that had existed for millennia in Inner Mongolia [25]. In recent years, rural livelihoods in Inner Mongolia have increasingly shifted from subsistence agriculture and animal husbandry to include non-agricultural, off-farm work for wages and government subsidies [18,26]. Adapting to these changes has required households to take risks and look for new opportunities, leading to continuous transformation of rural landscapes, land uses and livelihoods by changing the dependence of these households on local grasslands.

In the present study, we had the following main goals: to identify indicators of changes in the livelihoods of residents of our study area in Inner Mongolia; to reveal the dynamics of household livelihoods in response to changes in access to natural assets and in their agricultural activities; to quantify the financial adjustments of households to changes in their dependence on local grasslands; and to investigate their perceptions of careers for the next generation of their family. This paper also aims to provide a better understanding of the grassland use policy changes and the process of policy influencing livelihoods and household adoptive strategies and to contribute to the sustainable use of natural resources.

2. Description of the Study Areas

We selected China's Inner Mongolia Autonomous Region for the case study. This region has an arid to semi-arid continental climate [27] with strong climatic gradients and grassland as the dominant land use (Figure 1). Inner Mongolia is China's third-largest province, covering an area of approximately 1.18×10^6 km^2 [28]. The population amounted to 25.05×10^6 people in 2014 [28]. Typical steppes, meadows and semi-desert and desert steppes are the major grassland types [29]. Grasslands were traditionally used for grazing and animal production before 1995 [30]. Frequent drought was the major natural disaster, although severe winter weather was also a frequent problem [31]; Inner Mongolia has suffered from decades of climate fluctuation that have exacerbated the effects of human disturbance (e.g., over-grazing, excessive reclamation of grasslands for agriculture), so grassland degradation is a widely-observed problem. Zhang et al. [21] found that both degradation and improvement of the grasslands have occurred since the 1980s, but that grassland degradation was the major trend. The area of degraded grassland increased from 18.08×10^4 km^2 in the 1980s to 22.47×10^4 km^2 in the 2010s, and its distribution shifted from the central-eastern to the western parts of Inner Mongolia, from mainly in the Hulun Buir and Xilin Gol grasslands in the 1980s to mainly in the Ordos and Alxa grasslands in the 2010s.

We chose three regions of Inner Mongolia as county-level study sites: the West Ujimqin Banner, the Zhengxiangbai Banner and the Alxa Right Banner. These areas are representative of three typical and fragile grassland areas. The West Ujimqin Banner has a continental temperate semi-arid climate; the mean monthly temperatures range from a minimum of –19.5 °C in January to a maximum of 19.5 °C in July, and the growing season is from April to September. The annual precipitation decreases from 400 mm in the northeast to less than 300 mm in the southwest and occurs mostly (68%) during the summer (from June to August). The main vegetation type is a typical steppe, and over 96% of the total area is grassland, which has high drought tolerance. The rural residents live mainly by grazing their animals in grasslands and by livestock rearing. The West Ujimqin Banner is one of the most important animal husbandry regions in China. The area of cultivated land accounts for only 0.2% of the total area [32].

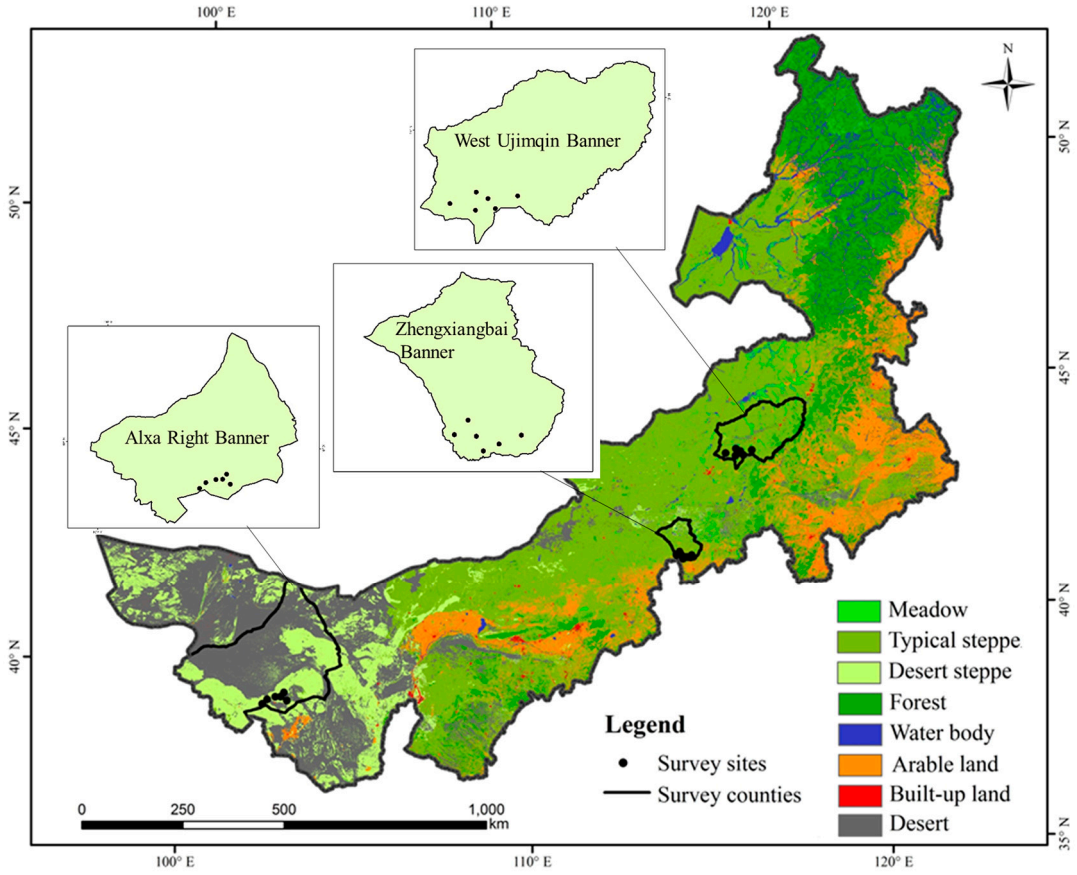

Figure 1. Maps of the land use types and locations of the survey sites in Inner Mongolia.

