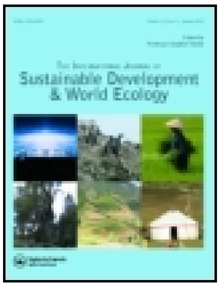

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Climate change, risk management and the end of Nomadic pastoralism

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Title: Climate Change, Risk Management and the End of *Nomadic* Pastoralism[1]

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Abstract: Mobility has been argued to be the single factor explaining why some pastoralists do relatively well during extreme climatic events, while others do not, because mobility works by taking advantage of the spatial and temporal structure of resource failure by moving away from scarcity towards abundance. In spite of this, a common governmental management strategy is to resettle pastoral populations and thereby significantly reduce mobility. By revealing the underlying logic of mobility for Tibetan pastoralists, this paper questions official policy that aims at privatizing communally owned rangelands since it reduces pastoral flexibility and access to key resources. This is especially pertinent in the face of climate change. While little is known as to the specifics of how climate change will affect nomadic pastoralists, environmental variability is likely to increase. Consequently, policies resulting in decreased mobility may exacerbate the negative effects of climate change because of a positive feedback between climate and negative density dependence.

Keywords: fragmentation, climate change, density dependence, risk, nomadic pastoralism, grazing patterns, Chang Tang, Tibetan Plateau, China.

[1] This is the accepted version of the paper and as such may differ from the final corrected proof which can be accessed at http://dx.doi.org/10.1080/13504509.2013.779615.

INTRODUCTION

Environmental hazards, such as drought, floods and icing have been found to significantly affect livestock survival and reproduction. For example, in Africa mortality rates for cattle during drought has been estimated to be between (1) 35-75% (Nkedianye *et al.* 2011: 11), (2) 10-25% (mean = 18%, n = 5 locations, Little *et al.* 2001a: 157), and (3) average of 25% (McPeak and Little 2005: 91). Small stock losses have been found to range from 1 to 35% (mean = 24.2%) for sheep and 5-30% (mean = 16.6%) for goats (Little *et al.* 2001a: 157). McPeak and Little (2005:91) also found that the number of stockless households increased from 7 to 12% because of drought. In Mongolia, Templer et al. (1993: 113) reported that icing in 1993 resulted in the deaths of three-quarter of a million livestock where 110 households lost every animal they herded, and 2090 (~10 000 people) households lost >70% of their herds, while between 1999-2002 Janes (2010: 239) reports that 12 million livestock died in winter disasters, and many thousands of households lost their livelihoods. Similarly, in the reindeer husbandry in Finnmark, Norway mass starvation due to severe winter conditions have been recorded to dramatically reduce reindeer populations: in 1918 one reindeer population was, for example, reduced by a third (Bjørklund 1990: 79) and adverse weather events in 1958, 1962, and 1968 also caused substantial reductions in reindeer populations (Hausner *et al.* 2011: 6).

Not surprisingly, pastoral systems are characterized by livelihood strategies that have evolved in order to: (1) reduce the pastoralists' and their livestock's vulnerability to adverse climatic conditions, and (2) manage the impacts of adverse environmental occurrences when they do occur (e.g. Morton 2007). Of importance is the concept of risk, which, following Cashdan (1990), may be defined as unpredictable variations in ecological or economic parameters, and outcomes are viewed as riskier depending on their degree of variability.

The logic of mobility

Mobility in the face of environmental risks has been argued to undergird the survival of most nomadic pastoralists (Agrawal 1993) and pastoral mobility have for centuries provided herders with the flexibility needed to survive in patchy and unpredictable low-productivity environments (Fernandez-Gimenez and Le Febre 2006). Little et al. (2001b) argue that mobility is the key pastoral risk management strategy where pastoralists who migrate with their herds have considerably fewer livestock losses during climatic disasters than their sedentary counterparts. In general, mobility has been argued to reduce the probability of experiencing hazards ranging from drought, insect and disease outbreaks to political upheaval and border disputes (Fernandez-Gimenez and Le Febre 2006). From a risk perspective mobility works by taking advantage of the spatial and temporal structure of resource failure by moving away from scarcity towards abundance (e.g. Niamir-Fuller and Turner 1999). In arid and semi-arid environments, pastoralists use mobility to manage resource variability (Samuels *et al.* 2008), because mobility allows full exploitation of forage resources that are unequally distributed in space and time (Schwartz 2005) and because flexible movements to spatially dispersed resources are key to livestock survival (Scoones 1995). More to the point, mobility allows pastoralists to take advantage of resources found in different habitat types and thus *supports more animals than if they were stationary* (Fernandez-Gimenez and Le Febre 2006: 343). Oba and Lusigi (1987), for example, argues that the entire concept of nomadism may be considered as a means of coping with and exploiting highly variable resources made possible in part by geographical mobility. In fact, Little et al. (2001a) argues that mobility is the single factor explaining why some pastoralists do relatively well during extreme climatic events, while others do not.

The challenge of climate change

Scenarios for future climate change generally predict an increased average, variance and even a changed distribution of important climatic variables like precipitation and temperature (e.g. Sun *et al.* 2007). Moreover, these changes are predicted to vary both temporally (e.g. Rowell 2005) and spatially (e.g. Hanssen-Bauer *et al.* 2005). Global climate change will most likely result in more frequent extreme precipitation events, a trend that is already empirically evident on several continents (e.g. Coumou and Rahmstorf 2012). In short, global climate change may exacerbate pastoral production risks (Næss 2012). This paper aims at investigating the underlying logic of mobility in the north-western parts of Tibet as well as discussing possible positive feedback between policies that dissect natural systems into spatially isolated parts (i.e. fragmentation) and climate change that challenges the future of nomadic pastoralists both in Tibet and globally. From a global point of view, land tenure changes that increase fragmentation can be argued to restrict the movement of people and livestock. As a consequence, while environmental variability is predicted to increase with climate change, the nomads' ability to respond is reduced.

