

Pastoral nomadism in the forest-steppe of the Mongolian Altai under a changing economy and a warming climate

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ABSTRACT

The population structure, educational level and the livelihoods of 82 households of pastoral nomads, the organization of livestock husbandry and its impact on the grassland and forest ecosystems of the Dayan high valley (>2000 m a.s.l.) in the Mongolian Altai, western Mongolia, were surveyed using interviews and secondary information from official sources. Changes following the transition from centrally planned (before 1990) to market economy were analyzed. Two thirds of the monthly mean income of ca. 310 USD per nomad household is cash (ca. 55 USD) or non-cash (ca. 165 USD) income from livestock husbandry. Cashmere sale accounts for 70% of the cash income from livestock husbandry, which has led to a strong increase of goat numbers after 1990. Forests are used for livestock grazing, fuel wood collection, logging, and fruit collection. Livestock breeding and the seasonal migration of the nomad households are no longer organized by the government. To avoid transportation costs, two thirds of the families have reduced their seasonal migrations. This trend was favored by rising temperatures and earlier snowmelt during the last few decades, but resulted in a shortage of fodder and intensified forest use. Therefore, the use of grasslands and forests in the Mongolian Altai is no longer considered to be sustainable.

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1. Introduction

Pastoral nomadism is the prevailing form of land use in Mongolia. Currently around one third of Mongolia's population lives as nomads from livestock husbandry (Dagvadorj et al., 2009). Others work as traders, drivers, government employees or workers in the food or textile industries from goods produced by the herders or they provided services that are needed by the herders' families. The Altai Mountains in westernmost Mongolia belong to Central Asia's oldest settlement areas, where modern humans are thought to have appeared between 100,000 and 60,000 years ago (Rybin, 2005; Schlütz and Lehmkuhl, 2007). The present lifestyle of pastoral nomadism is thought to have become established in the Mongolian Altai between 2000 and 3000 years ago (Novgorodova, 1989; Rudaya et al., 2008). The nomads' seasonal migrations are determined by the climate and aimed at maximizing the carrying capacity of the pastures in order to feed their livestock in good grazing places and to fatten them up thereby increasing their chance to survive the cold Mongolian winter (Krader, 1955; Neupert, 1999).

Mongolia's political and economic systems were subject to strong changes during the last two decades. During the Communist period, Mongolia's livestock production system was converted from a natural pastoral economy to a system which possessed traits of an industrial economy (Johnson et al., 2006), though the harsh climate still considerably hampered a purely demand-driven control of livestock production. Under Communism, livestock husbandry was based on government-employed herders, who kept collectivized flocks for a monthly salary and had to fulfill a planned production target for livestock products. Collectivization of livestock started in 1928, but was not completed until 1959 (Humphrey, 1978; Mearns, 1993). At that time, each herder specialized on one livestock species, and animals were kept in flocks of similar sizes on a common pasture without fences. Wells in arid regions, daily collection of milk, transport of livestock for sale, hay for harsh winters, and seasonal migrations of nomad households and livestock were centrally planned and provided by the collectives (Fernández-Giménez, 1999a; Sankey et al., 2006). The Communist system was replaced by a parliamentary democracy in 1990 and the centrally planned economy was subsequently transformed into a market economy (Dorj and Yavuuhulan, 2003; Griffin, 1995).

The change in the economic system after 1990 had a strong effect on the life of pastoral nomads even in remote areas of

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Mongolia, since the strong economic ties with and the financial support from the Soviet Union and Eastern Europe suddenly disappeared with the concomitant breakdown of the Soviet Union. Financial support of the Mongolian government by the Soviet Union amounted to one third of the GDP until 1989, but was reduced in that year and completely ceased in 1991 (Sneath, 2004). Unemployment resulted due to the post-Communist depression of Mongolia's economy and the simultaneous privatization in 1992 of the formerly state-owned livestock (Fernández-Giménez, 2002; Griffin, 1995) leading to an increase in herder families. This and the financial incentive to herd as many animals as possible in the market economy caused a nation-wide increase of livestock numbers in Mongolia after the privatization of the livestock sector, from 22 million animals in 1990 to presently more than 40 million (NSO, 2011). Furthermore, three-digit inflation rates during the 1990s (Jeffries, 2007) were an incentive for many Mongolians to keep their savings in livestock and to sell only as many animals as needed to fulfill the current needs for cash. This led to grassland degradation in many places (Lise et al., 2006), as did the change in animal composition, because herders throughout Mongolia steadily increased the proportion of goats, as cashmere is the main source for cash income (Janzen, 2005; Lecraw et al., 2005). At the same time the old structure of the organization of pastoral livestock husbandry disappeared (Janzen and Bazargur, 2003; Sternberg, 2008). After the liquidation of the collectives, maintenance of wells, transportation of products for sale, organization of seasonal migrations and the preparation or purchase of winter fodder were the responsibilities of the individual nomad families. This often led to impoverishment and a decline of productivity mostly to subsistence level, which also affected the urban population by significantly increasing prices for meat and milk (Sneath, 2004). In the Mongolian Altai, the situation was aggravated by the fact that most inhabitants belong to the Kazakh minority, who have less access to education and a lower mean income than the average of the Mongolian population (SDC, 2011).

Economically the pastoral nomads now live an unstable life, because they are forced to keep their livestock on ecologically vulnerable pastures with often low carrying capacity (Fernández-Giménez, 2000). Particularly, inexperienced herders, who resumed livestock husbandry after livestock privatization, lost much of their livestock in a series of extremely cold and harsh winters ("dzuds"; Begzsuren et al., 2004) from the late 1990s on and (re-)migrated into cities in an economically uncertain future (Nitta et al., 2005).

