THE LIVING PLATEAU

Changing Lives of Herders in Qinghai

Concluding Seminar of the Qinghai Livestock Development Project

Editors

Nico van Wageningen

Sa Wenjun

EU-CHINA

Qinghai Livestock Development Project

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ICIMOD

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FOREWORD

Rangeland ecosystems comprise more than seventy per cent of the land cover of the Hindu Kush-Himalayan (HKH) region, with the vast majority located in the alpine zone of the Qinghai-Tibetan Plateau of China. Most of this vast area is subject to very erratic environmental conditions in terms of climate and forage availability. Although relatively sparse in human population compared to areas where there is more rainfall and where elevations are lower, this area serves as an invaluable forage resource for millions of livestock; and livestock account for a relatively high percentage of the economic output of these regions. The Plateau region also provides important watershed functions and contains a diverse array of flora and fauna. Given the importance of rangelands in the Hindu Kush-Himalayas, the International Centre for Integrated Mountain Development (ICIMOD) initiated the Regional Rangeland Programme in 1999 with the aim of improving understanding of rangeland ecosystems and pastoral production systems, to develop capacities in interdisciplinary and participatory approaches to pastoral development, and to build networks among those working in pastoral regions.

ICIMOD's first contact with the Qinghai Livestock Development Project (QLDP) funded by the European Union was in 1999 when our Rangeland Management Specialist visited the project site in Dari County. Since that time, we have maintained an on-going professional relationship for information exchange with staff of the project. The idea for this book to be published by ICIMOD arose out of our mutual desire to promote the work of the project. Their successes, and the challenges they have faced, are representative of the problems and potentials of the marginal environments of the Qinghai-Tibetan Plateau region. Their experiences provide valuable lessons for those professionals working in pastoral development, and serve as excellent 'fodder' for future innovation and policy.

The publication of this book has been generously funded by the European Union. Although primarily highlighting the outcomes of the QLDP, it also complements ICIMOD's ongoing programme related to rangelands and pastoral development. The lessons offered by the QLDP not only help us to adjust our own programmes, but also provide valuable guidance to our partner institutions that work in similar environments. For ICIMOD it is a great privilege to share these experiences with others in the region.

Dr. J. Gabriel Campbell
Director General

ACKNOWLEDGEMENTS

The editors would like to thank those who have written down their experiences and observations in more than 80 papers and 40 reports — they are mentioned in the lists of references; the colleagues who summarised these documents and inspired their systematic discussion in a three-day workshop; and the participants at the concluding seminar, including officials of institutions for development cooperation between P. R. China and the European Commission, for their critical contributions. And we would like to thank ICIMOD and in particular Camille Richard, Greta Rana, and Sushil Man Joshi for recognising the importance of informing others about this document and then ensuring its publication in a practical and professional way.

ABSTRACT

The Living Plateau is about interventions by a development project for the improvement of the livelihood of sheep and yak herders on the Qinghai-Tibetan Plateau, near the source of China's three main rivers. Between 1995 and 2000, this project facilitated activities of researchers, of provincial, county, and township development officers, of herder representatives, and of teachers of a training institute, aimed at bringing about such improvements.

The outcome of these efforts was critically reviewed at the end of the project, in order to document and share with other projects and organisations, the findings and lessons learnt and the priorities conceived for future action.

The document first takes stock of rangeland and livestock resources and it describes the socioeconomic situation of herders in Guoluo Prefecture. It then summarises the outcome of field trials and technical interventions in the area of rangeland rehabilitation, the control of rodents, rangeland revegetation, seeded perennial forage and cereal fodders, the control of parasites in yak and sheep, and the control of young stock diseases. It further addresses the experiences of disseminating findings through extension services, and it reviews extension education and methodology development, including experiences with participatory rural appraisals. Finally it proposes priorities for future initiatives in research, extension, and general support to development.

ACRONYMS AND ABBREVIATIONS

BAH	Bureau of Animal Husbandry (Qinghai Province)
'Black Beach'	area of land where the topsoil has eroded and grass cover has disappeared leaving bare soil or only a few small herbs
CEU	Commission of the European Union
DOFTEC	Department of Foreign Trade and Economic Cooperation (Qinghai Province)
FHH	female-headed household
FW	fresh weight (of plants)
GIS	geographic information system
HYSAH	Huang Yuan School of Animal Husbandry
MOFTEC	Ministry of Foreign Trade and Economic Cooperation (Central Government)
NDVI	normalised difference vegetation index
PMU	project management unit
QAASVM	Qinghai Academy of Animal Science and Veterinary Medicine
QLDP	Qinghai Livestock Development Project
RMB	Ren Min Bi, the Chinese currency
RS	remote sensing
TA	technical assistance
mu	local unit of area: 15.15 mu = 1 hectare
Yuan	the largest unit of Chinese currency 1 yuan = US$ 8.26