ETHNOGRAPHIC BACKGROUND

Method

The research reported here is based on three 2-6 week visits to the Aru Basin in Tibet Autonomous Region (TAR, Fig. 1), in June 2000, September-October 2000, and May-June 2001. Information was gathered primarily through in-depth interviews by the use of translators with 10 out of 36 households in June 2000, 15 out of 28 households in September/October 2000, and 15 out of 24 households in May-June 2001. Informal interviews were made with all households present in the basin during one of our three trips, and interviews with local leaders and TAR Forestry Bureau officials was also undertaken (for details see Næss 2003, Næss *et al.* 2004).

Nomadic pastoralism on the Qinghai-Tibetan Plateau

The Qinghai-Tibetan Plateau (QTP) reaches around 1 500 km North-South and around 3 000 km East-West, and is around 2.5 million km^2 (Fig. 1). Over 80% of the plateau is located above 3 000 m in elevation, and about 50% is >4 500 m (Schaller 1998). The nomadic pastoral area encompasses a sub-region where the rangelands of the QTP includes all of TAR and Qinghai, most of the rangeland area of Gansu and Sichuan, and parts of southern Xinjiang; an estimated 1.6 million km^2 (Fig. 1)f. Tibetan pastoralism is found at elevations between 3 500-5 400 m, in environments too cold for crop cultivation but which supports extensive, productive rangelands where nomads continue to thrive (Goldstein and Beall 1990, Næss 2003, Næss *et al.* 2004). An estimated 12 million yaks and 30 million sheep and goats inhabit the Tibetan Plateau supporting around 5 million pastoralists and agropastoralists (Sheehy *et al.* 2006: 143, Harris 2010: 3).

Horses are kept for riding and as pack animals although they are almost non-existent in the western parts due predation (Næss 2003). Traditionally yaks were used for transportation, since they are well adapted to the high altitudes (Goldstein and Beall 1990), but today trucks are more commonly used (Næss 2003). Yaks also provide the nomads with food, shelter and clothing: the coarse belly hair is spun and woven into tent material. Yaks also provide the nomads with meat (Goldstein and Beall 1990) while the female yak can provide large quantities of milk throughout the year. In the western areas of the TAR both goats and sheep are milked while in the east the yak supply all the milk (milk is primarily used to produce yoghurt, butter and cheese, Næss 2003, see also Sheehy 1993). While goats produce more milk and for longer time periods than sheep, nomads in the western parts prefer milk and meat from sheep (Næss 2003). Goats have, however, increased in importance during recent year due to an increased demand for cashmere wool, which provides a substantial part of the nomads cash income (Næss 2003, Næss *et al.* 2004). In the southern parts of TAR, Goldstein and Beall (1990) noted that the percentage of goats in the herds had increased, suggesting that goats may have become a new economic basis.

The Aru Basin

The Aru Basin is approximately 2 300-km^2 with most of its area lying above 5 000 m. The basin is northwest-southeast trending, encompassing two lakes, Aru Co and Memar Co (Fig. 1). The permanently snow-covered mountains along the western edge of the basin create a moist and productive environment making the basin an attractive place for both wild herbivores and nomadic pastoralists. The Aru Basin is an important wildlife area in the 300 000 km^2 Chang Tang Nature Reserve (Bårdsen and Fox 2006), and parts of it have therefore been designated as a core area for wildlife protection within the reserve (Fox *et al.* 2004).

Nomadic hunters have probably used the Aru Basin for several thousands of years and nomadic pastoralists for perhaps the past thousand years. Næss (2003) indicates that present inhabitants claim that their kin have used the Aru Basin for at least the last 200 years and while the earliest users were nomadic pastoralists, the main reason for using the basin was related to hunting; wildlife was and still is abundant (Fox and Bårdsen 2005). Accordingly, the basin was used mainly during winter, when hunting was at its peak (Næss 2003). Nevertheless, the extent of the use of the basin is unknown, local estimates ranges from 10 families to 200 families (Næss 2003).

Although a small number pastoralists and hunters have used the Aru Basin for several thousand years, its use has changed in recent time. During the Cultural Revolution (a campaign to destroy the four olds, i.e. old ideas, old culture, old customs and old habits, see Shakya 1999, lasting from around 1972 to 1983 in this area, Næss 2003) nomads in the Aru Basin was forcefully removed and the basin was left uninhabited for around 15-20 years (Næss 2003). From the early 1990's on pastoralists moved back into the basin, and today administrative responsibilities for the basin is divided between two counties, or *xians*, namely Rutok and Gertse (Fig. 1). The basin is currently inhabited during summer by around 222 nomads with 10,000 sheep and goats, 500 yaks, as wells as 127 nomads with 7,000 sheep and goats, and 330 yaks during autumn and winter (see Næss 2003, Næss *et al.* 2004 for details). Consequently, the use of the basin changes seasonally, with summer as the season with the highest density of livestock and people.

CASE STUDY: MOBILITY AND SETTTELMENT PATTERNS IN THE ARU BASIN

Seasonal designation of grazing areas

As previously mentioned, administrative responsibilities for the Aru Basin is divided between two counties and is utilized by 3 groups of nomads on the Rutok side of the basin (of which only one use the basin all-year around) and at least 2 on the Gertse side (of which one group use the basin all-year around, see Næss 2003). While the boundary between Gertze and Rutok is clearly marked (and was officially established in 1995), individual herders sometimes cross the border. Specifically, nomads with kin in different counties sometimes cross the border with their animals to visit their relatives. As a consequence, nomads from Rutok sometimes utilize grazing areas on the Gertse side and vice versa when visiting relatives (see, Næss 2003 for details).