The Zhengxiangbai Banner is located in north-central Inner Mongolia and is dominated by semi-desert steppe, with annual rainfall ranging from 100 mm to 350 mm, of which 67% falls between June and August. The pan mean annual temperature averages 1.9 °C, but mean monthly temperatures range from a minimum of −19.1 °C in January to a maximum of 17.6 °C in July. The area of cultivated land (2.2%) is proportionally larger than in the West Ujimqin Banner, and more than half of the land is used to grow grains; most of the other half grows oil plants, fruits, vegetables and other crops [33]. The trend for animal husbandry and agriculture has been from personal use (i.e., subsistence agriculture) to professional use (i.e., selling animals and crops to earn income) and then to a large-scale industry.

The Alxa Right Banner of northwestern Inner Mongolia, which is bounded by the Baba Jilin Desert to the north, is covered by desert steppe or desert and has an arid climate, with only 100 mm of annual precipitation and 3000 mm of annual pan evapotranspiration. The average annual temperature is 7 °C, but mean monthly temperatures range from a minimum of −13 °C in January to a maximum of 27 °C in July. Traditionally, local herders were described as "the people who live on the backs of camels", but most of them no longer raise camels and instead raise cattle, goats and sheep. There is no significant agriculture, other than small gardens for household use [34].

3. Materials and Methods

3.1. Research Design, Questionnaires and Data Collection

To investigate the changes in household livelihood that have occurred in response to the stresses created by government policy interventions, grassland degradation and urbanization, we conducted a household survey (using guided interviews structured by a questionnaire) by visiting households in the three regions of Inner Mongolia in June 2011 (Zhengxiangbai Banner) and July 2012 (West Ujimqin

Banner and Alxa Right Banner). We asked households to report changes in their circumstances between 1995 (before the government ecological policies were implemented) and 2010. We interviewed a total of 135 households, at a total of 18 survey sites (each of survey site represents a smaller community) in 6 villages, with the survey frequency proportional to the population size of each village. In selecting villages, we specifically included two or three villages in each banner that differed in characteristics, such as the proportions of various economic activities and ecological characteristics. We surveyed a total of 35 respondents in the West Ujimqin Banner, 71 in the Zhengxiangbai Banner and 29 in the Alxa Right Banner. Based on our survey, most respondents performed both animal husbandry and farming rather than only one of these activities. Prior to the formal surveys, we conducted a re-visit in July 2014 to monitor the changes of their animal husbandry activities and household income and employment situations.

We selected the three banners beforehand and then used stratified random sampling to select the villages within each category (i.e., dominant activity or environment) in each banner. We used simple random sampling to select households for the survey in each village. We considered a sample size that included more than 70% of the total households in each village to be appropriate based on the recommendation of Tabachnick and Fidell [35] that a sample should account for more than 50% of the households when the total number of households is less than 100. Because the survey was carried out in person by interviews or by having the respondents complete the questionnaire under guidance from a member of the research group, we obtained a high response rate (94.5%). For respondents who did not speak Mandarin Chinese, we used a local interpreter to help us communicate clearly.

For each household, we asked the head of the household or a family member who was familiar with the household's characteristics to answer the questions. The interviewees were asked to provide: (1) personal and household information, including the age, education and technical and skill training of all members of the household, their land use assets, the number and species of livestock and their perceptions of the ecological context; (2) a description of livelihood changes in terms of their agricultural and animal husbandry activities, including cultivation patterns, investments and annual return on these investments; and (3) the household income and employment situation, consumption patterns (foods and fuels) and their perceptions of the next generation's potential career choices.

3.2. Selection of Indicators for the Livelihood Analysis

Because of the ecological changes (land degradation), government policy changes (grassland conservation) and urbanization in the study region, our livelihood analysis provides important data on changes in the use of local natural resources and on livelihood strategies (particularly changes) in response to the stresses facing the households (Figure 2). The results of this analysis reveal the elements that make a household more or less sensitive to the effects of environmental and government factors.

For the selected indicators (Table 1), we collected data to describe the change that occurred between 1995 and 2010. To quantify changes in the use of natural assets, we estimated the change in the percentage of total land use accounted for by grasslands. To investigate the change in agricultural assets, we obtained data on the number and type of livestock and how they were fed, as well as the extent to which households formed cooperative associations. We then determined the dependence of household income on agriculture, and the food (locally produced and purchased) and fuel consumption (based on the quantity of each major fuel that was consumed).

