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REPORT ON THE USE OF REMOTELY SENSED DATA IN THE ANALYSIS OF CONTEMPORARY PASTORALISM IN INNER ASIA

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Introduction

The data used for this report consists of a series of monthly GVI scenes for Inner Asia, totalling 36 scenes from January 1986 to December 1988.[1] The scenes were received in Idrisi format, which permitted our Project to superimpose the digitised national political boundaries of Russia, Mongolia and China, and the regional boundaries of the Tuva Republic, Buryat Republic and Chita Oblast (inside Russia) and the Inner Mongolia Autonomous Region and Xinjiang-Uighur Autonomous Region (inside China). See Maps 1 - 36.

In the future it should be possible to use Idrisi to make further analyses of such remotely-sensed data in relation to digitised maps produced by our Project of (1) pasture-type and land-use categories, (2) population densities, (3) livestock densities by species, and other materials.

Annual vegetation cycles and pastoralism

It might be expected that the pattern of livestock density over the steppes of Inner Asia (see Map 37) would correspond closely to the vegetation index in the winter months.[2] The GVI data for the three years of 1986-8 shows interestingly that

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1 According to our contract with JRC, during 1994 the MacArthur Project should have done analysis of NOAA data on Inner Asia. This was not possible for a number of reasons. We were supplied with only eleven of the 34 scenes we ordered, and JRC was not able to fulfill its part of the contract by processing these scenes. We were also held back by the fact that our data-manager left the MacArthur Project unexpectedly in autumn 1994.

2 Note that the Map of Livestock Density in Inner Asia (Map 37) refers only to open grassland. Areas of forest, plough agriculture, and bare rock have been excluded.

this is not the case. The livestock density broadly corresponds, on the other hand, with the summer vegetation index (see especially the regions of Western Mongolia and Xinjiang). How is this to be explained?

For all Inner Asian pastoral systems the amount of winter vegetation is crucial, since this sets a lower limit on the number of livestock that can be sustained throughout the year. The numbers of animals that can be kept on the summer pastures is significantly higher. This situation is affected, however, by human pastoral management systems, whereby livestock are fed during winter with hay gathered during the summer months.

In the cold and arid conditions of Inner Asia the short summer period of four months directly influences the curve of fodder production by diminishing the period of active growth of the vegetal cycle and increasing the period of biomass loss due to respiratory activity. The grasses remain dependent on such climatic conditions. Nevertheless, Inner Asian pastures can sustain significant herd densities. A calculation from Ujumchin in Inner Mongolia showed the average grass production over the eight winter months to be 600 kilos dry weight per sq. hectare, whereas during the four months of summer it is around 1,000 kilos. The summer figure can be further enhanced by re-growth after grazing or cutting. If a high cut is taken, the grass can experience two further periods of growth. Thus the forage reserve of one hectare of pasture in summer can reach up to six times that of the identical unit during the winter (Hell and Quéré 1993: 250-251). Pastoralists in all regions of our Project make some use of hay cut during the summer to feed the livestock during the winter. Such usage, supplemented by planted fodder, is more intensive in Russia and Inner Mongolia than in Mongolia. However even in Mongolia hay is widely used and transported across from the north-east to the south and west. This explains why the winter GVI data does not correspond to the pattern of livestock density, as would be the case in a pastoral regime reliant only on natural grazing. Rather, the correlation observed, taking the area of the Project as a whole, is between livestock density and **total annual fodder availability**, the great majority of which is produced during the summer. This is one significant effect which can be seen by using remotely sensed data.