While it was individual nomads through discussions that decided where to originally locate seasonal grazing areas, there is a difference in how the nomads from Gertse and those from Rutok have divided their total available grazing area (Næss 2003). This is partly due to difference in the level of control enforced from local town centres and partly due to different ideas that the nomads have concerning the separation of their areas into different grazing areas (Næss 2003). In terms of control, for example, it seems that the Rutok nomads are under more strict control from town centre leaders than Gertse nomads: e.g. while Rutok leaders decide the date nomads have to be in their seasonal designated pastures Gertse leaders only decide the month. The Rutok nomads have also clearer seasonal designation of grazing areas: for example, the group from Rutok that use the basin permanently have divided their grazing area into four zones: (1) summer grazing; (2) late summer and early autumn grazing; (3) autumn grazing; and (4) winter grazing (Fig. 2). The nomads usually move to their summer grazing area in the end of May or beginning of June, depending on the weather. The better the weather, the earlier they move. The nomads usually move to autumn grazing in the end of October or beginning of November while moving to winter grazing usually happens at the beginning of December (Næss 2003). Nomads using the Gertse part of the basin organize themselves differently, however, since no clear seasonal boundaries exist between different grazing areas (although winter grazing is usually commenced in the proximity of their winter houses). The rationale for this was provided by one nomad as the following:

> '*We do not have marked boundaries between for example winter grazing and summer grazing since this would only lead to conflict. If for example one nomad crossed with his animals over to the winter grazing area in summer, all the other nomads would complain. Now nobody knows exactly where the boundary is, and therefore nobody can complain'* (Næss 2003: 104, italics in original).

Even though the boundaries between the different grazing areas for Rutok are clear (marked with stones), they are only ideal, and utilizing e.g. the winter grazing during summer sometimes occurs (see below).

The seasonal designation of different grazing areas is connected to the growth season on the rangeland (Næss 2003). Tibetan nomads rear their livestock under a 'natural' system of pastoral production since they survive by grazing on range forage alone (Næss 2003). Because of the general high altitude, the growing season on the Tibetan Plateau is relatively short, starting in late April or early May, and ending in mid-September (Goldstein and Beall 1990). Consequently, since almost all areas on the plateau have roughly the same single growing season, i.e. since there are no areas where grass grows during winter there is no need to undertake long migrations. As a matter of fact, they try to minimize travel, saying that it weakens the livestock and increases mortality (Næss 2003). A crucial factor for the livestock is that the amount of vegetation left by the end of summer must sustain them until next year's growth begins (Goldstein and Beall 1990). Consequently, designated areas are 'saved' for grazing during seasons with no vegetation growth. This seasonal movement pattern extends the good grazing season by 3-4 months and helps building up the fat reserves before winter (Næss 2003). The seasonal grazing pattern thus resembles pendulation or alpine transhumance, i.e. movement that is, in general, seasonal but very limited in scope, perhaps restricted to one valley (Fernandez-Gimenez and Le Febre 2006).

Not surprisingly, since the total available area available for grazing in the Aru Basin is heterogeneous with regard to grass quality, quantity and climatic factors such as snow, knowledge pertaining to these factors forms the basis for the division into seasonal grazing areas. It would, for example, be of no use to have winter grazing area in a place that is affected by heavy snowfalls. Seasonal movement patterns thus emerge as quite predictable, since the areas, at least for Rutok, are relatively clearly marked, and also because when to move to seasonally designated areas is officially decided by town centre leaders (Næss 2003). It is, however, important to note that even though they have seasonally distinct grazing areas, they may not stay at the same specific location each year (apart from during winter when they stay in winter houses). Each year they have group discussions pertaining to where each household should put up their tents within, for example, the summer grazing area and where the decision they reach is largely based on quality and availability of grass since this regulates the number of households and animals that can live close together (Næss 2003). Seasonality thus cannot be understood with reference to taking advantage of an area's different growing season and moving accordingly (what has been termed rotation, Fernandez-Gimenez and Le Febre 2006: 349) but rather with reference to utilizing different areas during different seasons.

Responding to environmental stochasticity

The climate on the Tibetan Plateau is characterized by wet and humid summers with cool and dry winters. Most of the precipitation, >60–90 % of the annual total, falls between June and September, often as wet snow and hail, while <10% falls between November and February (Kang *et al.* 2010, Miller 2000). Average annual precipitation gradually increases from northwest to the southeast, from <50 mm to ~700 mm, and most of the nomadic pastoral area receives < 400 mm precipitation annually (Kang *et al.* 2010, Miller 2000). The annual temperature on the plateau varies spatially with the northern region having an annual average temperature <0°C, with western and southern areas of the region with an annual temperature of 0-5°C; and the Yarlung Tsangpo River Basin (i.e. Lhasa area) with annual air temperature of >5°C (Xu *et al.* 2008). Because of the high elevation a severe continental climate predominates in Tibetan nomadic pastoral areas (Miller 2000). While winters are generally dry, heavy snowfalls which bury forage occur periodically and prevent animals from grazing.

Tibetan nomads have always had to deal with snowstorms and cold weather, making nomadic pastoralism on the Tibetan Plateau a high-risk enterprise (Goldstein and Beall 1990, Miller 2000) where decisions have always been aimed at mitigating risks and averting disasters (Sheehy *et al.* 2006). While environmental induced risks are problematic for pastoralists in general, according to Sheehy *et al.* (2006), these risks are an especially critical constraint for nomadic pastoralists in Tibet. For example, a Russian explorer noted over 100 years ago that a caravan consisting of 1 000 animals on its way from Lhasa lost all their animals in the course of one snowstorm (Prezewalski, 1876 in Schaller 1998). Jiang (in Miller 2000: 87) reports that from 1955 to 1990 six harsh winters with heavy snowfall resulted in 20-30% livestock losses on the Tibetan Plateau. Goldstein & Beall (1990: 70) reported that in the Phala area of Shigatse Prefecture (TAR) some households experienced a 100% neonatal mortality of sheep and goats in 1988. Also, nomads in the same area experienced losses of up to 70% of juvenile goats and 20% of lambs and the loss of one quarter of their adult goats during the winter of 1996-97 (Miller

2000: 88). Livestock losses due to snow also occur during summer, Goldstein & Beall (1990: 70) reported that after five days of snow in the summer of 1986, one nomad area lost 30% of its livestock. Similarly, during the severe winter of 1997-1998 herders in Nyerong County (Naqu Prefecture) lost 23.8% of their yaks; 19.1% of their sheep and 15.3% of their goats (Miller 2001: table 12). Before the winter, 20% of the pastoral population in Naqu Prefecture lived in poverty while the following year this number had doubled to 40% (total population was 340 000, see Sheehy *et al.* 2006: 148). For the TAR in general, some townships lost up to 70% of their total livestock population, and by April 1998 it was estimated that the region had lost over 3 million head of livestock, estimated as a loss of US $ 125 million (Miller 2000: 88). As for the eastern parts on the Qinghai-Tibetan Plateau, in Yushu Prefecture (Qinghai Province) snow disasters resulted in, e.g.: (1) 1967-1957: 30% loss of livestock (926 876 heads); (2) 1971-1972: 9.17% and 26.7% loss of adult and young respectively (724 000 heads); (3) 1974-1975: 15.54% and 24.3% loss of adult and young respectively (787 000 heads); (4) 1981-1982: 9.9% livestock loss (1 320 000 heads); (5) 1984-1985: 17% livestock loss (990 000 heads); and (6) 1995-1996: 33.37% livestock loss (1.290.000 heads, see Nori 2004 : 13).