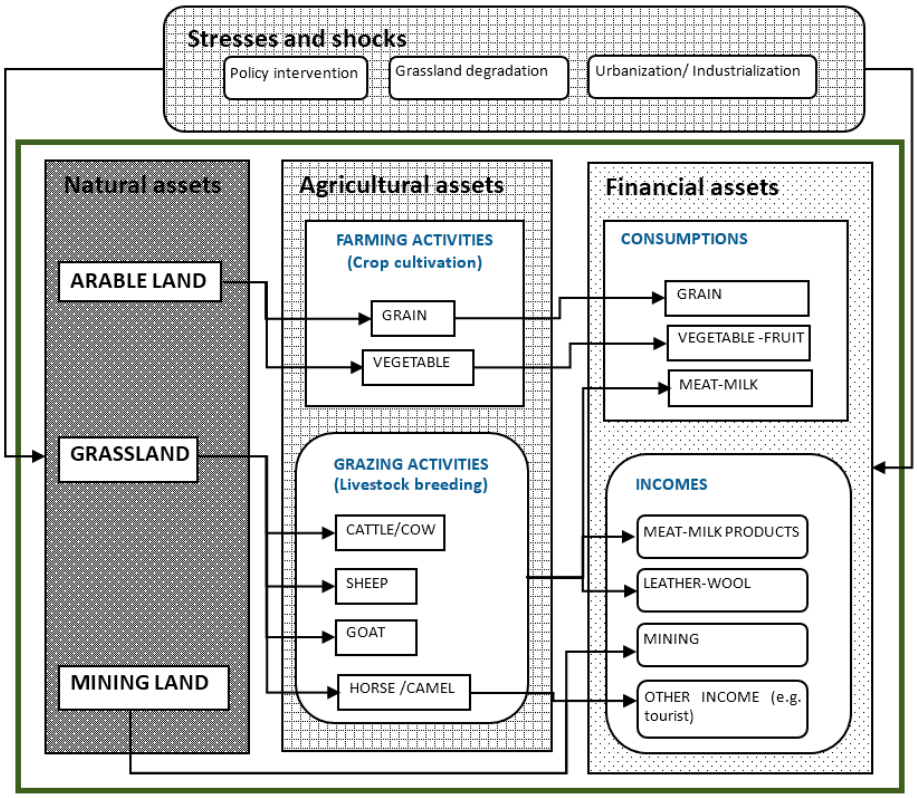

Figure 2. Main components of herders' livelihood in the study area.

Table 1. Selection of indicators for livelihood assessment.

Components of Livelihood	Selected Indicators	Rationale
Natural assets (land use)	Changes in percentage of grasslands	Comparison the changing percentage of land use, especially the grassland changes.
	Perception on Changing Grassland context	Households' perspective on the general quality of grasslands, which includes grass diversity level, biomass, soil quality and vegetation coverage rate.
Agricultural assets (farming and grazing activities)	New social relations	Pasture leasehold relation; closer economic ties by building cooperative associations.
	Controlled animal breeding mode	Including activities of decrease of livestock holding numbers, stall-fed livestock, etc.
	Changes in livestock species	Switching from conditional goat/sheep grazing to modern daily cattle breeding.
Financial assets (incomes and consumption)	Net annual per capital income	Sum of farm income from sale and trade of crop and livestock products, from livestock services; off-farm income; and the diversity of income sources.
	Agricultural land based employment	Number of the population participating in grazing or crop cultivation.
	Food and fuel consumption	Change of food and fuel consumption.

3.3. Calculation of Household Dependence on Local Grasslands Based on Income and Employment

To determine changes in household dependence on grassland, we divided all sources of income into income derived from agriculture and income derived from other sources (non-farm income). We then calculated a dependence ratio as follows:

$$\text{Income dependence ratio} = \text{Farm income}/\text{Total household income} \quad (1)$$

The value of this ratio ranged between 0 and 1, with greater values representing greater dependence on farming and raising of livestock.

We also assessed the dependence of households on off-farm labor by calculating an employment dependence ratio, as follows:

$$\text{Employment dependence ratio} = \text{On-farm employment}/\text{Total labor force} \quad (2)$$

In this calculation, the total labor force excluded children in school or those who could not work (the disabled, the elderly and very young children). In this calculation, household survey data for on- and off-farm employment were obtained and reported by herders or farmers from each household. These data accounted for the number of hours of each form of employment by an individual as a proportion of their total number of hours of work.

4. Results and Discussion

4.1. Use of Natural Assets and Changing Ecological Context

Inner Mongolia has a low economic development level, and household livelihoods rely heavily on the exploitation of the local natural resources. The use of natural resources reflects the changing land use patterns. Table 2 summarizes the changes in these uses from 1995 to 2010. Grassland occupied the largest proportion of the total area in 2010, with areas of 1.97×10^6, 0.59×10^6 and 4.23×10^6 ha in the West Ujimqin Banner, the Zhengxiangbai Banner and the Alxa Right Banner, respectively [32–34]. The changes in land use were consistent among the three banners: the forest and grassland area increased significantly (by an average of 9.4% and 2.5%, respectively), and the area of cultivated land decreased greatly (by an average of 21%) from 1995 to 2010 (Table 2). The main reason for this trend was the implementation of the government conservation policy. Our survey suggested that grazing prohibition and control of livestock rearing were most responsible for the increasing area of grassland. The analysis showed that herders increasingly (23% of respondents in 1995 and 78% in 2010) grew vegetables in a home garden. This may have resulted from the implementation of the controlled livestock rearing policy to limit the number of animals raised annually; about 82% of the herders and farmers reported reduced meat consumption and increased vegetable consumption. Table 2 shows that the area of land cultivated for fruit and vegetable consumption increased greatly, which supports the self-reported data.

Table 2. Results of the livelihood analysis for the three banners in Inner Mongolia. All households were asked to provide data from 2010, even though the surveys were conducted in different years.