In addition to the recent changes in the political framework and the economy, herders in Mongolia are faced with a rapidly warming climate. The mean annual temperature increased by 2.1 °C during the last 70 years (Dagvadorj et al., 2009). Heat waves are more frequent and more prolonged than formerly, resulting in summer drought and temporary degradation of rangelands (Sternberg et al., 2011). Moreover, the precipitation distribution is changing, as the frequency of heavy rain showers increased in place of steady rainfall, which is better exploited by the vegetation (Nandintsetseg et al., 2007). Trends for changes in the annual amount of precipitation vary strongly between different regions in Mongolia (Dulamsuren et al., 2010a). In areas of Mongolia with increased summer drought, climate warming has already reduced the growth of trees and inhibits the regeneration of forests (Dulamsuren et al., 2010a,b). Tree growth in the forest-steppe ecotone is, in turn, correlated with biomass production in the steppe (Liang et al., 2003). The herders' perception of such environmental changes is significant, since it influences their decisions on land use organization and their assessment of long-term economic prospects (Fernández-Giménez, 1993).

The impact of livestock grazing in Mongolia is not restricted to grasslands, but also includes forests. These two ecosystems co-occur on a small spatial scale in the forest-steppe ecotone with forests at the wetter sites, i.e. north-facing slopes and river valleys, and steppe on south-facing slopes and in dry valleys (Hilbig, 1995). Furthermore forests are affected by logging and deadwood collection for fuel and construction wood (Erdenechuluun, 2006). Since the forests grow at their drought limit on the edge of the steppe and increasingly suffer from water constraints due to rising temperatures (Dulamsuren et al., 2010b, 2009), they are, like the grasslands, highly susceptible to increased land-use intensity.

In the present study, we investigated the socioeconomic conditions of a pastoral nomad community in Dayan, a high valley of the Mongolian Altai. The present state of pastoral livestock husbandry was analyzed based on interviews with the nomad families and secondary information from qualified official sources. The analysis included data on (1) the population structure, educational background of the population, and the infrastructure of the Dayan region, (2) the organization of livestock husbandry and forest use, (3) the livelihoods of the population, and (4) the herders' perception of climate warming and changes in land-use and their concerns about the future. Furthermore, a key objective of our study was to test the hypothesis that socioeconomic conditions deteriorated and land use became less sustainable in the Mongolian Altai following the transition to a market economy, and as a consequence of climate warming.

2. Methods

2.1. Study area

Field work was carried out in the Mongolian Altai (Fig. 1) in the Dayan administrative subunit ("bag") of Sagsai county ("soum") (3140 km²; 5100 inhabitants in 2009): The region lies in the province ("aimag") of Bayan-Ulgii (45,700 km²; 93,000 inhabitants), western Mongolia, 110 km SW of the city of Ulgii, which is the capital of the Bayan Ulgii aimag. Dayan (48°27'N, 88°90'E) is part of the Altai Tavan Bogd National Park (6360 km²). The infrastructure of Dayan is basic. The area is only accessible on a dirt road, which can be used by four-wheel drive cars. Dayan is not connected to public transportation or the electricity network. Water is drawn from streams. There is a primary school, a kindergarten, a small hospital and a small military unit for border control (the distance to the border with China is 20 km) in Dayan. Dayan is located at >2000 m a.s.l., with most nomad households in the region settling at elevations between 2000 and 2300 m a.s.l. Despite high inter-annual variation of weather conditions and thus fodder availability, pastures in the semiarid Mongolian forest-steppe, where the study area is situated, are thought to be equilibrium grazing systems where pasture quality is directly influenced by livestock density (Briske et al., 2003; Johnson et al., 2006). The vegetation is formed by alpine meadows and steppes. Forests of Siberian larch (*Larix sibirica* Ledeb.) occur on north-facing slopes between elevations of ca. 2000 and 2500 m a.s.l.

Climate data used in this study were available from the village of Altai (48°17'N, 89°31'E, 2150 m a.s.l.), 40 km east of Dayan (Fig. 1). Gaps in the data were filled by means of regression analysis with data from the weather station at Ulgii City (1960 m a.s.l.), which cover the period from 1940 to 2010. The mean annual temperature (from 1940 to 2010) was -3.4 ± 1.0 °C, with -21.2 ± 3.4 °C in January and 12.9 ± 1.1 °C in July. The annual precipitation in Altai is 120 ± 26 mm. Temperature in Dayan is overestimated and precipitation is underestimated relative to the weather data from Altai, as the elevation of this weather station is lower than Dayan. Furthermore, Altai is located in the lee of a mountain ridge, which



Fig. 1. Study area in Dayan (asterisk) in the Mongolian Altai, western Mongolia.

rises east of Dayan. During the past 70 years, the annual temperature at Ulgii increased by $2.0\text{ }^{\circ}\text{C}$ ($r = 0.57$, $P < 0.001$), whereas there is no significant long-term trend for precipitation.

2.2. Interviews and access to secondary information

During summer, about 90 households live in Dayan, which equals 8% of the households in Sagsai soum. The present survey covers 82 households. Households not included were families who were absent from Dayan during field work in July 2010 or who settled in the small military base. Interviews were held with at least one member of each household at their home either in the Mongolian language or in most cases, if people were not fluent in Mongolian, with the help of a translator in Kazakh. A fixed list of ca. 300 questions was used for the interviews including questions on the number, age and education of household members, income and expenditures, livestock numbers, the organization of livestock husbandry and seasonal movements, the utilization of forests, perception of climate warming as well as asking for an overall assessment of their economic present and future prospects. Secondary information was obtained by visiting the local governments of Sagsai soum and Bayan-Ulgii aimag. Data on income and expenditures are based on the interviews with the 82 nomad households and no comparable data are available for the period prior to and after 1990. Reliable data of the Communist period could not be obtained from interviewees given the age structure of the population in Dayan, since 19% of the population was >40 years old. In the paper, data are presented as mean values and standard deviations.