Snow, and then especially blizzards, affects the Aru nomads as well, for example, during the winter of 1997-1998 one household lost 50% of around 1 200 sheep and goats while another lost ~50% of his herd of 1 000 during one night in 1997. Another group in the basin reported that they lost around 500 animals during the same winter. Moreover, snowfalls in the spring of 2001 had significant effects on livestock survival, where one group of nomads (n = 11 households) reported an average of 34.93% mortality (range 5.04-63.29%), against an average recruitment of new-borns of 21.33% (range 8.83-56.12%) based on herd size from previous year (Næss 2003). The high losses were attributed primarily to severe snowfall conditions especially during April and May (many carcasses of sheep and goats were observed near some of the late winter encampments, Næss 2003). Accordingly, Yangzong (2006: 37) argues that '[t]he impacts of animal mortality from snowstorm disasters are a major cause for rural poverty in the region' (see Table A1 in Appendix A for a presentation of average number of people and animals per household from different locations on the QTP). For nomadic pastoralists on the Tibetan Plateau, the problem is that while snowstorms may be viewed as seasonal or annual phenomena on a large temporal scale, snowstorms are unpredictable on a day-to-day basis for individuals within the system and thus represent a significant risk.

While the seasonal movement between different grazing areas can be considered as relatively large scale, just as important for the Aru nomads are so-called micro-mobility (that can be defined as the daily scale movements of livestock, see Butt *et al.* 2009). Consequently, the Aru nomads move their herds (but not necessarily campsites) quite frequently within different seasonal grazing areas, and sometimes even cross into another seasonal grazing area if necessary. As seen above, heavy snow during summers, for example, cause problems: since sheep and goats are poor diggers, the nomads have to wait to bring the sheep and goats out to graze until after the snow has melted. Nevertheless, since it can snow continuously for days at end it may be impossible to bring the animals to the summer pasture. As a consequence, nomads often have to utilize the winter grazing area during summer because the winter grazing area is further away from the mountains and thus relatively free from snow during summer. The ability to move is thus not only restricted to seasonal utilization of different grazing areas, but also incorporates the ability to respond flexible to day-to-day variation in climatic factors such as snow.

DISCUSSION

Mobility in the Aru Basin and in Tibet in general seems to follow the logic stipulated for African pastoralists which can be classified as (1) resource exploitation mobility and (2) escape mobility (Oba and Lusigi 1987: 9). While resource exploitation mobility is undertaken in response to unpredictable resource distribution (e.g. forage), escape mobility involves movements to escape environmental hazards. Accordingly, in either case, the primary objective is usually to maximize livestock survival (Oba and Lusigi 1987). Nevertheless, despite obvious beneficial aspects of mobility, pastoral mobility is under threat.

Common pastures and fragmentation: privatization reconsidered

Mobility has led governments to look at pastoralists as 'backward', lacking the technological level and skill to successfully exploit their existing adaptation. Thus, in many areas of the world large governmental sedentarization programmes have been established to raise the technological level and to enhance the profit of pastoral production (Humphrey and Sneath 1999).

As for Tibet, the patterns of moving and grazing in the Aru Basin have undergone significant changes. Traditionally, the Aru Basin was only used seasonally, with winter as the primary season due to great hunting opportunities. As a consequence, nomads would only use parts of the basin for a relatively short period time. Today the pattern has changed: Now two groups of nomads use the basin all year round, i.e. they never move out of the basin. As a consequence, mobility has decreased and the use of the basin has increased. Traditionally, land was owned by monasteries and pastures were re-allocated at three-year intervals based on individual households' herd size. Additional pastures were allocated to households whose herds had increased, and pastures were taken away from those whose herds had decreased (Goldstein *et al.* 1990). Under Chinese rule, however, this relatively flexible system of pasture allocation has changed, aiming at minimizing the impact of the government perceived 'tragedy of the commons' (see Appendix A for details and justification of a 'tragedy of the commons' and Ho 2000b, Harris 2010, Bauer 2005 for general information).

From 1950s-1980s Chinese agricultural production was mainly managed collectively in communes which were responsible for administering agricultural production, including livestock and pastures (Taylor 2006, Yan *et al.* 2005). By the end of the 1970s (early 1980s in some pastoral areas) the communes system was dissolved and the Household Responsibility System (HRS) was introduced. In short, the HRS re-established the household as the basic unit of production and management decisions were largely devolved to the household level and where households were entitled to residual income as long as certain quota and tax requirements were met (Banks 2003, Ho 2000a). The implementation of the HRS in farming areas was a success resulting in, for example, increased agricultural output and income (Ho 2000a, Banks

2003). Consequently, the HRS became the accepted form of agricultural land tenure and was subsequently extended to the pastoral sector (Ho 2000a).

For pastoralists, the HRS was implemented in two stages: the first stage was the privatization of livestock (Yangzong 2006, Banks 2001, Yan *et al.* 2005) while the second stage opened up for the privatization of rangelands: the Rangeland Law from 1985 states that '[…] the user right of state or collective rangeland may be leased to households or collectives for a 'long term'' (Ho 2000a: 389). Since the dissolution of the commune system Chinese government policies have emphasized that individual household tenure is a necessary condition for sustainable rangeland management (Banks 2001) as well as increased production (Williams 1996). Accordingly, by the end of 2003 of around 70% of China's usable rangeland was leased through long-term contract, where 68% was contracted to individual households and the rest to groups of households or to villages (Yan *et al.* 2005: 32).