Year		West Ujimqin Banner			Zhengxiangbai Banner			Alxa Right Banner			Average		
		1995	**2010**	**Change (%)**	**1995**	**2010**	**Change (%)**	**1995**	**2010**	**Change (%)**	**1995**	**2010**	**Change (%)**
Land use (ha) [32–34]	Grassland	1,896,600	1,968,700	3.8	567,774	585,700	3.2	4,210,450	4,231,133	0.5	2,224,941	2,261,844	2.5
	Cultivated land [a]	4150	3267	−21.3	21,432	13,867	−35.3	2140	2000	−6.5	9241	6378	−21.0
	Grain production	*3670*	*2280*	−37.9	*18,664*	*9066*	−51.4	*1700*	*1016*	−40.2	*8011*	*4121*	−43.2
	Fruit and vegetable production	*480*	*987*	105.6	*2768*	*4801*	73.5	*440*	*984*	123.6	*1229*	*2257*	100.9
	Forest	74,500	81,540	9.5	8125	9087	11.8	302,340	323,133	6.9	128,322	137,920	9.4
Livestock number [b]	Sheep	325	162	−50.2	139	21	−84.9	88	18	−79.6	184	67	−71.5
	Goats	50	21	−58.0	125	4	−96.8	20	6	−70.0	65	10	−74.9
	Cattle	7	13	85.7	10	8	−20.0	5	7	40.0	7.3	9	35.2
	Horses and camels	3	1	−66.7	9	1	−88.9	4	1	−75.0	5.3	1	−76.9
	Total livestock	385	197	−48.8	283	34	−88.00	117	32	−72.7	261.6	87	−69.8
Employment [c]	Land-based	1.3	1.2	−11.4	1.8	1.6	−11.4	1.1	0.6	−47.8	1.4	1.1	−23.5
	Non-land-based	0.9	0.9	4.6	0.5	0.6	23.1	1.2	1.6	30.6	0.9	1.1	19.4
	Total workforce	2.2	2.1	−5.0	2.4	2.3	−3.8	2.3	2.2	−6.9	2.3	2.2	−5.2
	Employment-based dependence ratio	0.6	0.6	−6.7	0.8	0.7	−7.7	0.5	0.3	−43.8	0.6	0.5	−19.4
Per capita net income (CNY/year) [d]	Land-based	3759	8000	112.8	3275	5046	54.1	3086	4681	51.7	3373	5909	72.9
	Non-land-based	1061	6695	531.0	1134	7054	522.1	1662	6736	305.3	1286	6828	452.8
	Total income	4820	14,695	204.9	4409	12,100	174.4	4748	11,417	140.5	4659	12,737	173.3
	Income-based dependence ratio	0.8	0.5	−30.8	0.7	0.4	−43.2	0.7	0.4	−36.9	0.7	0.5	−37.0

[a] The area of cultivated land is including the areas of Grain production and Fruit and vegetable; [b] source: field survey data from the present study, in units of No. per household on average; [c] land-based-employment is the number of people who participated in grazing or crop cultivation on average per household; non-land-based employment includes all work outside the household's farming activities; source: field survey data from the present study; [d] land-based net income includes all agricultural activities. Non-land-based net income comes from non-agricultural activities, such as non-land-based employment, subsidies and government fees paid as compensation for land expropriation; source: field survey data from the present study.

Many previous studies reported that grassland degradation was a widely-observed problem in the 1990s (especially in northwestern and north-central areas, e.g., the Alxa Right Banne and Zhengxiangbai Banner), but that the grasslands were recovering in the 2000s as a result of the implementation of the "returning grazing land to grassland" restoration project [21,36]. The present results, based on household interviews, confirm this trend. More than 84% of respondents believed that their pasture had improved compared to its condition in the 1990s. In addition, 66.7% reported that the vegetation cover had improved, and 45.9% believed that biomass had improved (Figure 3). However, they believed that the grassland was still degraded compared with its quality during the 1980s (before the most serious degradation began). The most significant changes were in the biodiversity of grass species; 88.1% of respondents believed that biodiversity was declining (not only for plant diversity, but also for forage grasses). The original grass species in the West Ujimqin Banner were dominated by an important fodder species (guinea grass, *Leymus chinensis* Tzvel.), which reached an overall height of 40 to 50 cm [37]. However, possibly as a result of climate change combined with overgrazing, the abundance of guinea grass decreased, and the abundance of *Stipa capillata* L. increased to replace it [38]. *Stipa capillata* reaches an overall height of 60 to 70 cm. This height difference explains the biomass increase (Figure 3), but this increase may be deceptive. A serious problem resulting from this species change is that the mature seeds of *Stipa capillata* are sharp and hurt the mouths and skin of the livestock, potentially leading to lost production or even mortality of the animals. In addition, 54.8% of respondents reported no improvements in soil quality (Figure 3) and believed that such changes would require a long time.

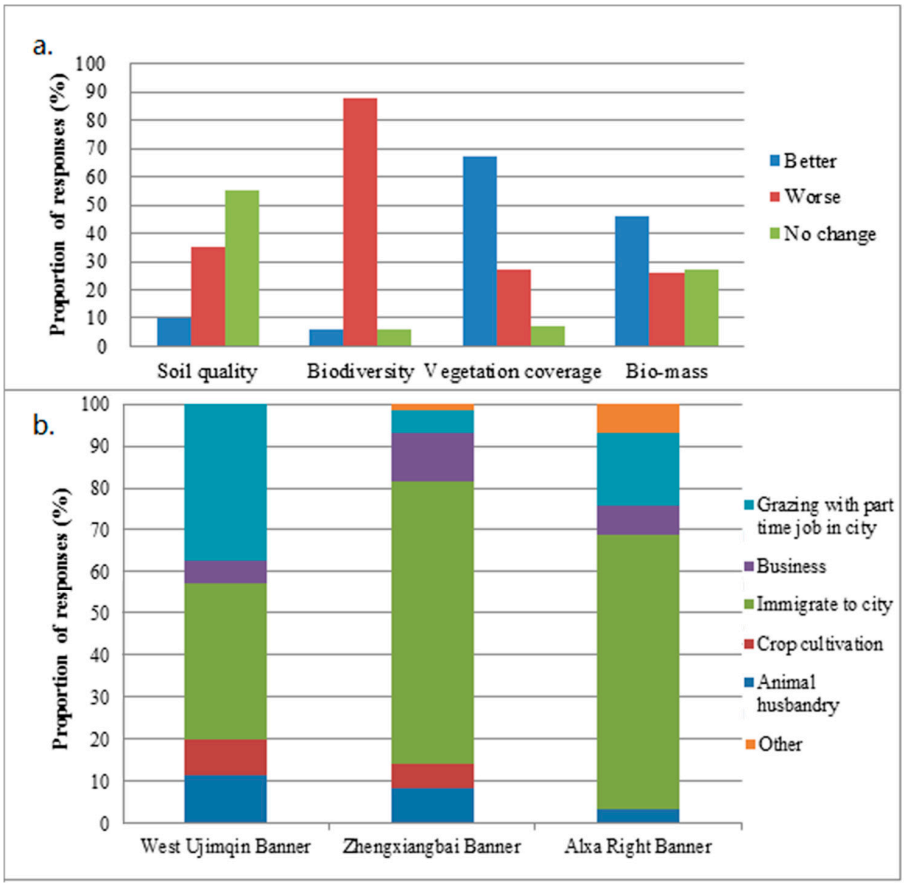

Figure 3. Household perceptions. (**a**) Changes in household perceptions of grassland conditions compared with conditions in the 1980s, before grassland degradation became increasingly serious; (**b**) Perception of the next generation's probable career choices.