3. Results

3.1. Population structure

The 82 interviewed families comprise 442 members, which is 8.6% of the total population of Sagsai soum. Every household

includes 5.5 ± 1.9 family members. All people in the Dayan region belong to Mongolia's Kazakh minority. Nearly half of Dayan's population is less than 20 years old (48%), whereas only 19% of the population is 40 years or older (Fig. 2). This age distribution matches exactly that of the entire Sagsai soum (Sagsai soum unpublished population statistics) and does not differ between males and females. The birth rate in Sagsai soum exceeds the

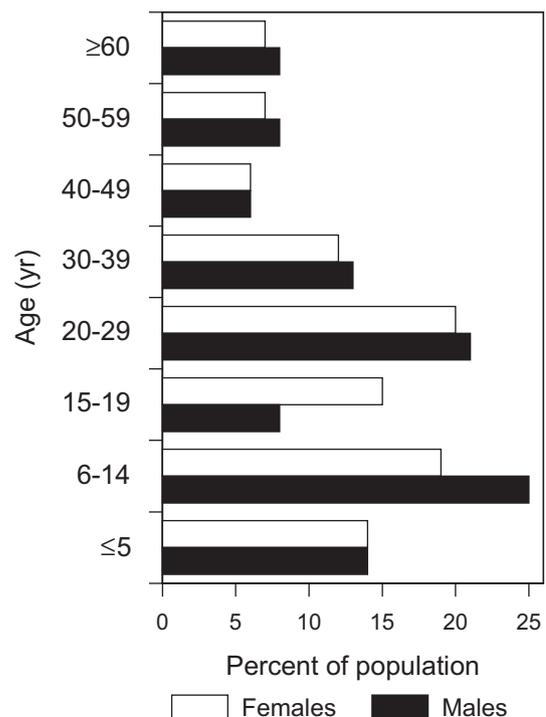


Fig. 2. Age structure of the population in Dayan (interviewed households).

average for Mongolia (ca. 27 vs. 21.7 births per 1000 people; NSO, 2011). Only 19% of the population of Dayan speaks Mongolian, which is the only official language in Mongolia, whereas the others can only communicate in Kazakh. Fifty-one percent of Dayan's Mongolian speaking population is over 40 years old and served in the army during Communist times. The literacy rate of the ≥ 8 -year old members of the interviewed households is 97.8%. Nevertheless, one third of the population has not finished school. Sixteen percent of the individuals above school entrance age have higher education with 8% having a university degree, 2% graduated from a vocational school and 6% are currently enrolled at a university. Five percent of the population above school entrance age, mostly from the older generation, received no formal education.

3.2. Livestock husbandry

Ninety-five percent of the families in Dayan keep a total of more than 9100 animals (Table 1). The mean herd size per family is 111 ± 73 animals, while the maximum number of animals in one household amounts to 347. Two thirds of the households own between 50 and 200 animals. Sheep account for more than half of the livestock, as do goats for another third of the total livestock. Yaks (7% of the total number of animals), horses (5%) and camels (0.1%) are kept in much smaller numbers (Table 1). Data on the temporal development of livestock numbers is available at the soum level (Fig. 3). Compared to 1990, the number of goats has tripled, whereas the total number of sheep and horses remained constant. The number of yaks slightly increased (by a factor of 1.1), while the already low number of camels was halved. Livestock numbers were (temporarily) reduced in harsh winters ("dzud"), which occurred in 1997/98 and less severely in 2008/09 (Table 2). The winters of 2000/01 and 2001/02 (which were characterized by two consecutive dzuds in most areas of Mongolia and killed 11 million animals in the whole country; Mahul and Skees, 2006) had no significant effect on livestock numbers in the study area, as 99% of the livestock survived (Sagsai soum unpublished livestock statistics).

The organization of livestock husbandry in Dayan has changed substantially since the introduction of the market economy. During Communist times, herders used to move four times a year. They usually came to Dayan in mid June to spend the summer there, before they moved, in late August, to lower elevations to the autumn camp 10–40 km away from Dayan. In November, the nomads used to migrate to the winter camp, 100–150 km away from the autumn camp. The winter camp was left in February for the spring camp, which was 120–140 km away from the winter camp and 150–170 km away from the summer camp. Today, only one third of the interviewed nomad families in Dayan follow the traditional seasonal migration pattern, whereas another third of the households does not move anymore. The remaining families reduced the seasonal migrations either by moving only three or two times per year or by retaining the migration frequency but strongly reducing the distances between the seasonal campsites.

In all interviewed families, the reduced migration frequency implies an extended use of the pastures in the Dayan region. Herders

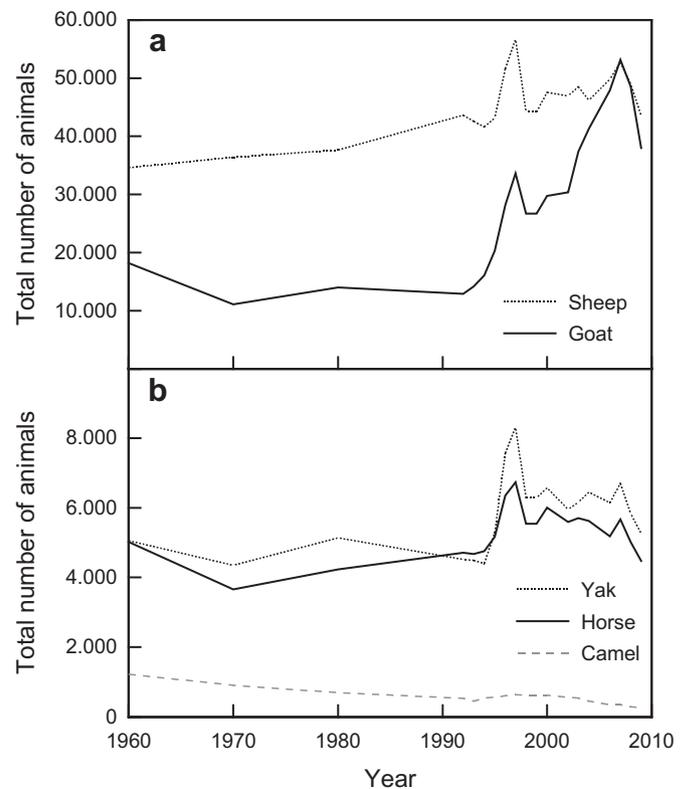


Fig. 3. Changes in livestock number in Sagsai soum between 1960 and 2010: (a) sheep, goats; (b) yaks, horses, camels.

mentioned three different rationales for their changed migration behavior since 1990. Seasonal migration was reduced (1) to avoid the costs for relocating the household and the livestock, (2) to reduce labor, and (3) because of changes in climate and pasture quality. The nomads' equipment is nowadays transported with rented trucks. To facilitate spring migration, the soum administration grants credit for this purpose to households with economic difficulties, which is particularly necessary after hard winters. Under unfavorable weather conditions, individual families find it necessary to move to better pastures even during winter. In such cases, the soum administration helps with clearing the road from snow using tractors and trucks. The move from the winter to the spring camp is especially time-consuming, since the animals, which are not transported with trucks, are in poor condition and thus usually need two weeks to cover the distance between the camps.