In the Tibetan Autonomous Region the process started in 1994 but government and local informants have reported that it was not until 2002 that the land management laws were implemented and then with a provision permitting grasslands to be distributed not just at the household level, but also at village levels (Bauer 2005: 66). Yan et al. (2005: 45) argues that while evidence of individual management exists, it encompasses only 10% of household in the northwestern parts (i.e. TAR) and up to 30-40% on the eastern parts (Sichuan and Gansu Province). In contrast, Yangzong (2006: 6) argues that the process of dividing grassland among households initially started in 2001 in TAR and that 89.2% of the usable rangeland has been allocated to individual households, covering 64.85% of the pastoral households. As for the Aru Basin, Yangzong (2006: 31) writes that for one township encompassing the Aru Basin, grassland allocation to individual households started in June 2005. In this area rangelands were leased to individual household with long-term contracts (50 years); where allocation was based on human and livestock population for 2004. Importantly, the area allocated is kept constant even in the face of population increase or decline (both livestock and human) and when new households are established they are established within already allocated pastures (i.e. by sub-dividing one of the parents' pasture). Each household received a grassland contract certificate and only 5-10% of the total grassland was kept as commons to be used during crisis (Yangzong 2006: 41-2).

Importantly, late in 2006 fences were being erected as a result of 'on-the-spot renegotiation of Rutok vs. Gertsé County grazing rights and boundaries' (Fox *et al.* 2008: 13) as well as fencing of herding group boundaries (Fox *et al.* 2009: 185).

From a general point of view, Bauer (2005: 61, italics added) argues that '[d]uring both feudal and collective periods, pastoral movement was facilitated by large, herd-owning institutions. One of the effects of de-communisation [both in terms of livestock and rangeland privatization], then, was to reduce the spatial range of movements undertaken by pastoral households'. Nevertheless, it should be noted that the practical implementation of the HRS has varied on the QTP where both collective and individual user rights are currently co-existing. On the eastern parts of the QTP (Maqu County, Gansu Province), for example, 96% of all available pasture had been contracted to households by 2003 (Cao *et al.* 2011: 219). Nevertheless, in practice two management patterns are present, i.e. multi-household where grassland is jointly managed by two or more households without clear delineation between individual household pastures (reflecting the traditional pastoral production model) and single-household management where grassland is separately managed by individual households and where fences are erected between individual pastures (Cao *et al.* 2011: 217). Similarly, in Ningxia Muslim Autonomous Region the pasture contract system was established in the middle of the 1989s and implementation occurred in several stages from issuing contracts to villages to issuance of pasture contracts to individual or two or more households (Ho 2000a: 393). In a survey of 284 household, Ho (2000a: 393) found, however, that only 7% of had been given rangeland contracts while 62% had never heard of it. In Xinjiang the official policy is that the collective or state own grasslands but user rights are contracted to households. Accordingly, on paper 94% of useable rangelands were contracted to individual households by 1999 (Banks 2003: 2133). Nevertheless, while contracts specifying the area of different seasonal pastures available to individual households have been issued, in practice this has not resulted in the delineation of household boundaries and previously established group tenure arrangements have largely persisted (individual tenure occurs primarily in hayfields and croplands, see Banks 2003: 2133). Nevertheless, use of rangelands has been privatized to some degree and the fact that contracts, whether they are issued to individuals or groups of individual, creates fixed boundaries that are difficult to change (see also Li and Huntsinger 2011).

The rationale for privatization can be found in a 'traditional' view that exclusivity of use promotes human welfare and sustains natural processes without resulting in overexploitation of natural pastures because property rights works as an incentive for sustainable land stewardship (Thompson *et al.* 2008: 26). While privatization in itself may not be a cause for concern, privatization is often followed by *exclusivity* in terms of use which can be viewed as increasing rangeland fragmentation – defined as the dissection of natural systems into spatially isolated parts (Galvin 2009:186). As a consequence, pastoralists' access to resources that vary over time and space have been limited (cf. Galvin *et al.* 2008). This despite the fact that the ability for pastoralist and livestock to move freely to spatially variable resources on commonly held pastures has 'proven to be a highly persuasive counterargument to privatization' because it results in lower vulnerabilities (Turner 2011: 478).

The effect of possible fragmentation have been documented in Mongolia, where changes have been undertaken that aims at enlarging administrative boundaries (Ojima and Chuluun 2008). This policy is being implemented to counter the negative effects of privatization after the collapse of the Soviet Union. With privatization the Soviet initiated collective state farms were dissolved, and ownership of livestock was again in private hands. The suspension of collective farms reduced mobility as the costs of moving was carried by individual households rather than the collectives (Ojima and Chuluun 2008). As a consequence, land-use areas decreased resulting in the destabilization of the pastoral system by forcing them to utilize resources within fragmented units (Ojima and Chuluun 2008).

Fragmentation thus decreases pastoral mobility which may again have negative effects. It has, for example, been noted in Africa that areas with concentrated use are marked by severe and spreading degradation leading in turn to lower herd productivity, increased herd size requirements for meeting household needs, which again accelerates environmental degradation and the probability of poverty (Schwartz 2005). Privatization and fragmentation has resulted in an increased concentration of both people and livestock and as such resulted in increased grazing intensification and consequently rangeland degradation (Williams 1996). As for China, while one rationale for privatizing rangeland is to counter several decades of open access and rangeland degradation (Cao *et al.* 2011), evidence from Inner Mongolia indicates the opposite: since no obvious changes in rainfall or ecology has been observed during 1982–2000, Li et al. (2007: 465, italics added) argues that '[…] it is reasonable to assume that the *property rights regime change [i.e. privatization] might be one of the reasons for grassland degradation*' and may in fact have accelerated degradation (Taylor 2006). In a study comparing changes experienced by pastoral societies and their environments in Mongolia, Inner Mongolia, Xinjiang, Buryatia, Chita, and Tuva, Sneath (1998: 1148, italics addded) found that the highest levels of rangeland 'degradation was reported in districts with the lowest livestock mobility; in general, *mobility indices were a better guide to reported degradation levels than were densities of livestock*.'

