Carrying capacity dynamics, livestock commercialisation and land degradation in Mongolia's free market era[1]

Dietz, A.J.[a], Amgalan, E.[b], Erdenechuluun, T.[c], Hess, S.[d]

[a] Professor of Human Geography, University of Amsterdam and scientific director CERES, Utrecht University, The Netherlands; corresponding author (a.j.dietz@uva.nl)
[b] Director Centre for Policy Research, Ulaanbaatar Mongolia
[c] Researcher Centre for Policy Research, Ulaanbaatar Mongolia, and University of Mongolia, Dept. of Economics
[d] Institute for Environmental Studies IVM, Free University Amsterdam

Abstract

The dramatic consequences of the severe winters and droughts between 1999 and 2002 drew world-wide attention to Mongolia's important livestock sector and its extensive – and growing - nomadic pastoralists. Much of the focus in this regard was put on the impacts of the change from communist rule to a free market regime. In a recent section of the journal '*Development and Change'* 35(1), co-ordinated by Robin Mearns, these consequences are discussed extensively. However, concepts like ´nature´, ´market´, and ´degradation´ are used as container concepts, without much empirical specificity. A recent research project run by Mongolian and Dutch researchers applied models of carrying capacity dynamics, and caloric terms of trade, to better understand the relationships between the dynamics of nature and the dynamics of the market in this volatile environment. The project applied these models to Mongolia as a whole, and to two case study areas: Ugtaal in the north, and Gurvansaikhan in the south. The analysis shows the importance of policy attention for livestock commercialisation. A large majority of herders simply do not have enough animals to sustain themselves in the traditional way. They are either forced to combine subsistence livestock-keeping with a variety of other jobs, or they can choose to become more market-oriented herders. If they do this wisely, they can increase their incomes, improve their health, and maintain the pastures. However, this depends on renewed forms of land and water management institutions preventing the few rich (and partly absentee) herders from over-utilising the pastures to the detriment of their poorer, and more market-oriented, fellow pastoralists.

PREM Working Paper: 05/10

Keywords: Pastoralism, carrying capacity, caloric terms of trade

Date: 2 June 2005

---

[1] This publication is a result of a study financed by the Netherlands Directorate General for International Co-operation of the Ministry of Foreign Affairs, as part of the PREM research programme, co-ordinated by IVM (Institute of Environmental Studies, Free University Amsterdam, Poverty Reduction and Environmental Management; project "Pastureland degradation and poverty among herders in Mongolia"), other researchers were Wietze Lise (IVM), and Byamba Purev (CPR).

Table of Content

Acknowledgements

The authors would like to acknowledge funding from the Poverty Reduction and Environmental Management Project administered by the Institute for Environmental Studies (IVM) at Vrije University, The Netherlands.

Poverty Reduction and Environmental Management (PREM)

PREM aims to deepen and broaden the exposure of economic researchers and policy advisors in developing countries to the theory and methods of natural resource management and environmental economics. It is envisaged that this will encourage effective policy change in developing countries with the joint goals of poverty reduction and sustainable environmental management.

This Working Paper Series provides information about the scientific findings of the PREM projects. All publications of the PREM programme, such as working papers, press releases and policy briefs are available on the website:
www.prem-online.org

Institute for Environmental Studies
Vrije Universiteit
De Boelelaan 1087
1081 HV AMSTERDAM
The Netherlands
Tel. +31 (0)20-5989 555
Fax. +31 (0)20-5989 553
E-mail: prem@ivm.vu.nl

1. The Mongolian livestock crisis

After the collapse of communist rule in Mongolia in 1991, the demise of the livestock collectives resulted in individual (household-based) livestock ownership, and unclear range management institutions. Between 1991 and 1998, the livestock enterprise rapidly expanded, partly assisted by relatively good weather conditions, and partly by the many new entrants in the livestock economy. The latter was a result of the de-industrialisation of the urban economy (for more details see Mearns, 2004). In 1990, Mongolia had 25.9 million domesticated animals. By 1998, this had grown to 32.9 million, an increase of 27%. The increase was not a result of a growing number of sheep: the number of sheep even decreased slightly, from 15.1 million to 14.7 million. The number of camels also decreased: from 0.5 million to 0.4 million. The growth was due to increasing numbers of horses (from 2.3 million to 3.0 million), cattle and yaks (from 2.8 million to 3.7 million), and particularly goats (from 5.1 million to 11.1 million). The rapid growth in the number of goats was the result of a strong demand for goats' hair, cashmere (NSOM 2001).

Between 1990 and 1998, the weather conditions in Mongolia were rather favourable. Compared to the 1980s, rainfall was higher, and the winters less severe (Batjargal, 2000). The carrying capacity of the Mongolian grazing lands improved, and the growing livestock population could, on average, be accommodated by these improved grazing conditions. However, changes in livestock mobility and range management styles, as well as unclear grazing institutions under privatised livestock management regimes, began to create carrying capacity tensions in some areas. Where water wells were no longer maintained, some grazing areas were abandoned, resulting in condensed grazing in other areas[2].

Between 1999 and 2002, winter conditions deteriorated (with extreme *dzud*s[3]) and spring/summer rainfall declined. In combination, this had quite disastrous consequences for Mongolian livestock and for the expanded herder community. It was estimated that 12 million animals died nationwide, and out of an estimated 190,000 herding households in 1998, 11,000 families lost all their animals (Danker, 2004, p. 26). By December 2002, the total number of animals had gone down to only 24 million (back to the level of the late 1980s). Compared to the situation in 1998, losses were most severe amongst horses (-64%) and cattle (-49%), and least severe amongst goats (only -18%).

To calculate overall changes in the livestock sector, we need a measure to give relative weights to various species of animals. Mostly these are based on the feed needs of animals in terms of biomass consumption.

In Mongolia there are two ways of calculating animal weights: i) sheep units and ii) *bod*s, the latter being the equivalent of one horse, cow or yak (see Mearns, 1993) (Table 1)[4].

---

2 According to CPR (2003) out of 41,600 wells operational in 1990, only 30,900 were still operational in 2000.

3 *Dzud* is the Mongolian term for those severe winters in which livestock cannot find enough grazing food.

4 This comes close to a measure used in tropical livestock science: the Tropical Livestock Unit (TLU). Here, camels are 1 TLU, cattle 0.7 and sheep and goats 0.1. If we use cattle as unity, this means camels are 1.4, sheep and goats 0.14. The biggest difference with *bod*s is in the valuation of goats. In the literature we also find other determinations of *bod* values.