The herders feel that the conditions of the pastures have deteriorated during the past 20 years. The pastures in the high valleys of Dayan, where the nomad families live, increasingly offer insufficient forage for the livestock. To compensate for this, families intensified haymaking during summer to supply their livestock with additional fodder during winter. They started to erect more

Table 1
Livestock number in the interviewed households in Dayan in 2010.

	Mean number (\pm SD) per household	Max. number per household	Total of all households
Sheep	59 \pm 47	215	4869
Goat	38 \pm 26	110	3150
Yak	7.3 \pm 5.6	31	599
Horse	5.9 \pm 5.1	24	486
Camel	0.1 \pm 0.6	4	11
Total livestock	111 \pm 73	347	9115

Table 2

Decline of livestock numbers in Sagsai soum during harsh winters ("dzud") in past 20 years (percentage of livestock surviving the winter and, in parentheses, the original total of livestock before the winter).

	1997/98	2008/09
Sheep	78% (56,676)	89% (49,028)
Goat	79% (33,624)	78% (48,590)
Yak	76% (8315)	90% (5838)
Horse	82% (6734)	89% (5027)
Camel	99% (639)	93% (291)
Total livestock	79% (105,988)	84% (108,774)

and more wooden fences to exclude the livestock from areas reserved for haymaking during the last 10 years. However, as these enclosures are built in the same valleys where the nomads live with their livestock for reasons of accessibility, haymaking further aggravates fodder scarcity in these grasslands and compounds the degradation of Dayan's main pasture lands. During Communist times, hay was harvested in the forests. The herders stopped this practice as today the ground vegetation is considered to be insufficient due to increased forest grazing. Until 1990, the grasslands offered enough pasture so that it was unnecessary to use the forests for grazing. The herders tried to keep their livestock away from the forest, as they are less easily controlled and because there are more mosquitoes and wolves than in the steppe. Today, livestock is herded in the forest especially in May or even earlier, as the first grasses to become green at the end of the winter are on the sun-exposed forest edges. Herders explained that they would herd their goats and sheep on the forest edge especially in the morning hours and that they would keep their livestock from the forest interior. However, according to our own observations unattended goats and sheep browsed the forest edge at all times of the days and livestock dung was regularly found also in the forest interior. Yaks rarely browse in the forest. They are not herded and mostly graze in the steppe of the high valleys. Horses often graze in the forests during winter.

To reach better pasture during summer, goats and sheep are regularly led to the alpine grasslands above the (mostly narrow) forest belts. Livestock in the alpine grasslands is attended by herders all day and led down to the valleys in the evening for watering, milking and better protection against predators. Over the years, livestock have carved broad pathways through the forests on their way from the valley steppe to the grasslands. Commonly, several households merge their livestock into a joint flock and rotate the responsibility of herding their animals on the mountain tops. Horses are not herded, but often graze above the treeline by themselves. The vegetation in the alpine grasslands is as short as in the high valleys where the nomads live.

3.3. Forest use

Except for livestock grazing, forests are used for obtaining fuel and construction wood as well as for collecting non-wood products. The formal regulations for timber harvesting in Dayan restrict the use of wood from the forest to the collection of deadwood (standing and lying logs, stumps) and dry branches from living trees. Living trees may not be felled, except by the holders of special permits which are granted at marriage. It became evident during our field work that the real wood consumption in Dayan considerably exceeds the officially allowed amount. Collection of fuel wood requires the purchase of a permit which costs 8000 MNT (Mongolian Tugrik) [ca. 2 USD] per m³. Many nomads in the survey did not pay this fee (or were not even aware of its cost) or pay for less wood than the amount they collected. Live trees are also cut for fuel and apparently often left in the forest until the cut surfaces age. Furthermore, the harvest of construction wood is clearly not restricted to freshly married couples. Nevertheless, only few violations against the Forest Law of Mongolia, which regulates logging and wood collection, are recorded by the authorities. For the entire Bayan-Ulgii aimag, the total of registered violations was 10 in 2006, 22 in 2007, 19 in 2008, and 21 in 2009. Against this background, the information on wood consumption obtained from the nomads in the interviews has to be judged with care, as the quantity of logged trees is probably underestimated.

From the survey, we estimate the annual fuel wood consumption per household to be ca. 8 m³, which is the amount of wood which can be transported on one truck. This means that the total

consumption of all households in Dayan amounts to approximately 700 m³ per year. The need for fuel wood is reduced by the use of dung, which is the traditional fuel of the pastoral nomads and was more commonly used before 1990 than today. Nevertheless, one truckload of compressed dung (primarily used for stock for the winter) and one truckload of uncompressed dung are used per family and year. In addition to the nomad households, the school and the hospital at Dayan each consume 32 m³ wood per year. The military base uses 72 m³ of wood per year in addition to coal, which is imported from the aimag center Ulgii.

Construction wood is harvested for home consumption and for sale. In the late 1980s, the nomad families started to build wooden houses with a perimeter length of 5–6 m. These houses are used in winter. In the Dayan region, there are so far ca. 150 houses, as most families have built two of them. Before houses were erected, people had small gers (traditional nomad tents) for winter and large gers for summer, for the construction of which much less wood is needed than for building houses. Furthermore, the nomads use wood for building small shelters and barns and for the fences around the hay meadows. A few households even log trees for sale in the aimag center. The drivers, who are involved in the transportation of the gers during the moves from one camp to another one, are paid in part by supplying them with timber for sale in the city. All these commercial activities are illegal and should be monitored and stopped by two control points along the road to Ulgii.