Feedback: climate change, fragmentation and mobility

Concurrent with land tenure changes that reduce pastoralists' ability to respond to environmental variability by moving away from affected areas, environmental variability has both increased during the last few decades and is predicted to increase in the future due to climate change (cf. Coumou and Rahmstorf 2012). In Africa, for example, climate change is predicted to increase the variability and frequency of rainfall and it has been estimated that the proportion of arid and semiarid lands is likely to increase by 5-8% by the 2080s (Galvin 2009: 192). For Mongolia, regional climate predictions anticipate an increase in areas affected by droughts and in the frequency of extreme events (Marin 2010). As for Tibet, global climate models, under a middle of the road estimate of future emissions, projects that a 4°C warming is likely to occur over the Tibetan Plateau during the next 100 years (e.g. Kang *et al.* 2010). As for precipitation, models project increased precipitation during winter and several models also simulate increased precipitation during other seasons (cf. Næss 2012).

In terms of observational evidence, Galvin (2009: 193) argues that severe events are occurring with increased frequency and longer duration on the worlds' dry grasslands. Blackwell (2010) argues that in the Greater Horn of Africa drought has now become the norm rather than the exception. While previously pastoralists experienced one major drought every decade coupled with minor occurrences every 3-4 years, droughts now occur every year (Blackwell 2010). For Mongolia the long series of droughts and winter disasters of 1999-2002 have been argued to be unprecedented (Marin 2010). Importantly, droughts have almost doubled in frequency during the last 60 years and the worst droughts on record (>50-70% of the country) have occurred during the last decade (Marin 2010: 171). As for the Tibetan Plateau, evidence suggests that both precipitation and temperatures are increasing. Air temperatures on the Tibetan Plateau have been rising by 0.4-0.6°C during the last 50 years, a trend that is similar to that of China in general (cf. Næss 2012). Evidence also suggest that glaciers are declining and research has showed that more than 80% of glaciers in western China have retreated, losing 4.5% of their combined area coverage. Similarly, both the extent and depth of the permafrost on the Tibetan Plateau is known to have changed and a preliminary estimate for the reduction of the permafrost area on the plateau is 100 000 km^2 from 1970s to mid-1990s (cf. Næss 2012). As for extreme events, in 2007 western parts experienced nine continuous days of gale force wind and dust storms, a 20-year record high. In June of the same year, western areas reported an average temperature increase of 1-2°C and an average decrease in precipitation by 20-90% (Anonymous 2009: 15). In January 2002 western parts of the Tibet were hit by blizzards and experienced snow depths around 120 cm (Anonymous 2009: 15).

Considering the negative impact that environmental hazards have been found to have on livestock survival and reproduction, climate change thus represents a significant threat for pastoralists. Nevertheless, it has been argued that by reinforcing the traditional strategies pastoralists have developed to deal with climate variability in addition to introducing newer techniques, the economic, social, and cultural well-being of pastoral societies can be supported in the face of climate change (SCBD 2009:48). Moreover, a case has been made that pastoralists are in a unique position to tackle climate change due to extensive experience managing environmental variability in marginal areas (Nori *et al.* 2008) and it has been argued that the ability to withstand environmental shocks is a *defining* feature of pastoralism (Hatfield and Davies 2006: 27).

Mobility may be a case point: depending on the spatial scale of extreme weather events, mobility may provide pastoralists with recourse from the most detrimental effects of climate change because they may be able to move away from the affected areas. From a general point of view it has been argued that it is not climate change by itself that is problematic for pastoralists but rather '[…] the limitations imposed on pastoral coping and development strategies, especially their ability to move and to access critical resources in different territories' (Nori *et al.* 2008: 3). Consequently, it may not be mobility *per se* that fails, but rather mobility in increasingly fragmented landscapes. Rather than helping to alleviate possible problems related to climate change, governmental policies that increase rangeland fragmentation thus exacerbate them by reducing the pastoralists' ability to respond flexibly to spatio-temporal variation (see e.g. Galvin 2009, Nori *et al.* 2008 for a similar argument). In effect fragmentation can be argued to intensify negative density dependence: High densities of both people and livestock may exacerbate the negative impacts of environmental hazards such as drought. At low densities it may be possible to move away from affected areas and animals may not be weakened because of resource competition (high density has been found to have a negative effect on livestock body mass, e.g. Clutton-Brock *et al.* 1996). At high density, the situation changes: while it may still be possible to move away from areas experiencing environmental induced shocks, the benefits may be reduced since surrounding areas may be utilized by others. In general terms, livestock are limited by how both environmental conditions (climate) and negative density dependence affect body mass: small individuals are: (1) less likely to reproduce; (2) give birth later; and (3) produce less viable offspring that are more prone to starvation and predation (cf. Bårdsen and Tveraa 2012). Evidence from Africa indicates that while mobility may be beneficial for pastoralists leaving drought affected areas, it is not so beneficial for pastoralists already inhabiting areas used as drought refuges: a higher stocking density (as a result of influx of pastoralists escaping drought stricken areas) led to heightened competition for forage and subsequent starvation for resident livestock (Nkedianye *et al.* 2011).

In short, since it has been argued that at higher densities the negative effect of climate is stronger (e.g. Bårdsen and Tveraa 2012) policies that exacerbate the negative effects of density dependence may result in a positive feedback between climate and density dependence that may have dramatic consequences for pastoralists.