Despite the severity of grassland degradation and the changes in their lifestyle, more than 80% of the herders and farmers did not want to move to the city, for three main reasons: lack of suitable skills, low education and a desire to preserve their culture. Even herders and farmers with high levels of education and skills training felt strong ties to their local social network and culture. However, herder and farmer perceptions of the next generation's career choices (Figure 2) showed different results, and these can be used to predict the degree of the next generation's dependence on the local grasslands. Of the six career choices they identified (animal husbandry, crop cultivation, immigrate to city, establish a business, grazing combined with obtaining a part-time job in the city and "other"), the most likely career for the next generation was moving to the city to obtain a stable job (37.1% in the West Ujimqin Banner, 67.6% the Zhengxiangbai Banner and 65.5% in the Alxa Right Banner). The next most common choice was grazing combined with obtaining part-time work in a city in the West Ujimqin Banner (37.1%), starting a business in the Zhengxiangbai Banner (11.3%) and grazing with part-time work in a city in the Alxa Right Banner (17.2%). Respondents in all three banners believed that crop cultivation (<3%) and animal husbandry (<10%) were the least likely careers. Because the respondents believed that the natural conditions greatly influenced crop planting and animal husbandry, they felt that the basic needs of these careers could not be guaranteed under the current poor environmental conditions and unstable climate. They reported a high willingness to help their children free themselves from the grasslands: about 84% of the respondents thought it would be good to send their children to a big city to improve their education and employment options.

4.2. Changes in Agricultural Production Activities

4.2.1. Controlled Animal Husbandry: From Traditional Grazing of Goats and Sheep to Modern Raising of Dairy Cattle

To comply with the grassland conservation policy, households decreased the total number of livestock per household from an average of 261.6 in 1995 to 88 in 2010 (Table 2), a 66.7% decrease. More than 60.0% of respondents reported that their number of livestock had decreased by more than half from the 1995 level. Because of the continually implementing of the grassland conservation policy, the result of a re-visit in 2014 shows the number of livestock per household kept the same level of 2010. The number of animals varied among the three banners in 2010, with the highest mean being 197 in the West Ujimqin Banner, followed by 34 in the Zhengxiangbai Banner and 32 in the Alxa Right Banner. These results were strongly related to the natural conditions in each banner and particularly the per capita land ownership: 17.6, 9.9 and 9.2 ha, respectively, in the West Ujimqin Banner, the Zhengxiangbai Banner and the Alxa Right Banner.

The livestock most commonly domesticated in the surveyed villages was dairy and beef cattle, sheep, goats, horses, camels, donkeys and poultry. Most respondents increased cattle rearing to compensate for decreased grazing of goats and sheep and replacement of this grazing by stall rearing of cattle. The herders usually chose the livestock species most appropriate for their local environment and raised the species that produced the most income to compensate for their loss of income caused by the grazing restrictions. Herders traditionally raised cattle, goats and sheep to produce meat and milk; horses, camels and donkeys were retained as traditional "vehicles" or to support domestic needs, such as the production of skins and blankets (e.g., camel wool, leather) and plowing the land. However, horses, camels and donkeys were increasingly replaced by cars, motorbikes and tractors, so most households retained only one or two horses and camels, mostly for tourist purposes. Goats and sheep produce less profit than cattle, because the cattle provide larger amounts of meat and produce milk. Therefore, replacing goats and sheep by cattle mitigates the loss of agricultural income caused by the government policies. In addition, raising cattle both increased and symbolizes wealth.

For the household-level variables, we used the proportion of stall-fed livestock and the proportion of seasonally-grazed livestock as indicators of the livestock strategies of the herders. About 60% of the households used only stall feeding, and the others adopted a combination of stall feeding in winter (November to March) and local grazing in summer (April to October). When grazing is

restricted in the local grasslands, herders must purchase fodder from outside their area to feed their animals. In traditional animal husbandry, daily fodder was obtained from each household's grassland. However, at present, the major components of livestock fodder are crop residues, leaves from fodder plants and herbaceous plants from adjacent forests, and this indicates that grasslands are no longer the only sources of fodder. This change increased costs for the purchase and storage of forage, which is one of the frequently-reported adaptation strategies in Inner Mongolia. More than 74.8% of respondents reported a need to purchase or store forage.

Since the implementation of the conservation polices, the household dependence on local grasslands has decreased based on both the employment and income dependence ratios: the employment ratio decreased by an average of 19.4% and the income ratio by 37.0% (Table 2). This has resulted from replacement of traditional animal husbandry (grazing of goats and sheep) by intensive modern animal husbandry (raising dairy and beef cattle), especially for emigrants from severely-degraded grassland areas. These emigrants were resettled in dairy cattle villages in peri-urban areas, where they adopted modern dairy cattle production techniques to raise income from the sales of meat, milk and leather. In addition to using grassland as their basic capital goods, the emigrants received technical and financial assistance from the local government to support dairy production. The government offers loan guarantees so households can access low-interest loans from local banks to alleviate the financial burden and invest in the establishment of dairy cattle facilities, such as milking centers. The combined business plus household system provides ongoing income for the emigrants. Modern raising of dairy cattle permits more sustainable use of the grasslands and has also reduced the grassland damage caused by overgrazing, including the loss of ground flora, depletion of soil nutrients and impaired regeneration of the dominant grass species. On the other hand, this new mode of animal husbandry has increased the household resilience in terms of their ability to adapt to and mitigate the impacts of climatic disasters, such as drought, freezing rain and snow, which historically led to serious consequences for households, including famine.