One possibility that needs to be considered is that high intensities of livestock, introduced for economic reasons, might cause over-grazing, and that this would have such a deleterious effect on the grassland that it would show up on the vegetation index. There is high livestock density in eastern Inner Mongolia (between approximately 110° and 118° Long and 43° and 47° Lat) which extends as far as the political boundary between China and Mongolia. This can be seen in Map 37 (Total Livestock Density in Inner Asia, 1990), which shows a marked difference in the standard stocking units per Km^2 on either side of the border. This corresponds with the recent Chinese management strategy that makes intensive use of hay resources. Ecologically similar steppes on the other side of the border support a much smaller density of livestock. It is significant that the GVI on either side of this border for the months of active plant growth **does not reflect** the markedly higher livestock densities on the Chinese side. This suggests that, in very general terms, the high density of livestock in Inner Mongolia is not sufficient to cause gross and widespread reduction in vegetation such as would appear on the 8 km data.

In central-western Mongolia there is a high density of livestock, particularly of horses, cattle and camels (as opposed to sheep and goats). The density reaches 90 - 140 SSUs per Km^2, which is comparable with the high levels in China and Russia. The GVI summer maps show that even such high densities do not cause reduction in vegetation. This can be seen from the fact that the GVI rating for central-western Mongolia is similar to that for the more northerly region of Hubsgol (approx 100° Long and 50° Lat) which has a much lower density of livestock - though analysis at this stage is complicated by the fact that Hobsgol has more forest cover than the central-western regions of Ar-Hangai and Obor-Hangai.

Evidence of severe over-grazing would be suggested if the GVI pattern during the summer months were to differ markedly from the precipitation distribution. Map 38 (average annual precipitation in Inner Mongolia) and Map 39 (average annual precipitation in Mongolia) demonstrate, however, that the precipitation and summer GVI distributions are in broad correlation in the steppelands of Inner Asia.

The GVI data reveals one important exception to this correlation. This is in the regions of Chifeng and Jirim in Inner Mongolia (a broad swathe from south-west to north-east covering approximtely 118° - 122° Lat and 42° - 44° Long and 120° - 128° Lat and 44° - 46° Long). This area shows a markedly low summer GVI rating in each of the three years 1986-8 (see Maps 7, 19 and 31). However, the average annual rainfall of this area does not differ from that of surrounding regions. Meanwhile, Map 37 shows that livestock density is extremely high in the region. There is independent evidence that the percentage of pasture area which is degraded is higher in Chifeng and Jirim than elsewhere in Mongolia.

Table 1
Extent of pasture degradation in Inner Mongolia Autonomous Region by Prefecture, 1988[3]

Prefecture	Percentage degraded	Percentage of degradation which is: light	medium	heavy
Chifeng	84	37	34	29
Hulun Buir	14	59	34	7
Hinggan	25	40	26	34
Jirim	67	32	27	40
Shilingol	49	48	42	10
Ulanchab	26	64	24	12
Ihejao[4]	74	39	45	19
Alashan	9	53	45	2
Bayannuur	32	70	29	1

3 Source: Longworth and Williamson 1993: 82, using statistics provided by IMAR Animal Husbandry Bureau.

4 Ihejao (Ordos) is an arid area where pastoralism has long since been largely supplanted by plough agriculture. This caused extensive degradation in the 1950s-60s, though land reclamation programmes are now under way..

In addition, the regions of Jirim and Chifeng have been used for widespread agriculture for several decades. These prefectures have significantly higher population density than the neighbouring pastoral districts of Hulun Buir and Hinggan.

Table 2
Agriculture, population and pasture in certain prefectures of Inner Mongolia , 1990[5]

Prefecture	Pop. density (person/km2)	Total arable land ('000 mu)	Total pasture ('000 mu)	Usable pasture
Chifeng	47.86	12,075	82,402 (63%)	69,620
Jirim	65.1	10,680	68,542 (76%)	55,705
Hulun Buir	12.5	9,060	169,470 (46%)	149,706
Hinggan	30.9	5,955	45,511 (51%)	39,183

The combination of all this evidence suggests that land degradation, probably caused by a combination of over-grazing and inappropriate agriculture, is the explanation for the low summer GVI rating in the given area shown in Maps 6-8, 16-19 and 29-31. Agriculture on its own does not appear in the form of a low GVI rating, as can be seen from the crescent of high index points near the city of Hohhot, the capital of Inner Mongolia (approximately 107° Long 41° Long). This crescent occurs in a region of intensive agriculture. See Maps 7,8, 18,19, 31,32 and discussion below.