CONCLUDING REMARKS AND MANAGAMENT IMPLICATIONS

Fernandez-Gimenez and Le Febre (2006: 343) argues that by minimizing environmental degradation and reducing competition for resources, mobility reduces social conflict between user groups. From a general point of view, Turner (2011: 475-6, italics added) argues that '[l]ivestock mobility should not be seen as an end in itself but a *means that will benefit rangeland ecology, livestock productivity, and agropastoral risk management'*. Accordingly, Nkedianye et al. (2011: 2) argues that mobility as a positive factor for pastoralists has attained the status as a *paradigm* and is also the oldest described drought coping strategy. It has been argued that fragmentation of heterogeneous grazing areas has as one of its consequences that overall landscape productivity decreases as the ability to move according to temporal and spatial variation is reduced (cf. Galvin *et al.* 2008). Consequently, management policies that increase rangeland fragmentation should be looked upon with care, as it has been demonstrated in several pastoral areas that rather than decrease overexploitation of grazing areas, privatization accompanied by reduced mobility has exacerbated overgrazing. Furthermore, scenarios for future climate change generally predict an increased average, variance and even a changed distribution of important climatic variables like precipitation and temperature (e.g. Rowell 2005, Sun *et al.* 2007) and may thus exacerbate pastoral production risk. While a case has been made that pastoralists are in a unique position to tackle climate change due to extensive experience managing environmental variability in marginal areas (Nori *et al.* 2008), climate change together with management policies that reduce pastoral flexibility may have dramatic negative consequences for pastoralists because of a positive interaction between density dependence and climate variability, i.e. increased density dependence due to privatization may very well exacerbate the negative impacts of climate. To understand the effects of climate change on nomadic pastoralists it is thus necessary to move beyond the simplistic dichotomy of characterizing pastoral system as *equilibrial* (density dependence: livestock and pastures are regulated by grazing pressure) or *non- equilibrial* (density independence: livestock and pastures are limited by external factors such as climate) and look at the interplay between density dependent and density independent factors (see Little *et al.* 2001a:151 for a similar sentiment).

For Tibetan pastoralists, however, this may be a moot point. While in Mongolia authorities attempt to counter the negative effects of fragmentation by enlarging administrative and territorial units since this may increase flexibility (Ojima and Chuluun 2008), the People's Republic of China's official policy seems to be to permanently resettle the nomads (Ptackova 2011, Isom 2009). Initiatives (like 'retire livestock, restore pastures') aim to break the link between pastoralists and the land on which they make a living (Harris 2010) because *only* the complete elimination of livestock (for varying number of years) can restore rangeland productivity and reverse rangeland degradation (Harris 2010). While mobility as a buffer against environmental risk cannot be considered as panacea, comparative evidence indicates that decreasing pastoral mobility is a very bad idea indeed.

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FIGURES

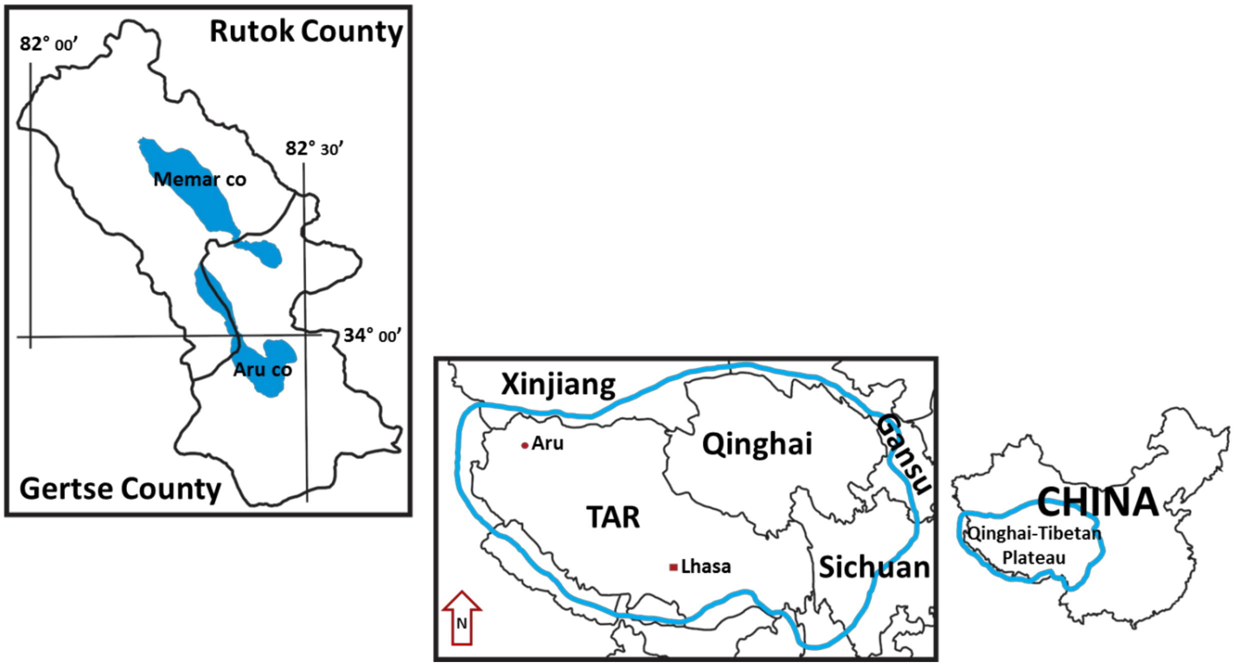

Figure 1. The ~2 300-km^2 Aru Basin study area within Qinghai-Tibetan Plateau (part pertaining for Aru adopted from Bårdsen unpublished, while rest adopted from Harris 2010). Two administrative districts divide the basin's grazing areas: Gertse and Rutok County (Næss 2003).