4.2.2. Improved Socio-Economic Relations: Leasing of Land and Development of Cooperative Associations

To lower the ecological risk of grazing and stabilize income sources, about 23.7% of the respondents ceased grazing and leased their grassland to others who wanted to expand their access to pasture. In this way, leaseholders could earn greater profits because they could support larger herds with the extra pasture. Additionally, the leasers could engage in non-farm businesses, such as working outside the community or running a home business, and even some households moved to peri-urban or urban areas to find other opportunities [39]. Thus, as we noted earlier, grasslands were no longer the only basic capital goods used to guarantee their livelihood; their degree of dependence on the grasslands has decreased. On the other hand, about 34.3% of the households in the West Ujimqin Banner, versus 23.9% in the Zhengxiangbai Banner and 17.2% in the Alxa Right Banner, leased pasture from others. Those who leased pastures became more dependent on the local grasslands; animal husbandry both provided their livelihood and provided income to pay for the leasing of grassland. In theory, decreasing the number of households who live in grasslands can reduce the pressure on this land, allowing ecological improvement, but we lack the data to support this hypothesis because leasing of pasture is too recent for clear trends to have emerged.

To mitigate the effects of the government policy, climate hazards and fluctuations in the prices of livestock products, many herders in all three banners have created or joined a cooperative association: this accounted for 45.7% of households in the West Ujimqin Banner, 28.2% of households in the Zhengxiangbai Banner and 69.0% of households in the Alxa Right Banner. The goals of these cooperatives were to support market-oriented activities, such as pooling pastures for grazing, unified management of livestock and selling production together to establish a "brand" reputation for quality. The cooperatives appear to have increased the income and efficiency of rangeland utilization and have accelerated the adoption of technologies, such as communal storage of fodder to prevent food shortages

during certain times of the year, that decrease the risk of starvation and disease. The government has provided skill training and technology transfer to promote the adoption of more efficient methods. The formation of cooperatives has somewhat restored the traditional cooperation among nomadic households that was lost when they were forced to relocate to permanent villages [40].

4.3. Household Dependence on Grasslands Based on Income and Consumption Behaviors

4.3.1. Diversification of Income Sources and Reduction of Land-Based Employment

The proportion of total income accounted for by non-agricultural income increased greatly between 1995 and 2010: by 531.0%, 522.1% and 305.3%, respectively, in the West Ujimqin Banner, the Zhengxiangbai Banner and the Alxa Right Banner (Table 2). In contrast, agricultural income increased only slightly. As a result of these changes, the proportions of total income accounted for by agriculture decreased from 78.0%, 74.3% and 65.0%, respectively, in the West Ujimqin Banner, the Zhengxiangbai Banner and the Alxa Right Banner in 1995 to 54.4%, 41.7% and 41.0%, respectively, in 2010. These changes resulted mainly from the reduction in the number of livestock and the increased cost for grazing and purchases of fodder. Based on the results of the re-visit in 2014, the non-agricultural income still kept the increasing trend, and the agricultural income maintained the same level of 2010.

Employment showed similar trends. In 1995, land-based employment was the dominant form, especially Zhengxiangbai Banner, employing two- to three-times the number of people who were employed in non-land-based employment. With the increase of the urban process and controlled use of grasslands (grassland management policies) at all research sites from 1995 to 2010, the total workforce decreased slightly in the West Ujimqin Banner, the Zhengxiangbai Banner and the Alxa Right Banner (by −5.0%, −3.8% and −6.9%, respectively). However, the non-land-based employment increased more dramatically, by 4.6%, 23.1% and 30.6%, respectively, in the West Ujimqin Banner, the Zhengxiangbai Banner and the Alxa Right Banner. This can be explained by the combined effects of the grassland conservation policy and an urbanization process that encouraged herders and farmers, and especially young adults, to move to towns and cities to seek employment in off-farm businesses, thereby decreasing the human pressure on the grasslands.

Between 1995 and 2010, the mean income-based dependence ratio decreased from 0.7 to 0.5, and the employment-based dependence ratio decreased from 0.6 to 0.5. This indicated that although the land remained the main source of capital for daily life, the dependence on grasslands has gradually decreased. The main reason for these decreases is that the area of grassland used for animal husbandry has decreased. The macro-level policy changes and micro-level livelihood adjustments by the affected households have caused large changes in the land use asset structure. For instance, herders who lost the right to access grassland were more severely affected than those who retained access to pastures under the grassland conservation policy. Because these changes were implemented rapidly, herders who lost access to pasture were forced to sell most or all of their livestock, although the government provided partial compensation for this loss. On the plus side, this decreased their dependence on grasslands and increased the rate of business operation and employment in non-agricultural economic activities.

Simultaneous with the process of urbanization, the herders and farmers acquired new skills and new opportunities to earn money, so their income and employment were less constrained by their former dependence on the land. Comparing the income and employment situations among the three banners provides insights into the dependence of livelihoods on the local grassland. The Zhengxiangbai Banner had the largest proportional decrease in the income-based dependence ratios (−43.2%), followed by the Alxa Right Banner (−36.9%) and the West Ujimqin Banner (−30.8%). One of the most important reasons for this difference is that the Zhengxiangbai Banner is close to many megacities, including Beijing, Hohhot and Tianjin, so residents have more opportunities to seek high income with urban employment. Alxa Right Banner had the largest proportional decrease in the employment-based dependence ratios (−43.2%), followed by the Zhengxiangbai Banner (−7.7%) and West Ujimqin Banner (−6.7%). This is because Alxa Right Banner has the most venerable grassland type (desert steppe or

semi-desert steppe), which has been severely influenced by ecosystem degradation [21]. The herders in Alax Right Banner have to give up their land and are engaged in non-land-based employment. Our survey revealed that about 77.1% of respondents in the West Ujimqin Banner, 91.5% of respondents in the Zhengxiangbai Banner and 89.7% of respondents in the Alxa Right Banner believed that finding urban employment was the best way to increase their income and that diversification of income sources would play a crucial role in securing their household livelihood. Especially in poorly-developed areas, off-farm employment and activities could increase cash income and improve household risk resilience by increasing their capacity to cope with shocks.