Table 1 Calculating livestock weights.

Type of animal	In Sheep Units	In Mongolian stock units (bods)
Sheep	x 1	x 0.14
Goat	x 0.9	x 0.1
Horse	x 7	x 1
Cattle/Yak	x 6	x 1
Camel	x 5	x 1.5

If we re-calculate the changes in Mongolian livestock numbers in 1990, 1998 and 2002, using these two valuation measures, we can see the overall impact (Table 2). Based on sheep units, it can be concluded that the 26% gains during the 1990-1998 period were completely lost between 1998 and 2002: by -44% compared to 1998, and by -29% compared to 1990. In relative terms, the composition changed dramatically. There was a much lower emphasis on horses and camels, more or less stable shares of cattle and sheep, and a much higher presence of goats. Based on Mongolian stock units the trends are comparable, with a slightly less dramatic relative increase in goats.

Table 2a Livestock numbers in Mongolia (1990, 1998, 2002) in livestock equivalents (numbers of animals (in sheep units, x million).

Species	1990		1998		2002	
	number	%	number	%	number	%
Horses	15.8	29	21.0	30	7.6	20
Cattle/Yak	17.1	31	22.2	32	11.3	29
Camels	2.7	5	2.0	3	1.3	3
Sheep	15.1	27	14.7	21	10.6	27
Goats	4.6	8	10.0	14	8.2	21
Total	55.3	100	69.9	100	39.1	100

Table 2b Livestock numbers in Mongolia (1990, 1998, 2002) in livestock equivalents (number of animals (in Mongolian stock units, or bods, x million).

Species	1990		1998		2002	
	number	%	number	%	number	%
Horses	2.3	27	3.0	29	1.1	19
Cattle/Yak	2.8	33	3.7	35	1.9	33
Camels	0.8	9	0.6	6	0.4	7
Sheep	2.2	26	2.1	20	1.5	26
Goats	0.5	6	1.1	10	0.9	16
Total	8.6	100	10.5	100	5.8	100

2. Livestock and land: on the notion of carrying capacity

With regard to the land's livestock carrying capacity, range management scientists use 'rules of thumb' to determine if there is a chance of land degradation through over-utilisation. Over-utilisation can result in further degradation (erosion, diminishing biomass production, desertification), and hence a downward spiral of deteriorating conditions for livestock production. Often, these rules of thumb are rather crude and static. The Mongolian Research Institute of Animal Husbandry estimated that, for Mongolia as a whole, the carrying capacity of the combined pastures was 69.2 million sheep units (CPR, 2003). This would mean that in 1998 there was a slight over-utilisation of the combined pastures in the country, but that both in 1990 and certainly in

2002 there was a lot of unused capacity. The same institute used detailed regional assessments of the various administrative units in Mongolia to arrive at the following conclusion: in 2002, western *aimags* exceeded their carrying capacity by 80%, while eastern *aimags* had 55% excess pasture (Danker, 2004, p. 14). Before 1991, when collective livestock enterprises used the same type of carrying capacity assessments, managers would base their decisions on livestock growth and sales on these data. The story goes that after 1991 not much collective management was left, and livestock growth and decline was left much more to the whims of nature. And nature was harsh between 1998 and 2002, resulting in a restoration of the pre-1991 situation. Based on meteorological information, the UNEP (2002) estimated that 78.3% of the pastures were degraded in 2001, of which 22.1% were "severely to highly degraded". Given the severity of weather conditions in 2001, this is quite understandable; but it should not be seen as a 'stable' assessment of Mongolia's pastureland conditions.

Current thinking in range management circles takes more notice of the variability of range conditions, and recognises that livestock management on a collective level needs to be based on more complex models. These include:

- The availability and accessibility of range lands (this includes looking at the distribution of water points, and the relative differences in security, social and legal barriers, and labour availability for movements to remote areas; Fernandez-Gimenez and Batbuyan (2004) provide interesting data about changes in livestock mobility and pasture use, and its impact, between 1995 and 1999);
- The relative usefulness of different types of biomass for livestock utilisation, which partly depends on range management institutions;
- The weather conditions. Lower-than-average (spring and summer) rainfall translates into more than proportional decreases in feed availability (including hay production for winter storage)[5]. In Mongolia specifically, differences in the severity and length of winters translates into different stress levels.

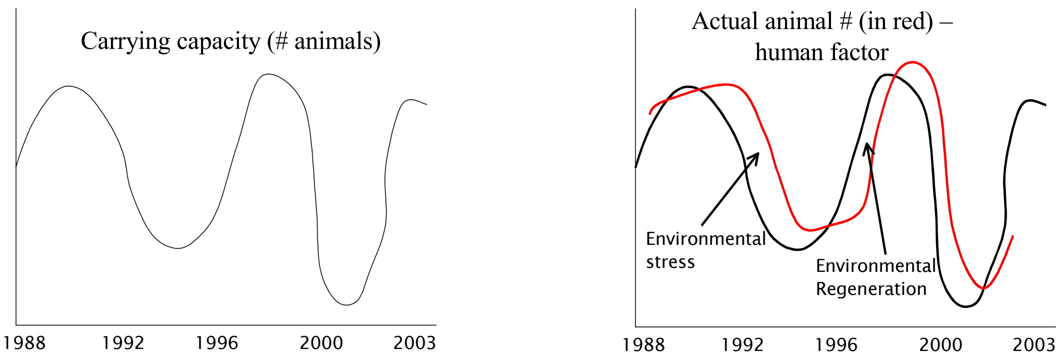

Figure 1 Variable carrying capacity over time and the realised herd sizes.

By performing this dynamic analysis of the carrying capacity, we try to establish the cause of environmental degradation in Mongolia.

---

5 With the existing summer evapotranspiration levels, and spread of rainfall during the year, we estimate that Mongolia has i) arid conditions (P/ETP< 0.25) when annual rainfall is below 250 mm and ii) semi-arid conditions (0.25<P/ETP<0.40) when rainfall is between 250 and 400 mm. Thus, we assume that for Mongolia as a whole, annual evapotranspiration is in the range of 1000 mm.

It is very possible that the range conditions of 1998 could easily have 'carried' the livestock population of the then almost 70 million sheep units; however, the range conditions of 2001 were not even sufficient to 'carry' half of it.