Non-wood products used by the nomads from the forest include 10 kg of berries per year and household, 10–20 kg of wild onions (*Allium altaicum* Pall.) and 2–3 kg of wild garlic (*Allium obliquum* L.). Berry species collected are black currant (*Ribes altissimum* Turcz. ex Pojark., *Ribes nigrum* L.), gooseberry (*Ribes aciculare* Smith), and strawberry (*Fragaria orientalis* Los.). Most herders said that they would like to collect more non-wood products, but that the resources are limited. To compensate for the limited local resources, families from Dayan collect berries of black-currant also outside the Dayan region. Hunting is of limited importance and is also illegal.

3.4. Livelihoods

The monthly mean income of the interviewed nomads is estimated to amount to 448,000 MNT (=315 USD) per household (Table 3), which equals 81,000 (=57 USD) per capita. Cash income from the sale of livestock products (18%), various wages and salaries (13%), grants from the government (i.e. a per capita grant that is provided to every Mongolian citizen; 11%) and pensions (9%) contribute to only a little bit more than the half of the total income (53%). The remaining 47% of the total income derives from the use of self-produced livestock products, including meat and milk. The monthly milk consumption per household amounts to 115 L. In addition, each family consumes the meat of one sheep and 0.6 goats per month. Adding the monetary and non-monetary income, livestock husbandry accounts for two thirds of the total income. The households in Dayan have no income from tourism, though 1075 tourists were counted in the Altai Tavan Bogd National Park in 2009 and 80% of the tourists are estimated to visit Dayan.

Total household income increases with the total number of livestock (Fig. 4). Positive correlations with income are found for all species of livestock, except for camels. The most important source of cash for the nomads is cashmere, which accounts for 70% of the total cash income from livestock husbandry. On average, each household sells 15 kg of cashmere per year for a price of 30,000 to 48,000 MNT (=21–34 USD) per kg. Goat and sheep skins are also sold, but rarely sheep wool, as its value is less than the transportation costs to the aimag center or farther. Due to the remoteness of the Dayan region, only a few households sold meat (i.e. complete animals),

Table 3
Monthly cash and non-cash income and cash expenditures (in MNT) per household in Dayan.

	MNT			USD ^a
	Mean ± SD	Min.	Max.	Mean
Total income	447,909 ± 237,141 (100%)	20,667	1,160,750	314
Monetary income, total	209,993 ± 156,167 (53%)	20,667	638,833	147
Livestock husbandry	80,265 ± 64,910 (18%)	0	351,250	56
Wages and salaries	47,268 ± 103,502 (13%)	0	430,000	33
Retirement pensions	31,488 ± 55,541 (8%)	0	211,000	22
Disability pensions	3281 ± 11,769 (1%)	0	54,000	2
Grants from government	39,876 ± 19,969 (11%)	10,000	94,000	28
Non-livestock products	7815 ± 30,884 (2%)	0	200,000	6
Non-monetary income, total	237,915 ± 126,870 (47%)	0	632,500	166
Own consumption of livestock products	237,611 ± 126,064 (47%)	0	632,500	166
Goods received from other nomads free of charge	304 ± 1931 (<0.1%)	0	13,325	0
Total expenditures (monetary)	212,650 ± 136,704 (100%)	81,452	731,550	149
Food	63,255 ± 24,665 (30%)	25,292	124,750	44
Non-food expenses, total	149,395 ± 124,493 (70%)	10,000	627,917	105
Transportation	38,206 ± 36,556 (18%)	0	185,833	27
Tuition fees	26,667 ± 84,063 (13%)	0	416,667	19

^a Based on the exchange rate from 1 August 2010.

while milk products usually cannot be sold. In the year preceding the interview, only 14 out of the 82 households sold 316 sheep for an average price of 35,965 MNT (=25 USD). Other livestock species were rarely sold; yaks (21 animals, 201,905 MNT [=141 USD], 8 families), horses (21 animals, 345,714 MNT [=220 USD], 4 families), goats (7 animals, 23,571 MNT [=17 USD], 2 families), camels (1 animal, 500,000 MNT [=350 USD], 1 family). Seasonal migration patterns of the nomad households are not correlated with their total income (Fig. 5).

Thirty percent of the expenditures of the nomad households are on food (Table 3). On average, 39% of the money spent on food is used to buy flour, as are 12% for purchasing tea, further 12% for biscuits and candies and 8% for vodka. Among the non-food expenditures, costs for transportation and education are most significant. The costs for the seasonal moves of the nomad households from one campsite to another one account for 40% of the transportation costs or 7% of total expenditure.

3.5. Herders' perception of global change and land-use changes

The nomads consistently reported that winters in Dayan are becoming shorter and experience less snowfall. Today snowmelt

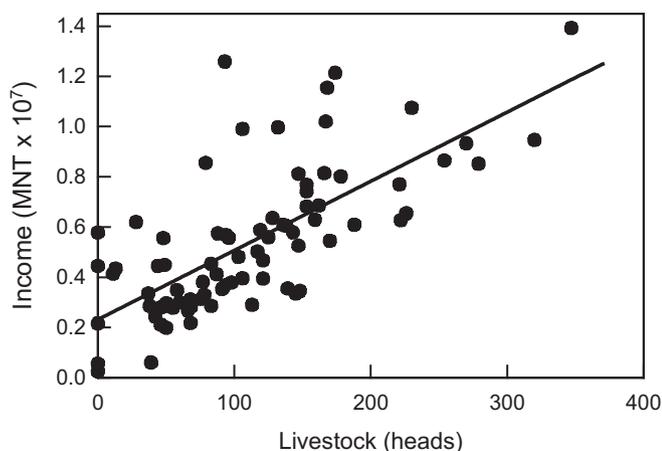


Fig. 4. Annual income of households in Dayan versus total number of owned livestock ($r = 0.71$, $P < 0.001$).