4.3.2. Household Food and Fuel Consumption

In the three banners, most of the pasture area (95%) was fenced; 37% of the pasture area was totally protected from grazing in the past five or 10 years. Thus, the former livelihoods of herders changed fundamentally, causing them to shift their activities to raising dairy cattle in stalls, cooperative activities, such as the sales and transportation of livestock, or milling of grains. Moreover, as household income changed, this directly affected consumption patterns, especially in terms of the dietary structure and fuel consumption. We defined the food (including grains, fruits, vegetables, milk and meat) and fuel (biofuels, such as firewood, dry dung and crop residues) as the main household biological products, which are consumed by the local population. Additionally, we separated household consumption into self-produced and purchased food and fuel (Table 3).

Based on the results of the food and fuel analysis, the total annual per capita bio-fuel and meat consumption decreased during our study period, from 2.3 t·year^{-1} and 180.3 kg·year^{-1} in 1995 to 1.3 t·year^{-1} and 165.3 kg·year^{-1} in 2010 and mainly comprised consumption from grasslands (Table 2). The main reason for the decreases was the grassland conservation policy, which substantially decreased the number of livestock (Table 2). Dried dung from livestock and firewood collected from forests and bush vegetation communities were traditionally important biofuels and were widely used in Inner Mongolia. The types and amounts of fuel consumed changed significantly during our study period. Usage of coal, gas and electricity increased in all three banners and increased particularly rapidly for electricity and gas (Table 3). The government statistics of Inner Mongolia reported that annual electricity consumption in the rural area kept an increasing rate (by 14.5% in average) during 2010 to 2015 [41]. This may have resulted from rapid economic development and government initiatives to provide cleaner sources of power to residents of the study area. Although cleaner energy, such as gas and electricity, is more costly, people prefer it because it is more convenient and efficient. The amount of biofuel consumed decreased because livestock numbers decreased (providing insufficient amounts of dry dung), the protection of forests increased (thereby decreasing the availability of firewood) and the availability of alternative fuels increased. Our survey revealed that up to 74.8% of the respondents sharply decreased their consumption of meat from cattle, sheep and goats and consumed more fruits and vegetables (Table 3). This represents a large change from their traditional nomadic diet; when the number of livestock was constrained under the government policy, more of the animals were kept to sell rather than for eating. The decreased consumption of meat from cattle, sheep and goats was compensated for by increased consumption of pork, poultry, fruits and vegetables from the market.

Table 3. The per capita fuel and food consumption in the three banners of Inner Mongolia.

	West Ujimqin Banner		Zhengxiangbai Banner		Alxa Right Banner		Average	
Year	**1995/2010**	**Change (%)**	**1995/2010**	**Change (%)**	**1995/2010**	**Change (%)**	**1995/2010**	**Change (%)**
Total fuel consumption (unit: t·year^{-1} for biofuel and coal; CNY·year^{-1} for electricity and gas)								
Biofuel [a]	3.1/2.4	−23	2.7/1.0	−63	1.2/0.5	−58	2.3/1.3	−48.0
Coal [b]	0.5/0.8	60	0.7/1.1	57	0.6/0.9	50	0.6/0.9	55.7
Electricity and gas [b]	53/175	230	54/174	222	57/245	330	55/198	260
Total Food consumption (unit: kg·year^{-1})								
Grains	170/160	−6	175/156	−11	196/180	−8	180.3/165.3	−8.3
Fruits and vegetables	50/110	120	195/206	6	110/160	45	118.3/158.7	57.0
Milk	86/64	−26	50/60	20	54/76	41	63.3/66.7	11.7
Meat	170/124	−27	84/77	−8	66/73	11	106.7/91.3	−8.0
Self-produced rates of food consumption (unit: %)								
Grains	6.3/5.1	−1.20	32.8/16.1	−16.7	18.6/7.6	−11.0	19.2/9.6	−9.6
Fruits and vegetables	19.5/23.4	3.90	50.2/49.7	−0.5	21.8/30.5	8.7	30.5/34.5	4.0
Milk	100/96.7	−3.30	57.0/49.3	−7.7	77.2/43.1	−34.1	78.1/63.0	−15.0
Meat	87.4/72.7	−14.70	66.2/46.3	−19.9	65.4/37.7	−27.7	73.0/52.2	−20.8
Purchased rates of food consumption (unit: %)								
Grains	93.7/94.9	1.2	67.2/83.9	16.7	81.4/92.4	11.0	80.8/90.4	9.6
Fruits & vegetables	80.5/76.6	−3.9	49.8/50.3	0.5	78.2/69.5	−8.7	69.5/65.5	−4.0
Milk	0.0/3.3	3.3	43.0/50.7	7.7	22.8/56.9	34.1	21.9/37.0	15.0
Meat	12.6/27.3	14.7	33.8/53.7	19.9	34.6/62.3	27.7	27.0/47.8	20.8

Source: field survey data from the present study. [a] Self-produced fuel; [b] purchased fuel. Biofuel: firewood, dry dung and crop residues; grains: flour and rice; meat: mutton, beef, pork, chicken and fish.