For Mongolian pastoralists, the quantity of feed that can be stored for severe winter times is of crucial importance. In the past, hay making areas were collectively managed and quite extensive; industrial feed production was also considerable. During the adverse weather conditions of the 1998-2002 period, the production of winter feed was hampered. According to the National Statistical Office of Mongolia (2003) land allocated to natural hay production for winter storage decreased from 1.2 million to 0.8 million ha (out of ca 129 million ha of natural pasture), between 1989 and 2002. Green fodder and silage production more or less disappeared, and manufactured feed production was more than halved.

3. Livestock, land and people: the notion of simple Population Supporting Capacity

The concept of 'carrying capacity' generally deals with the relationship between land (pasture) and livestock. The concept of 'population supporting capacity' (PSC) goes a few steps further. In its most simple form it translates the calculated carrying capacity, or the observed numbers of animals, into the number of people that can be fed from the land on a subsistence basis. For the time being, it considers "land" as a spatial unit, without linkages to the outside world.

The model that one needs to calculate these simple PSC assessments should contain:

- Information about the number and composition of the livestock, that can be (or is) sustained by the land;
- Actual or calculated information about the milk production that can be used for human consumption;
- Actual or calculated information about the meat production that can be used for human consumption;
- Calculated information about the food needs of the people, who should be fed on animal produce.

In Mongolia there are currently 2.5 million people (NSOM-website; January 2004). The Mongolian Centre for Food and Nutrition in Ulaanbaatar uses an average required Caloric consumption of 2,600 Cal for an average Mongolian or 950,000 Cal per annum. With between 40 (in 2002) and 70 (in 1998) million sheep units, an average Mongolian theoretically has access to between 16 and 28 sheep units per capita.[6] What is the annual caloric production of one sheep unit? That depends on a) how much milk is produced for human consumption, and b) how much meat is available. As i) a 'sheep unit' is a composite of very different types of animals, ii) the composition of the herd/flock has changed over time, and iii) production of meat and milk per animal is a function of good and bad years, one needs to do rather complicated combined calculations to provide a useful answer. But let us simplify matters:

i) Suppose all livestock was cattle (one head of cattle = 6 sheep units);

ii) Suppose 40% of all cattle in the national herd were milk-producing cows;

---

6 The –unrealistic – assumption is made here that all inhabitants of Mongolia have to be fed on the proceeds of the livestock sector.

iii) Suppose each milk-producing cow produced 400 litres of milk in a year, with 800 Cal/litre;

iv) Finally, suppose there was a 20% slaughter off-take per annum, available for 125 kg meat per animal, at 1800 Cal/kg[7].

This would mean an annual per capita availability of 340,000 Cal of milk, and 120,000 Cal of meat (in the situation of 16 sheep units per capita, as in 2002), which would be 49% of the average food needs. Or it would mean an annual per capita availability of 595,000 Cal of milk and 210,000 Cal of meat (in the situation of 28 sheep units per capita, as in 1998), or 805,000 Cal, which would cover 85% of all food needs on milk and meat alone[8]. Assuming that Mongolians use all types of animals for both milk and meat production, we can apply the same calculations to horses, camels, goats and sheep; however, we take into account that meat and milk calories differ (and milk and meat volumes might also differ relative to cattle). Table 3 gives some details, based on data from the Centre for Food and Nutrition in Ulaanbaatar. We can estimate that herds only consisting of horses would mean 68% of cattle-based food needs provisioning, sheep would mean 132%, and goats 81%[9].

Table 3 Food values of milk and meat for different species of livestock in Mongolia.

Livestock species	Calories per kg of meat (1st grade)	Calories per kg of milk
Horses	1671	487
Cattle	1872	798
Yaks	1057	Nd
Camels	1046	730
Sheep	2029	1146
Goats	1057	736

Knowing the livestock composition in 1998 and in 2002, we can calculate the average level of food self-sufficiency for the Mongolian population as a whole. Compared to the basis of our calculations (where the livestock would only consist of cattle), the 1998 and 2002 figures can be made more realistic if we take the actual livestock composition into account. For 1998, this would mean a downward correction to 0.93 x 85% food self-sufficiency; hence 79% sufficiency based on livestock food products. For 2002, this would remain as 49% food self-sufficiency based on livestock food products.

We can conclude this section about simple Population Supporting Capacity models (based on existing herds) by stating that the Mongolian people as a whole could almost be adequately fed on the basis of animal produce in 1998, when the total herd and flock was at its maximum. However, the population supporting capacity of the herd and flock in 2002, after the rather disastrous years between 1999 and 2002, was not at all sufficient; it couldn't even meet half of all food needs. To

---

7 We roughly base these assessments on recent FAO data on Mongolian livestock production (http://www.fao.org).

8 In bad years, like 2002, milk production was probably lower than calculated (as droughts diminish milk gifts), and meat production was probably higher (as adverse weather forces premature slaughter, although at lower than normal caloric values). In good years, like 1998, the reverse is true, so the overall effect is a bit more extreme.

9 This was calculated by taking the weighted difference between calories for meat and milk. E.g. for horses: horsemeat has 90% of beef calories and horse milk has 60% of cow milk calories: 90% x 120,000 + 60% x 340,000 = 312,000 Cal., which is 68% of the calories for an exclusively cattle herd.

avoid starvation, Mongolians had to find alternative food sources outside the livestock sector. Grains and potatoes are an obvious alternative, either produced in Mongolia or imported from abroad (Russia, China).

Table 4 Adjusting milk assessment to livestock composition in 1998 and 2002.

Livestock species	in 1998	in 2002
Horses	30% x 68% = 0.20	20% x 68% = 0.14
Cattle	32% x 100% = 0.32	29% x 100% = 0.29
Camels	3% x 81% = 0.02	3% x 81% = 0.02
Sheep	21% *132% = 0.28	27% x 132% = 0.36
Goats	14% * 81% = 0.11	21% x 90% = 0.19
in cattle equivalents	= 0.93	= 1.00

They can be exchanged for livestock export products, like cashmere. There are growing numbers of people and stagnating numbers of livestock in Mongolia, partly because of a stagnating or even deteriorating carrying capacity of the pasture lands (e.g. due to inadequate land and water management institutions). As such, a more structural solution could be the exchange of livestock products for grain from abroad. At lower levels of scale, the same strategy could be followed (and is being followed) by livestock specialists. These specialists exchange part of their livestock (produce) for grains and potatoes, which then become more important ingredients of pastoralists' diets. This strategy only works when the terms of trade between livestock products and crops are favourable.