Regional diversity and nomadic migrations.

The summer GVI maps indicate a significantly wide range in the vegetation index of closely adjacent regions in Western Mongolia and Xinjiang. The range is

[5] Source: Longworth and Williamson 1993: 81, using statistics provided by IMAR Animal Husbandry Bureau.

from 31 to 143 index points within a few miles (see for example Map 6). It is clear that these variations correlate with the micro-climates of the high mountain ranges of the Altai, which run in a North-West to South-East direction. In the flat eastern steppes of Mongolia, on the other hand, there are no such rapid alternations of high / low vegetation. Our Project has evidence that the Western region has a greater diversity of plant types and associations than that found in the east (Simukov 1935). Furthermore, research conducted by the MacArthur Project has shown that nomadic migrations are significantly longer in Western Mongolia and Xinjiang (the Altai zone) than they are in the east. In Hovd Sum (Western Mongolia) in 1993 the average length of all migrations during a year was 150 kilometres; in Altai (Xinjiang, China) the average per year was 380. This contrasts with central Mongolia, Sumber Sum, where the average was 80 kilometres, and Dashbalbar Sum in the far North-East of Mongolia where the average was only 35 kilometres. This suggests that pastoralists are taking advantage of the greater variability in both amount and type of vegetation in the West by making long moves across ecological zones in their annual migrations.

One might ask why the pastoralists do not stay in the better pastures all year round. In Western Mongolia and Xinjiang, where even summer grasses may be sparse (see Maps 7, 19, 30), herders have at least four distinct pastures according to altitude. They go to the highest pastures at over 2,500 feet in summer, to lower pastures in spring and autumn, and again to high pastures at around 2,000 feet in winter. It can be seen from Maps 1, 12, and 24 that the areas which have low ratings in summer have pockets of relatively good vegetation in winter; these correspond to south-facing valleys in the mountain ranges. It thus makes sense for the herders (a) to use high land in summer when there is some grass everywhere (thus saving the grass lower down for other seasons), and (b) again to use high pasture in winter, when sheltered valleys in the mountains preserve relatively good pasture.

An analogous point can be made about another region of our Project. The GVI maps for the three winters of 1986-88 all show interesting variations in the vegetation rating for the Gobi region. The Gobi is the name for the very arid semi-desert region in the south and south-east of Mongolia (approximately 96° - 112°

Long and 44° - 46° Lat). Now it is the **winter** vegetation index for this region which is not as uniform as either the average precipitation (Map) or the altitude. In fact, the relatively uniform summer lack of vegetation in the Gobi, which may be related to heat and lack of precipitation, is followed by winters in which, according to the GVI data, there appears to be more vegetation than in summer. In the context of the rest of the Inner Asian steppe this is an unexpected finding. However, it explains very well the pattern of herdsmen's migrations, particularly in the pre-Revolutionary period. At that time Mongolia was administratively divided into long, thin districts, called Banners, which ran in a north-south direction. The herdsmen were attached to their Banners and could not move outside them. However, the long, thin districts enabled them to cross the steppes and make use of different kinds of pastures at different times of year, specifically to make use of Gobi pastures in winter and more northerly and better-watered pastures in summer.

The remotely-sensed GVI data for the first time gives region-wide evidence of significant pasture resources in the Gobi during winter, which is normally the most difficult season of the year for herders. At the same time, discussion of pastoral migrations allows explanation of the significance of the Gobi-region variations seen in GVI Maps 1-3, 12-15, and 24-26. During the Soviet-influenced period of Mongolian history the administrative boundaries were changed, and herders were confined to smaller, approximately square-shaped administrative units. This meant that long migrations to winter pastures in the Gobi were no longer possible. To cope with this situation, hay fodder was transported to the south of Mongolia from grass-rich regions in the north. The present Report cautiously suggests that had the government retained the previous administrative units and a highly migratory system of herding it might have been able to avoid the expense of providing some of this fodder. However, other socio-economic factors took priority: the provision of services like education, health and retail outlets necessitated having smaller units with more numerous administrative centres. The MacArthur Report by B. Telenged (1995) details the changes in livestock breeding techniques and production goals that generally entailed a reduction in migration.