In additional, the meat and milk consumption from self-produced products decreased from 73.0% in 1995 to 52.2% in 2010 and 78.1% in 1995 to 63.0% in 2010, respectively (Table 3). Most of the consumed grain foods came from for purchased products, and this proportion increased from an average of 80.8% in 1995 to 90.4% in 2010. The total self-produced meat consumption decreased significantly (by 20.8%) between 1995 and 2010, especially in the Alxa Right Banner, because grassland in this banner is vulnerable and had sustained the most serious degradation, followed by grasslands in the Zhengxiangbai Banner and the West Ujimqin Banner. The West Ujimqin Banner maintained the highest self-produced rates of milk and meat consumption in 2010, at 96.7% and 72.7%, because this banner has high quality grassland and still maintains the traditional animal husbandry with the largest number of livestock (Table 3). The ecological conditions were also better than those in the Zhengxiangbai Banner and Alxa Right Banner. In contrast, the West Ujimqin Banner had the lowest self-produced rate of gain and fruits and vegetables consumption in 2010, at only 5.1% and 23.4%, respectively (Table 3). The decreased self-produced rate from meat and milk consumption indicated that the local herders and farmers relied less on their grasslands for food consumption, but this was achieved by placing some of the pressure of their food consumption on other areas that supplied imports of food and other materials. Therefore, household food consumption began to depend less on the available land and more on market factors. From a nutritional perspective, residents of Inner Mongolia are generally well nourished, even for low-income families [2]. The food being consumed is also becoming more diverse, and this can encourage both grassland conservation and human health.

5. Conclusions

Ecosystem degradation, urbanization and the enforcement of the restoration policy have greatly impacted rural life and the use of grasslands. Three main conclusions can be drawn from the results of the survey:

(1) Our analysis of household livelihoods and dependence on grasslands revealed that the implementation of grassland conservation policies had a strong impact on the livelihoods and security of households in three banners of Inner Mongolia. Both household-initiated adaptation and government-guided adaptation helped households to cope with the changes they were forced to endure. The main responses involved leasing of pasture, decreasing the number of livestock, adopting seasonal grazing supplemented by fodder purchases, increasing the intensity of livestock production, forming cooperative associations, seeking non-farming income sources and changing food and fuel consumption patterns. Table 4 summarizes the changes and household responses.

(2) We analyzed the dependence of household livelihoods on local grasslands and found that grasslands still provide vital functions. The annual household income and employment based on agricultural land still depended heavily on local grasslands, and most households owned some livestock, which they raised to sell for income or for personal consumption, especially in the West Ujimqin Banner and the Zhengxiangbai Banner. However, from 1995 to 2010 (before and after the implementation of the grassland conservation policy), the household dependence on local grasslands generally decreased, indicating a transition from traditional pastoral grazing to controlled grazing, modern raising of dairy cattle (intensive animal husbandry), diversification of income sources and decreases in land-based employment and in the household food and fuel consumption from grasslands. These changes increased the diversity of livelihoods and increased both household resilience and environmental sustainability.

(3) Despite this diversification, neither the government-stimulated adjustments nor household-initiated adaptations have liberated households from their dependence on the grasslands. However, most respondents reported a strong willingness for their family's next generation to move to a city to improve their education and employment opportunities.

Table 4. Changes in household dependence on local grasslands in the three banners in Inner Mongolia from 1995 to 2010.

Indicators	Sub-Indicators	Change from 1995 to 2010	Explanations
Improved social relations	Leasing of pasture	↑↓	Leasing allows the owners of the grassland to decrease their dependence on the land, while increasing the leaseholder's dependence on the land.
	Formation of cooperative associations	↑	Social connections were enhanced by the formation of cooperative associations.
Controlled animal husbandry	Number of livestock	↓	The decreased number of livestock per household led to decreased pressure on the grasslands to provide forage or fodder.
	Changes in species	↓	Herders and farmers decreased the number of goats and sheep and increased the number of cattle. Because modern raising of dairy cattle can produce a more diverse and stable income by making both meat and milk products available, it represents a more cost-effective use of the grasslands.
	Stall-fed livestock	↓	Stall feeding increased fodder purchases and the utilization of crop residues to replace grass fodder.
Income- and employment-based dependence ratios	Income (farm vs. non-farm income)	↓	Diversified income sources indicated the increased flexibility of livelihoods, and grasslands were no longer the only resources that provided income.
	Employment (land-based vs. non-land based)	↓	Increased labor engaged in non-land-based employment decreased the dependence on the grasslands.
Food and fuel consumption	Food consumption	↓	The transition from a diet dominated by meat to a more diverse diet was accompanied by purchasing more food from markets, thereby decreasing the meat consumption with less intensive use of the grasslands, but shifted some of this ecological footprint to other areas.
	Fuel consumption	↓	Fuel consumption patterns changed, with decreased use of biofuels (dried dung, firewood) and increased use of coal, electricity and gas; thus, the fuel consumption was mostly placed on mining or wind power generation plants that provided these resources.

Our findings raise new concerns. For example, as increasing numbers of residents abandon the grasslands, there may come a time when nobody remains to use or manage the grasslands. Since the grasslands have coevolved with nomadic herders for millennia, this could lead to significant negative ecological effects; although vegetation communities are likely to recover in response to reduced human pressure, they may not recover to something that resembles their original state. Thus, future grassland management will need to emphasize sustainable use of grasslands.

Within Inner Mongolia, basic management of most natural resources is weak and needs to be improved before sustainable management will be possible at the village or household level. Our results show how livelihood analysis provides a new perspective on resource and ecosystem management, especially in terms of linking micro-level household livelihood responses to macro-level policies. This approach provides insight into how new resource management strategies may differentially affect households. Further research will be required to fully understand the impacts of the policy-induced changes, with special attention to expanding livelihood diversity, enhancing resilience against environmental and economic stresses and advancing the urbanization process to improve the quality of life of grassland residents and reverse grassland degradation.

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