4. Market-based population supporting capacity models, based on positive (caloric) terms of trade between livestock products and crops

Almost everywhere in the world exchange values for a calorie of meat or milk are higher, and often much higher, than the exchange values for a calorie of grains or other crops. Let us look at the evidence for Mongolia. In Mongolia (Ulaanbaatar), in 2003, a sheep with 25 kg of meat could be sold for between 18,000 and 25,000t (t = tugrigs). In addition, 3,000t was paid for the skin, but we will overlook that. In total, one kg of sheep (carcass) could be sold for between 720 and 1000t. As one kg of sheep has about 2,000 Cal, it can be concluded that 1,000 Cal. of sheep could be sold for 360 to 500t. Milk could be sold for between 300 and 500t per litre (and one litre of milk has about 800 Cal.). Hence, 1,000 Cal. of milk could be sold for between 375 and 625t.

If a pastoralist selling (sheep) meat or milk buys wheat, he/she would be paying 110t per kg (of 3,500 Cal.); hence 1,000 Cal. of wheat could be bought for 31t. The caloric terms of trade for a pastoralist would be very favourable: he/she would exchange at a caloric exchange rate of between 1:20 (milk for wheat, high milk price), and 1:12 (meat for wheat, low meat price). It would be much less rewarding, though, to buy potatoes instead of wheat. In Ulaanbaatar, one kg of potatoes could be bought for 280t, and potatoes have 877 Cal/kg; hence 1,000 Cal. of potatoes cost 319t. The caloric exchange rate for pastoralists selling meat or milk and buying potatoes is only between 1:1.1 and 1:1.9.

Using official price data for Mongolia (Ulaanbaatar) for the period between 1996 and 2002, we can look at the trends in these price levels, and in the resulting caloric terms of trade. We restrict ourselves here to (sheep) meat, (cow) milk, and wheat. For wheat/meat we use a caloric conversion factor of 3500/2000 (= 1.8), and for wheat/milk of 3500/800 (= 4.4) (see Table 5). We can conclude that before the adverse weather conditions the caloric exchange rates for meat or milk for wheat were good (the lowest being 1:7.5 for milk versus wheat in 1996). However, the caloric exchange rates became much better during the 1998-2002 period. Wheat prices more or less stagnated, but prices for meat almost doubled, and for milk more than doubled, compared to 1996. So despite a livestock crisis in terms of carrying capacity, and in terms of numbers of animals (and hence subsistence production potential for pastoralists), the market potential for pastoralists became much better. Theoretically, this more than offset the decrease in overall livestock numbers. In addition, one of the non-food livestock products, goat-based cashmere, also experienced improved (world market and also local) prices[10]. Macro-economic data (NSOM, 2003) indeed show that the economic value of (marketed) crop production increased from 43 billion *tugrigs* in 1999 to 76 billion *tugrigs* in 2002; this indicates a combination of higher crop prices, and higher crop consumption. However, the overall value of gross livestock output decreased from 384 billion *tugrigs* in 1999 to 286 billion *tugrigs* in 2002. This indicates that the macro-economic impact of the livestock crisis was not offset by making good use of the potentially high caloric terms of trade. Herders have not yet adjusted to the necessity to change from a basically subsistence-based livestock system to a more market-oriented livestock system.

Table 5 Caloric exchange rates for meat, milk and wheat in Mongolia, Ulaanbaatar, 1996-2002.

	1996	1997	1998	1999	2000	2001	2002
meat t/kg	569	612	699	603	705	1002	1038
milk t/litre	207	306	401	308	449	519	446
wheat t/kg	120	115	101	92	102	115	120
meat/wheat	4.7	5.3	6.9	6.6	7.0	8.8	8.7
CToT meat/wheat	8.5	9.5	12.4	11.9	12.6	15.8	15.7
milk/wheat	1.7	2.7	4.0	3.4	4.4	4.6	3.8
CToT milk/wheat	7.5	11.9	17.6	15.0	19.4	20.2	17.7

5. A specific look at two research areas: Ugtaal and Gurvansaikhan

Two areas were specifically studied:

1. Ugtaal *sum,* in the north (with more rainfall -part of what is called the 'forest steppe'-, and more severe winter conditions);
2. Gurvansaikhan *sum,* in the south (with less rainfall, close to the Gobi desert, and less severe winter conditions). A recent contribution in Development and Change also deals with Gurvansaikhan, but focuses on the area in and near the Gobi Gurvansaikhan National Park (see Bedunah and Schmidt, 2004).

Let us first look at the weather data for the 1990-2002 period. Data on rainfall and temperature are available every 10 days in the period from 1990 until 2002 (with the exception of the second half of 1993). These data are presented graphically in Figure 2 and Figure 3. These figures show the climatic differences between the two regions. While precipitation is much higher in Ugtaal than in Gurvansaikhan, the winters in Ugtaal are also more severe than in Gurvansaikhan. While winter precipitation is generally low in Gurvansaikhan (indicating a relatively low snow depth) the amount of winter precipitation in Ugtaal is higher.

[10] Cashmere could be sold for 6,363t/kg in 1996, but the price increased to 35,835t/kg in 2000. In 2001, the price declined to 20,055 t/kg. Goat skins could be sold for 2,063 t/piece in 1996, and for 2,908t in 2001 (but ca 4,400t in 2000); horse hides increased from 3,464t/piece in 1996 to 6,998t in 2001; cattle hides from 5,366t in 1996 to 8,815t in 2001, and sheep skins from 3,175t in 1996 to 3,054 in 2001(via 4,501t in 1998) (NSOM 2003).

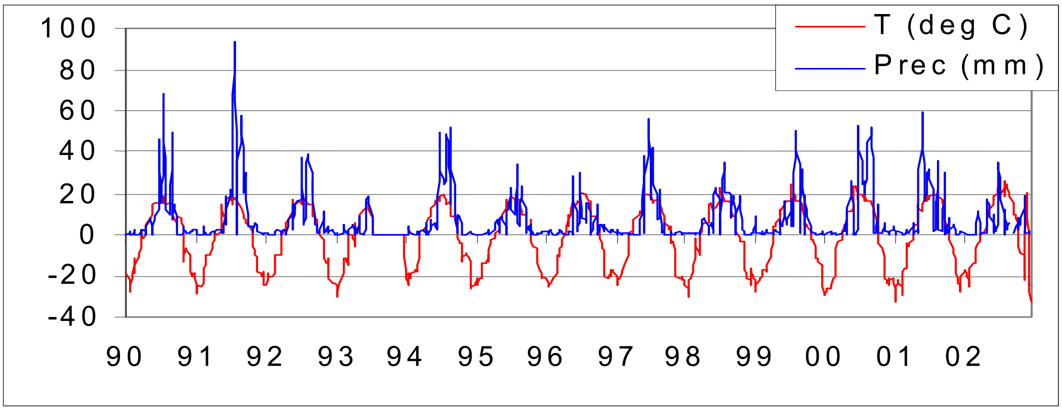

Figure 2 Rainfall and precipitation in Ugtaal from 1990 until 2002.