usually occurs in early May, as opposed to mid-June around 20 years ago. The prolonged growing season gives the herders the opportunity to stay on the Dayan pastures and influences the nomads' decisions to reduce mobility. The nomads feel that the changed climatic conditions and land-use practices have degraded the pastures and increased the competition for fodder. Therefore, all interviewees stated that they actually would prefer to leave the Dayan region, but would not be able to do this because they lack economic alternatives and the language barrier, which hinders migration to the Mongolian-speaking parts of Mongolia, including the capital Ulan Bator. Furthermore, all interviewees wished that their children would not live as nomads, as they are skeptical about the future economic prospects of pastoral livestock husbandry in the Mongolian Altai. Although forests are perceived as providing valuable resources contributing to their non-monetary income, 62% of the nomads stated that there is enough forested land in the Dayan region. Fifteen percent of interviewees noticed a moderate shortage of forested area, whereas no one felt that there is a strong need for more forests.

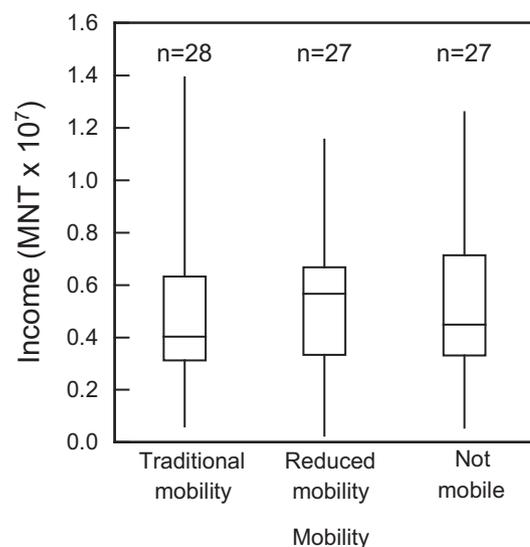


Fig. 5. Annual income of households in Dayan versus mobility. Boxes indicate median as well as 25% and 75% quartiles, and whiskers indicate minimum and maximum.

4. Discussion

Nomad families in Dayan primarily rely on their own livestock for subsistence. Sale of livestock products is less significant for the monetary income, as it accounts for less than one fifth of the total cash income, which is otherwise dominated by pensions, salaries received by individual household members and a per-capita monthly grant of 21,000 MNT (=15 USD) paid to every citizen by the Mongolian government. Sale of cashmere contributes 70% to the monetary income from livestock husbandry, since the trade of milk and meat is limited by high transportation costs to urban settlements. While in other areas of Mongolia nomads are increasingly concentrated along roads and near settlements to improve their market opportunities (but then have to deal with strong overgrazing; Okayasu et al., 2007), this strategy cannot be pursued in the Mongolian Altai since transit roads and cities are sparse. Strong dependence on livestock husbandry for economic security combined with limited market access drives people to increase the size of their herds, a phenomenon observed in many pastoral societies (Johnson et al., 2006; McPeak and Barrett, 2001). Since trade in milk and meat is economically unattractive because of the remoteness of the Mongolian Altai, increased herd sizes do not contribute much to the solution of one of Mongolia's important problems, namely the high food prices in urban areas (Sneath, 2004). Rather, large herds reduce the nomads' dependence on inter-annual climate variability, as cold, snowy winters and dry summers are less likely to reduce the herd size to a non-viable level. Moreover, the economic importance of cashmere even in remote areas, like Dayan, results in a close relationship between the number of herded goats and the monetary income. The present situation in which the nomads are largely cut off from their potential market for milk and meat is a step backwards since the introduction of market economy, as the marketing of livestock products was formally organized even in remote parts of Mongolia (Humphrey, 1978). The strong reduction of milk and meat sale increases the nomads' dependence on the purchase price for cashmere, which is quite variable (Lecraw et al., 2005). Moreover, increased goat numbers are ecologically problematic, as goats, more than other species of livestock, damage the vegetation and woody plants in particular (van Staalduin et al., 2006).

Fernández-Giménez (1993) highlighted the importance of the herders' perceptions on environmental conditions in guiding their decisions on land use. They concluded that it was not the objective circumstances, but the nomads' assessment of the conditions that served as the basis for all actions. While the marketing of livestock products has become more difficult, the nomads feel that the pastures have degraded both in the grasslands and the forests during the past two decades, their responses to these important changes are remarkably limited. The main response was to build fences to establish hay-making areas for preparing winter stock, which is problematic since hay-making is done in former grazing areas near the summer camps. It is very probable that rangeland degradation is at least partly the result of reduced seasonal migrations of the nomad families. After the privatization of the livestock sector, two thirds of the herders reduced or completely stopped seasonal migration to avoid labor and transportation costs. The nomads felt encouraged in doing so by their observations of rising temperatures, a perception which is confirmed by measurements of a significant increase of air temperature (Ch. 2.1). In the high mountain area of the Mongolian Altai, rising temperatures have led to earlier snowmelt, which reduce the nomads' motivation for moving. Furthermore, Erdenetuya et al. (2006) found that the glacier area at Mt. Tsambagarav (4193 m a.s.l.) in the Mongolian Altai has decreased since the 1940s by 13% in 1992, 29% in 2000 and 32% in 2002. A recent increase of temperature in

the Dayan valley was also substantiated in not yet published tree-ring analyses in the Dayan valley by our group (Dulamsuren, Khishigjargal & Hauck, unpublished). The improvement of climatic conditions for livestock husbandry in Dayan has led to the paradoxical situation that pastures deteriorated as the herders decided to stay longer in the area than before. In other areas of Mongolia, reduced migration is known to be linked to pasture degradation (Fernández-Giménez, 1999b; Marin, 2010). Nevertheless, it is unlikely that the families in Dayan will resume their former migrations without external financial incentives, because there is no direct correlation between the migration behavior of the individual household and its income. This is probably attributable to the fact that the pastures of herders who migrate in the traditional way over long distances are affected by the livestock of other herders who infringe the traditional rules of seasonal rotation (Mearns, 1993). The situation can probably not be solved by introducing a stationary, rotational grazing system, as in terms of water availability rangelands suitable for livestock husbandry are all already in use in the study area.