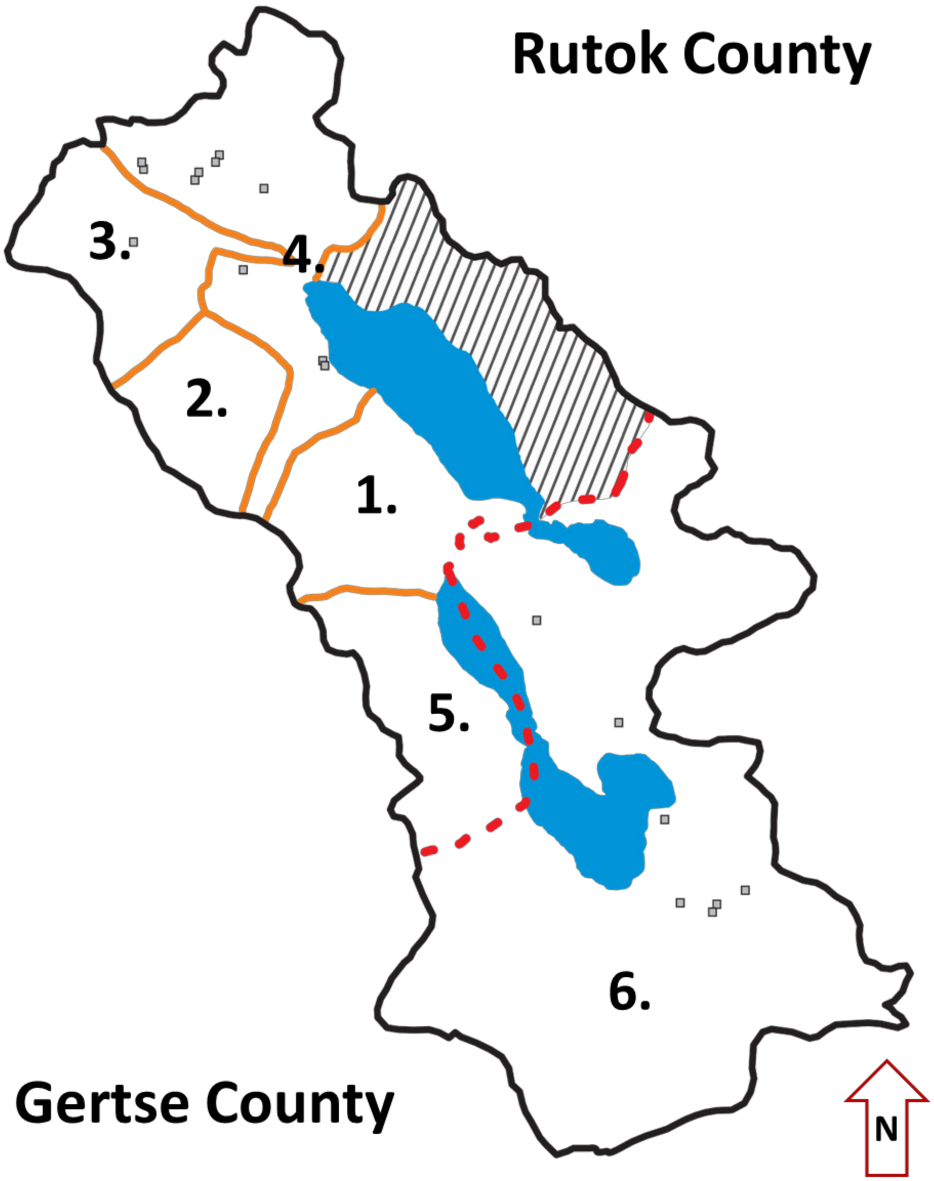

Figure 2. Showing the different seasonal grazing areas in the Aru Basin. *Rutok County*: (1) summer grazing area, (2) late summer and early autumn grazing area, (3) autumn grazing area, (4) winter grazing area, and (5) summer grazing area for nomads utilizing the basin during summer only. *Gertse County*: (6) no seasonal distinct grazing areas. Dotted line indicate border between Rutok and Gertse County. Squares show winter houses, while vertical hatched area is not utilized due to the presence of poisonous grass and lack of water. Figure adopted from Næss (2003: 105).

APPENDIX A

The tragedy of the commons

The term 'tragedy of the commons' refers to the problem that common pool resources, such as pastures, can easily be overused if user/property rights are not well defined (cf. Hardin 1968, Ostrom 1998). If use of common pastures is not regulated herders will maximise their own interest by adding more and more animals to the common grazing land because the cost of adding additional animals (e.g. overgrazing, degradation) is shared among all herders while the benefit adding additional animals (e.g. increase risk buffering) is attached to individual herders (cf. Hardin 1968, see also McPeak 2005, Næss and Bårdsen 2010). The presence of a 'tragedy of the commons' on QTP is justified with the perceived notion of increasing land degradation caused by increased livestock numbers, and a decline in the area of rangeland due to reclamation (Ho 2000: 241). According to Harris (2010: 3), in 1999 the State Environmental Protection Agency estimated that one-third of China's grassland was degraded, but in a very short time the figure that is often cited increased to 90 %.

Tables

Table A1. Average number of people and animals per household from different locations on the Qinghai-Tibetan Plateau (if present, *n* refers to number of households).

Location	People	Yak	Sheep	Goat	SEU[1]	SEU per person	Year	Source
Aru Basin (*n* = 22)[2]	5.0	14.0	173.0	88.0	322.2	64.4	2001	Næss (2003: 76)
Shenchen Township (*n* = 323)	4.6	10.0	147.1	85.1	273.7	59.7	2001	Yangzong (2006: 21)
Nyima	5.4	13.6	220.0	144.0	417.6	77.3	1993	Miller (2000: 92)
Shuanghu	5.8	18.2	282.0	107.0	469.3	80.9	1993	Miller (2000: 92)
Amdo County	5.3	45.0	189.0	25.0	436.5	82.4	1993	Miller (2000: 93)
Naqu County[3]	5-6	30-35	60.0	20.0	253.0	42.2-50.6	1993	Miller (1999: 19)
Takring Township[4]	~5	31.0	38.0	12.0	203.8	40.8	1999	Miller (2001)
Dangmo Township[4]	~5	30.0	52.0	15.0	215.5	43.1	1999	Miller (2001)
Namtsho (*n* = 22)	NA	44.0	168.0	36.0	420.4	NA	NA	Clarke (1987: 77)
Xixangpangma (*n* = 42)	NA	48.0	215.0	215.0	648.5	NA	NA	Clarke (1987: 77)
Hongyuan	5.3	85.0	7.3	0.0	432.3	81.6	1996	Miller (2000: 94)

[1] SEUs are calculated on the basis that one adult sheep is 1 SEU, 1 adult yak equals 5 and 1 adult goat equals 0.9 SEUs (Miller 2000: 88). Miller (2000: 88) argues that a family with less than 25 SEU per person would not be able to meet basic needs.

[2] Based on data for 2001 alone, for numbers for other periods see Næss (2003: 43-6) for details.

[3] For a typical family, 35 yaks used in calculations

[4] An average nomad family has about 5 people (Miller 2001).

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