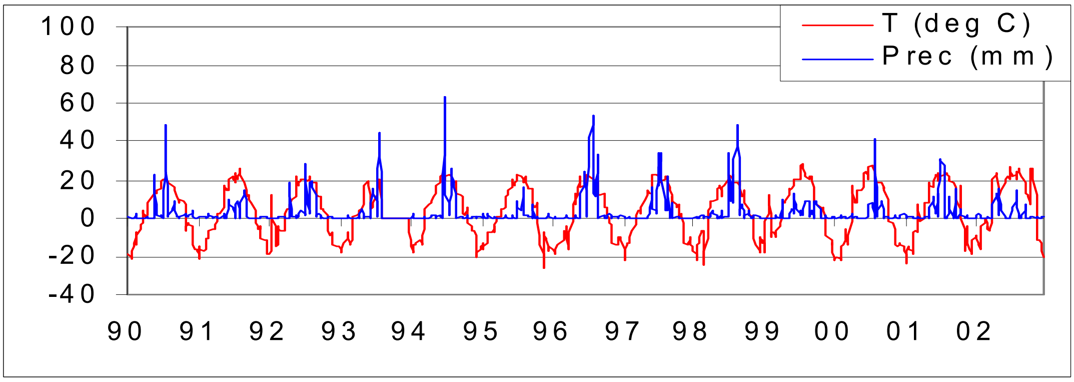

Figure 3 Rainfall and precipitation in Gurvansaikhan from 1990 until 2002.

In order to study the differences in weather patterns between Ugtaal and Gurvansaikhan in more detail, please refer to Tables 6 and 7. These tables present the average temperature per year, and temperature averages for winter months and summer months. In addition, the total level of precipitation is given. In order to obtain an estimate of snow-depth in these years, we considered 10-day periods with temperatures below –2 degrees Celsius as snow accumulation periods. The total amount of precipitation in that period is assumed to be snow. We present this estimate for the whole winter (from around October until early April). We have calculated an aridity index for all years, based on precipitation data for the vegetative period[11], divided by a proxy for evapotranspiration for that period[12].

---

11 We define the vegetative period for grasslands as all ten-day periods with an average temperature of 5°C for that ten-day period. This is based on data provided by the Meteorological Service of Mongolia for Ugtaal and Gurvansaikhan. For both areas, the vegetative period is between 140 and 180 days, normally sometime between April and September.

12 This was based on the assumption that the average temperature for the vegetative period (see previous note) x 100 gives an adequate evapo-transpiration assessment.

Table 6 Average temperature, precipitation, aridity and snow-depth in Ugtaal from 1990 until 2002.

	Average temperature °C			Precipitation -	Snow-depth	Aridity
	Jan-Dec (annual)	Veg. period	Oct-Mar	Veg. Period (mm)	Oct-Mar	(P/ETPv)[13]
1990	-0.2	12.6	-25.8	314.6	21.4	0.25
1991	-1.4	13.0	-25.1	335.1	15.9	0.26
1992	-0.8	13.7	-26.9	244.0	29.8	0.18
1993	NA	NA	NA	NA	NA	NA
1994	-1.1	12.4	-27.1	332.7	18.6	0.27
1995	-0.5	13.6	-25.9	165.0	14.0	0.12
1996	-1.2	13.8	-25.9	147.3	24.1	0.11
1997	0.0	13.3	-25.9	249.4	8.4	0.19
1998	-0.1	13.1	-30.0	207.8	39.1	0.16
1999	-0.5	14.7	-26.4	286.7	7.9	0.20
2000	-1.1	14.8	-34.1	372.1	23.2	0.25
2001	-1.0	15.1	-25.7	254.1	20.0	0.17
2002	0.8	16.1	NA	139.0	NA	0.09
average	-0.6	13.9	-27.1	254.0	20.2	0.18

In Ugtaal, rainfall was mostly in the semi-arid range before 1995 (>0.25) and in the arid range afterwards, with particularly severe drought conditions in 2002 and in1995-1996. We find the most extreme snowfall in the winter 1998-1999, which was accompanied by low temperatures and was a well-known dzud year. The winter of 2000-2001 was also harsh. In addition, the winter of 1992-1993 was severe. We have no data for the winter conditions of 2002, but from other sources it is clear that the winter of 2002/3 was also severe.

In the period since 1990, rainfall in Gurvansaikhan has continuously been below 200 mm. in the vegetative period, and in 1999, 2000 and 2002 it was below 100 mm. But the situation was even worse in 1991 and 1995. In aridity terms, the most severe years were 1991, 1995, 1999, 2000 and 2002. Inspection of the derived snow-depth in the table shows that there were no particularly extreme *dzud* conditions in Gurvansaikhan, although winter temperatures were far below average in 2000/2001.

[13] The aridity assessment was based on precipitation data (P, in mm) for the vegetative period and a proxy for evapotranspiration for that vegetative period, based on temperature data, (ETPv = T in degrees Centigrade times 100). For Ugtaal, we can see that it varies between 0.09 and 0.27, with an average for the period 1990-2002 of 0.18; this is below the cut-off point for semi-aridity of 0.25. For Gurvansaikhan, we can see that it varies between 0.03 and 0.12, with an average for the period of 0.07; this is in the hyper-arid range (below 0.10).

Table 7 Average temperature, total precipitation and snow-depth in Gurvansaikhan from 1990 until 2002.