In addition to the rangelands, the forests of Dayan are currently more intensely used than during Communist times. This results from the increased presence of the local nomad population due to reduced migrations and from changed customs, as now people tend to use more wood for fuel and building shelters than two decades ago. Furthermore, forests now suffer from considerable illegal logging activities for timber trade. Such activities are triggered by the needs of the local population for cash, especially for renting trucks, and are a supra-regional problem in Mongolia and former Soviet republics (Erdenechuluun, 2006; Kushlin et al., 2004). In contrast to milk and meat, the transportation of illegally felled trees over long distances is economically profitable for those individuals involved in this business. The present over-utilization of the forests is a serious threat for their continued existence and, with it, a substantial part of the biodiversity of the Mongolian Altai. A decline of species due to the reduction of thick-stemmed trees and deadwood has already occurred in the study area (Hauck et al., 2012). While herders worry a lot about the conditions in the grasslands, they expressed little concern about the forests in the interviews. Therefore, it is not likely that they will change to a more sustainable utilization in the near future.

Since the herders notice the vulnerability of their pastures and the instability of their livelihoods, they would prefer to find economic alternatives to their present life at least for their offspring. However, the low educational level of most nomads constrains them from shifting to occupations other than livestock husbandry. The inability of more than 80% of the population of Dayan to speak the Mongolian language hinders most of them from migrating to the cities, especially to the Mongolian capital Ulan Bator, which is an economic alternative for nomad families from other parts of Mongolia. Migrating to Kazakhstan is possible for Mongolia's Kazakh minority but rarely realized, since there job opportunities are very limited for individuals with the limited education level of the Dayan pastoral nomads in Kazakhstan.

5. Conclusions

Pastoral nomadism in the Mongolian Altai today has in many respects more the character of a subsistence economy than of a market-orientated livestock production economy. This is a step backwards compared to Communist times and creates economic problems because of increased prices for livestock products in urban areas. The dominance of cashmere sales among the herders' cash income from livestock husbandry makes their livelihoods dependant on the world market for cashmere, which is dominated by China. Due to the loss of the central regulation of the nomads'

seasonal migrations and the resulting lowered mobility of the nomads and their livestock, grasslands and forests of the Mongolian Altai are more intensely used today than in the Communist era. Our study suggests that neither the present use of grasslands nor forests is sustainable. Since the income of the nomad families is low, it is not likely that they will be able to increase sustainability by their own means. Keeping the present unsustainable land-use system, which developed after the introduction of the market economy, will most likely lead to the impoverishment of the local population, the loss of forested area and the degradation of grasslands in the Mongolian Altai.