Points for further investigation

1) A comparison of Map 37 (Total Livestock Density in Inner Asia, 1992) and the GVI maps for the summers of 1986-88 shows that high numbers of animals in the centre of Tuva correspond with a marked low vegetation index in this area (approximately 94° Long 53° Lat). The low GVI rating, in the 63 - 79 band, appears in all three years. The region in question is a low treeless steppe, surrounded by forested hills. A certain amount of extensive, strip-agriculture will fallow is carried out in the area. The reasons for the low GVI summer rating should be investigated.

2) As noted above, there is a crescent of high GVI rated land (in the 143-159 bands) in the area around the city of Hohhot in Inner Mongolia. A similar patch, with even higher summer GVI rating can be observed in the corridor between Ihejao and Alashan in the south (approx. 106.5° Long and 38-39° Lat). The winter GVI ratings for these areas are not markedly different from the surrounding land and may even show lower ratings. We suggest that this pattern indicates the presence of intensive, partially irrigated, agriculture in these areas.

3) The winters of 1986 and 1987 show a markedly lower vegetation rating for the region of south-east Mongolia and central Inner Mongolia than in the winter of 1988 (an area approximately covering 112° - 118° Long and 41° - 46° Lat). The low winter rating might have been caused by prolonged snow cover, which local herdsmen suggest does not necessarily have a deleterious effect on the following summers' growth of grass. However, a dry winter, which would also result in the appearance of low vegetation during January - March, will badly affect the following season's pasture growth. The GVI data shows that the low vegetation winters of 1986 and 1987 were in fact followed by distinctly lower summer vegetal ratings in this same region. This indicates that the low winter ratings of 1986-7 were probably not caused by snowfall but by low precipitation. Some evidence of animal losses in the late 1980s in this region may coincide with poor grass growth in these summers.

Conclusions

Our preliminary analysis suggests that GVI data provides a useful tool in the assessment of pastoralism in Inner Asia. In combination with other materials, such as livestock and population data, and altitude, precipitation and land-use maps, remotely-sensed data on vegetation can provide evidence for conclusions of both a general and a specific kind. GVI data at 8 km resolution is too crude to be used for local studies. However, knowledge of the land-use and migration patterns of herdsmen is important for the interpretation of GVI data.

The main importance of GVI data at this scale is to provide evidence for broad conclusions on the differing patterns of pastoral land-use, and it can aid in the discussion of issues such as over-grazing, soil degradation due to agriculture, and systems of optimal land use. This is relevant to the study of regions with serious problems of environmental damage, such as parts of Inner Mongolia.

This Report has suggested that another very interesting use of GVI data is in analysing the relation between annual migrations and variability of vegetation in mountain regions, and also in arid areas such as the Gobi. In both cases this is particularly interesting with respect to winter levels of vegetation, since the winter has always been seen as a contraint on pastoral development.

REFERENCES

Christian Hell and Philippe Quéré 1993 'Le systeme d'elevage de la banniere Ujumchin de l'ouest, Mongolie-Interieure, China,' Etudes Mongoles et siberiennes, 24, 237-290.

John W. Longword and Gregory J. Williamson 1993 China's Pastoral Region: sheep and wool, minority nationalities, rangeland degradation and sustainable development, CAB International: Wallingford, Oxon and Canberra, Australia.

A. Simukov 1935 'Pastbishcha MHR' (Pastures of the Mongolian People's Republic), Sovremennaya Mongolia, vol 2 (9), 76-89.

B. Telenged 1995 'Livestock breeding in Mongolia,' unpublished report for the MacArthur Project.