	Average temperature °C			precipitation in veg. Period (mm)	Snow-depth Oct-Mar	Aridity (P/ETPv)
	Jan-Dec (annual)	veg. period	Oct-Mar			
1990	3.2	14.7	-16.3	145.8	14.1	0.10
1991	3.2	17.1	-12.6	62.3	1.9	0.04
1992	4.3	16.5	-15.5	105.7	3.4	0.06
1993	NA	NA	NA	NA	NA	NA
1994	3.9	15.8	-13.9	178.1	9.0	0.11
1995	3.1	15.8	-19.6	47.1	7.2	0.03
1996	2.2	15.6	-15.1	183.1	5.4	0.12
1997	4.3	15.3	-16.8	156.3	3.8	0.10
1998	3.7	15.1	-12.2	153.6	7.4	0.10
1999	5.5	16.9	-15.9	73.1	5.1	0.04
2000	4.0	17.3	-18.7	71.4	5.6	0.04
2001	4.3	16.5	-13.0	116.5	5.5	0.07
2002	6.9	17.8	NA	73.8	NA	0.04
average	4.1	16.2	-15.4	113.9	6.2	0.07

If we compare the severity of drought and dzud conditions for 1998-2002 with the period as a whole, we find that in Ugtaal 1998 was a drought and severe dzud year, in 2000 there was another severe dzud, followed by a somewhat warmer summer in 2001 and another severe drought in 2002. In Gurvansaikhan, 1998 was not a real problem year, but 1999 and especially 2000 were very problematic drought years (worsened by an additional dzud in 2000) while 2002 was also a severe drought year. We give a summary in Table 8. We also add a tentative assessment of the variations in carrying capacity in sheep units. This is based on the aridity index for the two areas, and on a hypothetical carrying capacity model which combines the aridity index with environmentally sustainable sheep unit numbers[14]. Figure 4 shows the carrying capacity model itself, and the results in the two *sums* are depicted in Figure 5. In Figure 5, we also add an assessment of optimal numbers of sheep units, based on actual grass yields in a few sample areas in the two regions. These were collected by the Range Management Department of the Government of Mongolia.

However, multiplication of these data for the area as a whole has been done rather conservatively; as a result, we regard the overall figures as being too low. It is interesting that the trend based on grass yield samples very much resembles the theoretical trend based on our aridity assessment.

[14] This is based on Dietz (1987, p. 83 ff), which in turn was based on an analysis of carrying capacity assessments for African rangelands, derived from aridity indices. The most sophisticated source was KSS 1982 (pp 46-47). The model is based on an empirically derived assumption that if aridity (P/ETP) is 0.1, the carrying capacity would be 0.5 sheep units per hectare (or 0.05 tropical livestock units); if aridity was 0.25, the carrying capacity would be 2.5 sheep units per ha (or 0.25 TLU); if aridity was 0.4, the carrying capacity would be 10 sheep units per ha (or 1 TLU). This is based on the overall assumption that one sheep unit would have a live-weight of 30 kg, and a total annual feed consumption of 300 kg. It also assumes that less than 15% of all biomass production is consumable in the hyper-arid area, between 15 and 25% in the arid area, and between 25 and 40% in the semi-arid area.

Table 8 *Drought and dzud conditions in Ugtaal and Gurvansaikhan in 1998-2002, compared to the average situation in 1990-2002. An assessment of theoretical carrying capacity compared with actual livestock numbers in sheep units (SU) is also provided*[15].

Variable	Ugtaal					Gurvansaikhan				
	1998/ 99	1999/ 00	2000/ 01	2001/ 02	2002/ 03	1998/ 99	1999/ 00	2000/ 01	2001/ 02	2002/ 03
Temp. Veg period		+	+	+	++		+	++		++
Precip. Veg period	-				--		--	--		--
Aridity assessment	.16	.20	.25	.17	.09	.10	.04	.04	.07	.04
Aridity	-				--		--	--		--
DROUGHT	Yes	No	No	No	Yes!	No	Yes!	Yes!	No	Yes!
Temp. Oct-Mar	-		--		NA			--		NA
Snow-d. Oct-Mar	++		+		NA	+				NA
DZUD	Yes!	No	Yes!	No	No	(Yes)	No	Yes	No	NA
SU/ha	1.1	0.8	1.3	1.2	0.5	0.5	0.3	0.2	0.4	0.2
Th. CC x 000 SU [16]	132	96	156	144	60	265	159	106	212	106
Based on sample	114	96	128	136	54	90	60	80	130	10
Actual SU x 000	156	145	147	109	98	276	281	139	154	173

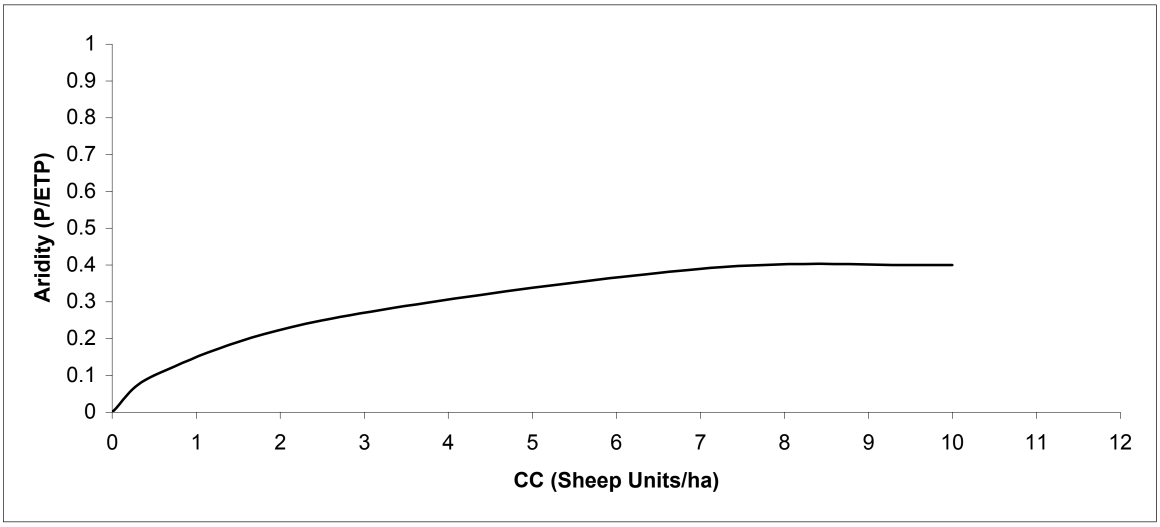

Figure 4 *Carrying capacity model.*

During the worst rainfall years in Gurvansaikhan (e.g. 2000 or 2002) the estimated potential sheep units per ha was around 0.2. In the best rainfall years (e.g. 1996) the carrying capacity increases to

15 In this theoretical assessment of the Carrying Capacity the accessibility of rangelands is not taken into account. As was stated in Section 3, a shortage of water points, social and legal boundaries, a shortage of labour availability (amongst other factors) can reduce the amount of usable pasture. As we know, livestock mobility reduced and rangeland management (e.g. the maintenance of wells) deteriorated after 1990. This resulted in condensed grazing in some areas, particularly around *sum and aimag* centres (where some social services are provided), and around the remaining water points. The actual Carrying Capacity of the two *sums* is therefore probably lower.