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References

- Begzsuren, S., Ellis, J.E., Ojima, D.S., Coughenour, M.B., Chuluun, T., 2004. Livestock responses to droughts and severe winter weather in the Gobi Three Beauty National Park, Mongolia. *Journal of Arid Environments* 59, 785–796.
- Briske, D.D., Fuhlendorf, S.D., Smeins, F.E., 2003. Vegetation dynamics on rangelands: a critique of the current paradigms. *Journal of Applied Ecology* 40, 601–614.
- Dagvadorj, D., Natsagdorj, L., Dorjpurev, J., Namkhainyam, B., 2009. Mongolian Assessment Report on Climate Change 2009. Ministry of Environment, Nature and Tourism, Mongolia, Ulan Bator.
- Dorj, T., Yavuuhan, D., 2003. Mongolian economic development strategy. *International Journal of Asian Management* 2, 93–98.
- Dulamsuren, Ch., Hauck, M., Bader, M., Osokhjargal, D., Oyungerel, Sh., Nyambayar, S., Runge, M., Leuschner, C., 2009. Water relations and photosynthetic performance in *Larix sibirica* growing in the forest-steppe ecotone of northern Mongolia. *Tree Physiology* 29, 99–110.
- Dulamsuren, Ch., Hauck, M., Khishigjargal, M., Leuschner, H.H., Leuschner, C., 2010a. Diverging climate trends in Mongolian taiga forests influence growth and regeneration of *Larix sibirica*. *Oecologia* 163, 1091–1102.
- Dulamsuren, Ch., Hauck, M., Leuschner, C., 2010b. Recent drought stress leads to growth reductions in *Larix sibirica* in the western Khentey, Mongolia. *Global Change Biology* 16, 3024–3035.
- Erdenechuluun, T., 2006. Wood Supply in Mongolia: the Legal and Illegal Economies. In: *Mongolia Discussion Papers*. World Bank, Washington, DC.
- Erdenetuya, M., Khishigsuren, P., Davaa, G., Ogtontogs, M., 2006. Glacier change estimation using Landsat TM data. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Science* 36, 240–243.
- Fernández-Giménez, M., 1993. The role of ecological perception in indigenous resource management: a case study from the Mongolian forest-steppe. *Nomadic Peoples* 33, 31–46.
- Fernández-Giménez, M., 1999a. Reconsidering the role of absentee herd owners: a view from Mongolia. *Human Ecology* 27, 1–27.
- Fernández-Giménez, M., 1999b. Sustaining the steppes: a geographical history of pastoral land use in Mongolia. *Geographical Review* 89, 315–342.
- Fernández-Giménez, M., 2000. The role of Mongolian nomadic pastoralists' ecological knowledge in rangeland management. *Ecological Applications* 10, 1318–1326.
- Fernández-Giménez, M., 2002. Spatial and social boundaries and the paradox of pastoral land tenure: a case study from postsocialist Mongolia. *Human Ecology* 30, 49–78.
- Griffin, K., 1995. Poverty and Transition to a Market Economy in Mongolia. Macmillan, Basingstoke.
- Hauck, M., Javkhlan, S., Lkhagvadorj, D., Bayartogtokh, B., Dulamsuren, Ch., Leuschner, C., 2012. Edge and land-use effects on epiphytic lichen diversity in the forest-steppe ecotone of the Mongolian Altai. *Flora* 207, 450–458.
- Hilbig, W., 1995. *The Vegetation of Mongolia*. SPB, Amsterdam.
- Humphrey, C., 1978. Pastoral nomadism in Mongolia: the role of herdsman's cooperatives in the national economy. *Development and Change* 9, 133–160.
- Janzen, J., 2005. Mobile livestock-keeping in Mongolia: present problems, spatial organization, interactions between mobile and sedentary population groups and perspectives for pastoral development. *Senri Ethnological Studies* 69, 69–97.
- Janzen, J., Bazargur, D., 2003. The transformation process in mobile livestock keeping and changing patterns of mobility in Mongolia – with special attention to western Mongolia and Ulaanbaatar. In: Ishikawa, Y., Montari, A. (Eds.), *The New Geography of Human Mobility – Inequality Trends?* Societa Geografica Italiana, Rome, pp. 185–222.
- Jeffries, I., 2007. *Mongolia: a Guide to Economic and Political Developments*. Taylor & Francis, Abingdon.
- Johnson, D.A., Sheehy, D.P., Miller, D., Damiran, D., 2006. Mongolian rangelands in transition. *Sécheresse* 17, 133–141.
- Krader, L., 1955. Ecology of Central Asian pastoralism. *Southwestern Journal of Anthropology* 11, 301–326.
- Kushlin, A., Schillhorn van Veen, T., Sutton, W., 2004. Kazakhstan: forest sector in transition. The resource, the users and sustainable use. Technical Paper. World Bank, Washington, DC.
- Lecraw, D.J., Eddleston, P., McMahon, A., 2005. A Value Chain Analysis of the Mongolian Cashmere Industry. USAID Economic Policy Reform Competitiveness Project, Ulan Bator.
- Liang, E.Y., Vennetier, M., Lin, J.X., Shao, X.M., 2003. Relationships between tree increment, climate and above-ground biomass of grass: a case study in the typical steppe, north China. *Acta Oecologica* 24, 87–94.
- Lise, W., Hess, S., Purev, B., 2006. Pastureland degradation and poverty among herders in Mongolia: data analysis and game estimation. *Ecological Economics* 58, 350–364.
- Mahul, O., Skees, J., 2006. Piloting index-based livestock insurance in Mongolia. *Access Finance* 10, 1–4.
- Marin, A., 2010. Chasing the Rains: Mongolian Pastoralists' Vulnerability and Adaptation to Climate Change in “the Age of the Market”. University of Bergen, Bergen.
- McPeak, J.G., Barrett, C.B., 2001. Differential risk exposure and stochastic poverty traps among east African pastoralists. *American Journal of Agricultural Economics* 83, 674–679.
- Mearns, R., 1993. Territoriality and land tenure among Mongolian pastoralists: variation, continuity and change. *Nomadic Peoples* 33, 73–103.
- Nandintsetseg, B., Green, J.S., Goulden, C.E., 2007. Trends in extreme daily precipitation and temperature near Lake Hövsogol, Mongolia. *International Journal of Climatology* 27, 341–347.
- NSO, 2011. *Statistical Yearbook of Mongolia 2010*. National Statistical Office of Mongolia, Ulan Bator.
- Neupert, R.F., 1999. Population, nomadic pastoralism and the environment in the Mongolian Plateau. *Population and Environment* 20, 413–441.
- Nitta, Y., Shiga, E., Kurokawa, I., Soyilkham, B., 2005. The impact of dzud and dynamic changes of nomads in Mongolia. *Review of Agricultural Economics* 61, 119–132.
- Novgorodova, E.A., 1989. *Drevnyaya Mongoliya*. Nauka, Moscow (in Russian).
- Okayasu, T., Muto, M., Jamsran, U., Takeuchi, K., 2007. Spatially heterogeneous impacts on rangeland after social system change in Mongolia. *Land Degradation and Development* 18, 555–566.
- Rybin, E.P., 2005. Land use and settlement patterns in the mountain belt of south Siberia: mobility strategies and the emergence of ‘cultural geography’ during the middle-to-upper Palaeolithic transition. *Indo-Pacific Prehistory Association Bulletin* 25, 79–87.
- Rudaya, N.A., Tarasov, P.E., Dorofuyek, N.I., Kalugin, I.A., Andreev, A.A., Diekmann, B., Daryin, A.V., 2008. Environmental changes in the Mongolian Altai during the Holocene. *Archaeology, Ethnology and Anthropology of Eurasia* 36, 2–14.
- Sankey, T.T., Montagne, C., Graumlich, L., Lawrence, R., Nielsen, J., 2006. Lower forest-grassland ecotones and 20th century livestock herbivory effects in northern Mongolia. *Forest Ecology and Management* 233, 36–44.
- Schlütz, F., Lehmkühl, F., 2007. Climatic change in the Russian Altai, southern Siberia, based on palynological and geomorphological results with implications on climatic teleconnections and human history since the middle Holocene. *Vegetation History and Archaeobotany* 16, 101–118.
- SDC, 2011. *Implementation of the Minority Rights of Kazakh Nationals*. Swiss Agency for Development and Cooperation in Mongolia, Ulan Bator.
- Sneath, D., 2004. Proprietary regimes and sociotechnical systems: rights over land in Mongolia's ‘Age of the Market’. In: Verdery, K., Humphrey, C. (Eds.), *Property in Question: Value Transformation in the Global Economy*. Berg, Oxford, pp. 161–182.
- Sternberg, T., 2008. Environmental challenges in Mongolia's dryland pastoral landscape. *Journal of Arid Environments* 72, 1294–1304.
- Sternberg, T., Thomas, D., Middleton, N., 2011. Drought dynamics on the Mongolian steppe, 1970–2006. *International Journal of Climatology* 31, 1823–1830.
- van Staaldin, M.A., Marinus, J.A., Werger, M.J.A., 2006. Vegetation ecology features of dry Inner and Outer Mongolia. *Berichte der Reinhold-Tüxen-Gesellschaft* 18, 117–128.