16 We use 120,000 hectares of realistic pasture land for Ugtaal and 530,000 hectares of realistic pasture land for Gurvansaikhan.

0.7 sheep units per ha. The average 'static' figure for 1990-2002 as a whole is 0.4 sheep units/ha. For Ugtaal, the worst rainfall years (e.g. 2002) have a carrying capacity of close to 0.5 sheep units per ha, and the best rainfall years (e.g. 1994) close to 3 sheep units/ha. The average 'static' figure for Ugtaal is 1.4 sheep units/ha.

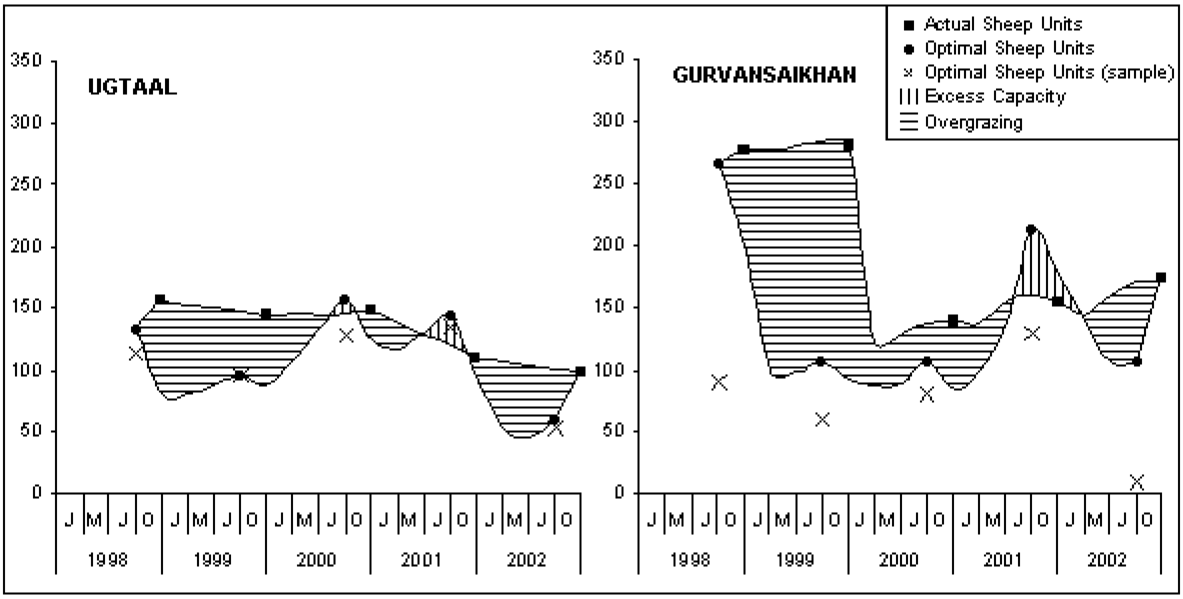

Figure 5 Actual and estimated optimal livestock numbers (Sheep Units x 1000) in Ugtaal and Gurvansaikhan.

In Ugtaal, 3,500 people (in 667 families) live on 154,800 ha: 2.3 inh/km². Ugtaal is 150 km west of Ulaanbaatar. The area had 110,000 hectares of pasture in good condition in 2003, 23,000 hectares of degraded pastures, and 1,200 hectares of hay-making land. There were also 15,000 hectares of arable land (partly available as stubble land after harvests), and 8,000 hectares of forest, with some additional feed availability. The *sum* governor still maintains some land as reserve pastures. The number of animals (not sheep units) decreased from 64,000 in 1995 (when it was at an all-time high), to 51,000 in 2002 after the death of many cattle and sheep due to the *dzuds.* In actual sheep units the situation deteriorated from about 150,000 in 1999-2000 to 100,000 in 2002. Compared to the theoretically derived assessment of sustainable numbers of sheep units, the situation between late 2000 and early 2002 was close to the optimum level (with some excess grazing capacity around October of both years). In the period before late 2000, and after early 2002, there were more sheep units than the theoretical carrying capacity. In 2003, the carrying capacity was locally judged to have been exceeded by 20%, and indeed patches of degraded pasture were visible. However, there were also areas with excellent pasture conditions. Socially, the situation had dramatically worsened though. In 2002, out of 667 families, 105 no longer had animals (and this was rare before 1998). Yet, 65 families had more than 200 animals (but this was more than in 1998): a clear case of asset polarisation.

In Gurvansaikhan, 2,600 people (in 121 families) live on 542,000 hectares of land. Almost all of this is pasture land. Hence the population density is extremely low: only 0.5 inh/km². Gurvansaikhan is 300 km south of Ulaanbaatar. In this *sum*, the impact of the 1999-2002 droughts and the 2000-2001 *dzud* has been severe. There were 50% losses in horses and 82% losses in cattle in 1999/2000 alone (in sheep units, numbers fell from 289,000 to 142,000). However, after 2000, livestock numbers began to increase again, to a level of 176,000 sheep units in 2002. In Gurvansaikhan, stock numbers were (far) in excess of optimal (theoretical) carrying capacity in 1999 and

2000. This was due to the adverse conditions, and indeed the slump in livestock numbers brought an adjustment to much lower levels. In 2001, weather conditions improved a bit and so did livestock numbers (which for a few months were below the optimum carrying capacity). However, soon the actual numbers exceeded the optimum numbers. Locally, a minimum herd of 200 animals is regarded as necessary for survival, based on livestock subsistence production. In 2003, less than 44% of all families had more than 200 animals.

For both areas, we may assume that the deterioration of livestock numbers and of local food production conditions caused a food crisis, which could only be solved by importing food from elsewhere. One possibility would be to sell livestock and buy grains, if the caloric exchange rates were good. Let us look at the evidence.

For both areas, we can estimate the trends in caloric terms of trade, based on price level data for various products (adjusted to local circumstances). Horse milk only has 487 Cal/litre, beef 1872 Cal/kg (mutton 2029 Cal/kg), but wheat flour and rice are both calculated as having 3,600 Cal/kg; hence the horse milk/wheat-rice conversion factor is 7.4; the mutton/wheat-rice conversion factor is 1.8; and the beef/wheat-rice factor is 1.9. Table 9 compares 1998 with 2002 for both *sums.*

Looking at the findings for the caloric terms of trade (CToTs) for these two case study regions, we can conclude that in all cases the CToTs improved during the livestock crisis, as expected. However, in Ugtaal, levels were always higher than in Gurvansaikhan. This probably reflects the difference in distance to Ulaanbaatar; with its 1.2 million inhabitants (out of the current 2.5 million Mongolians), this city is the primary centre of demand. However, it is also obvious that the CToT levels in and around Ulaanbaatar were much better, both in 1998 and in 2002, compared in Ugtaal and Gurvansaikhan. For meat exchanged for wheat, the CToT in 1998 was almost 4 times better around the capital city than in Ugtaal and almost six times better than in Gurvansaikhan. In 2002, the relative situation of Gurvansaikhan had improved a bit. For horse milk exchanged for wheat (based only on data for Gurvansaikhan) the difference, compared to in Ulaanbaatar, is less extreme.

Table 9 Caloric terms of trade in Ugtaal and Gurvansaikhan, 1998 and 2002

	Ugtaal		Gurvansaikhan	
	1998	2002	1998	2002
Beef t/kg	550	(900)	380	700
Mutton t/kg	600	(850)	400	700
Horse milk t/l	NA	NA	450	550
Wheat flour t/kg	320	380	350	400
Rice t/kg	450	420	420	400
beef/wheat	1.7	2.4	1.2	1.8
CToT beef/wh	3.2	4.6	2.3	3.4
beef/rice	1.2	2.1	0.9	1.8
CToT beef/rice	2.3	4.0	1.7	3.4
mutton/wheat	1.9	2.2	1.1	1.8
CToT mut/wh	3.4	4.0	2.0	3.2
horse milk/wheat	NA	NA	1.3	1.4
CToT milk/wh	..	..	9.6	10.4

6. Conclusion

Growing difficulties for increasing numbers of herder families to feed themselves on a subsistence basis, and rising stress on natural resources, can be countered (at least partly) by making much better use of urban, and export markets. These markets can be provided with livestock products in exchange for grains, which then become more important in pastoralists' diets. In other pastoral societies under rapid transition, inherent trends to change diets can be supported by government agencies. This can be done, for instance, by stimulating food trade (e.g. giving credit and training to grain providers) and by stimulating dietary changes (e.g. by modifying school dinners or by including recipes in the popular media). In Mongolia, some changes are already visible. Although official figures on the composition of the Mongolian diet (NSOM 2003) are rather doubtful[17], it is quite clear that cereals have indeed become important during the last few years; they currently represent 42% of all calculated caloric food intake. Meat and milk follow with 30% and 23% respectively. Potatoes only have a minimal share (3%), as do vegetables (2%). One can expect further developments along this road of ever more market-oriented pastoralism, for those herders who continue herding. A small percentage of herders can choose to remain 'traditional' subsistence-oriented herders. But the vast majority of herders simply do not have enough animals to sustain themselves in the old ways. This partly explains the dramatic increase in poverty among Mongolian pastoralists (see Mearns, 2004). They are either forced to combine subsistence livestock-keeping with other jobs, or they can choose to become more market-oriented herders. If they do this wisely, they can increase their incomes, improve their health, and maintain the pastures. However, this depends on renewed forms of land and water management institutions preventing the few rich (and partly absentee) herders from over-utilising the pastures to the detriment of their poorer, and more market-oriented, fellow pastoralists.

References

Batima, P. & Dagvadorj, D. (2000). *Climate Change and its Impacts in Mongolia*. Ulaanbaatar: National Agency for Meteorology, Hydrology and Environment Monitoring and JEMR Publishing.

Batjargal, Z., Dagvadorj, D. & Batima, P. (eds.) (2000). *Mongolia National Action Programme on Climate Change*. Ulaanbaatar: National Agency for Meteorology, Hydrology and Environment Monitoring and JEMR Publishing.

Bedunah, D.J. & Schmidt, S.M. (2004). Pastoralism and Protected Area Management in Mongolia's Gobi Gurvansaikhan National Park. *Development and Change, 35(1),* 167-191.

CPR Centre for Policy Research (2003). *PREM Mid-term Report*. Ulaanbaatar: CPR.

Danker, M. (2004). *Hörs-Gazar. Cry of a Woken Bull. Changes in Pastoral Life and Pastureland Management in Mongolia*. Amsterdam: Vrije Universiteit (unpublished M.Sc Thesis, as part of PREM programme).

Dietz, A.J. (1987). *Pastoralists in Dire Straits. Survival Strategies and External Interventions in a Semi-arid Region at the Kenya/Uganda border: Western Pokot 1900-1986*. Amsterdam: University of Amsterdam PhD Thesis (published as Netherlands Geographical Studies).

Fernandez-Gimenez, M.E. & Batbuyan, B. (2004). Law and Disorder: Local Implementation of Mongolia's Land Law. *Development and Change, 35(1)*, 141-166.

[17] Calculated diets for the 1999-2002 period would consist of an average of 507,000 Cal/capita, which would be much below the necessary food intake of the 'required 950,000 Cal./cap.' Probably a lot of consumption is not measured or taken into account. So figures on the composition of food intake should also be interpreted with care.

KSS (Kenya Soil Survey) (1982). *Exploratory Soil Map and Agro-Climatic Zone Map of Kenya 1980*. Nairobi: KSS.

Mearns, R. (1993). Territoriality and Land Tenure among Mongolian Pastoralists: Variation, Continuity and Change. *Nomadic Peoples, 33*, 73-103.

Mearns, R. (2004). Sustaining Livelihoods on Mongolia's Pastoral Commons: Insights from a Participatory Poverty Assessment. *Development and Change, 35(1)*, 107-140.

NSOM, National Statistical Office of Mongolia, and World Bank Mongolia (2001). *Participatory Living Standard Assessment 2000*. Summary report prepared for the Donor Consultative Group Meeting, Paris, May 15-16, 2001.

NSOM (2003). *Raw data* collected by CPR for PREM. Ulaanbaatar (unpublished).

UNEP (2002). *Mongolia: State of the Environment.* Nairobi: UNEP.