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Chapter 1
INTRODUCTION

1.1 About This Document and The Seminar It Refers To

The Qinghai Livestock Development Project (QLDP) was implemented by Qinghai Province's Bureau of Animal Husbandry (BAH) from 1996 to 2000, with technical assistance from the European Commission (EC). At the end of August 2000 a 'Concluding Project Seminar' was held in the provincial capital, Xining. The seminar reviewed the work executed by the project-related researchers and field workers and, based on the lessons learned from project execution, prioritised future interventions. This document gives an overview of the technical content that was discussed at the seminar.

While the project was only able to make a modest contribution to improving the herders' situation, it has gathered important information to guide ongoing and future interventions. These herders are amongst the poorest people of China. The harsh environment they live in covers the sources of China's three largest rivers and so environmental processes in the Qinghai rangelands can have important effects on extensive areas outside the province. This publication reports how the project has analysed the structure of poverty of sheep and yak herders; assessed changes in vegetation production over the past 17 years; reviewed veterinary treatments; and conducted trials to rehabilitate degraded rangeland and to grow oats in sheep pens. It also reports on experiences in trying to promote the introduction of

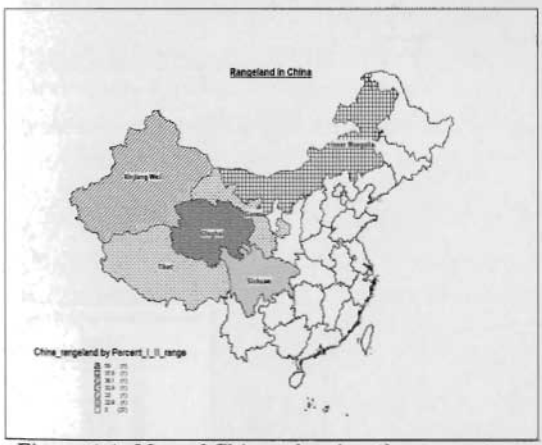


Figure 1.1: Map of China, showing the percentage of the area consisting of the best two classes of rangeland

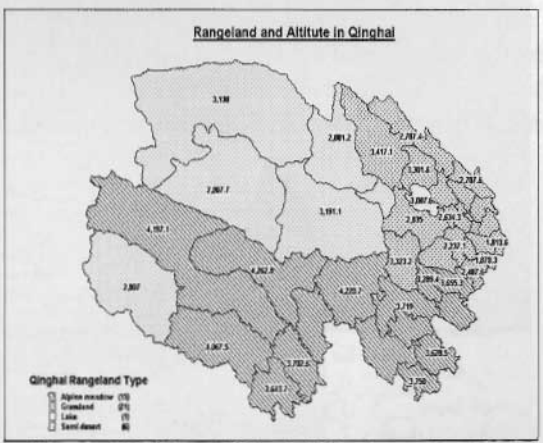


Figure 1.2: Map of Qinghai Province, showing average altitude in masl and type of rangeland

technological innovations in herders' communities. This document provides an overview of all technical content presented and discussed at the seminar and systematically reviews the technical papers and consultants' reports produced during project execution.

1.2 The Qinghai Livestock Development Project (QLDP)

The project area included eight 'Townships' in Maqin and Dari counties of Guoluo prefecture of Qinghai Province (see Figure 1.3).

The Qinghai Livestock Development Project began in 1996 to improve the livelihoods of sheep and yak herders in Qinghai Province by improving livestock production. The BAH established a Project Management Unit (PMU) staffed by Bureau of Animal Husbandry (BAH) representatives who worked alongside mostly short-term, non-Chinese experts in animal production, rangeland agronomy and management, veterinary care, land-use assessment, remote sensing, and pest control. These foreign experts were from a consortium of European agencies, with the Netherlands' RDP Livestock Services BV taking the lead in QLDP.

The PMU initiated three types of activities as follow.

- **Stock-taking** (descriptions and analyses of the existing rangeland situation, livestock, and the herder community)
- **Field trials** (with oats as winter feed, rangeland rehabilitation, control of rodent – especially 'pika' – damage, control of diseases and parasites in young stock)
- **Extension** (of promising findings of field trials, including training in participatory methods and monitoring).

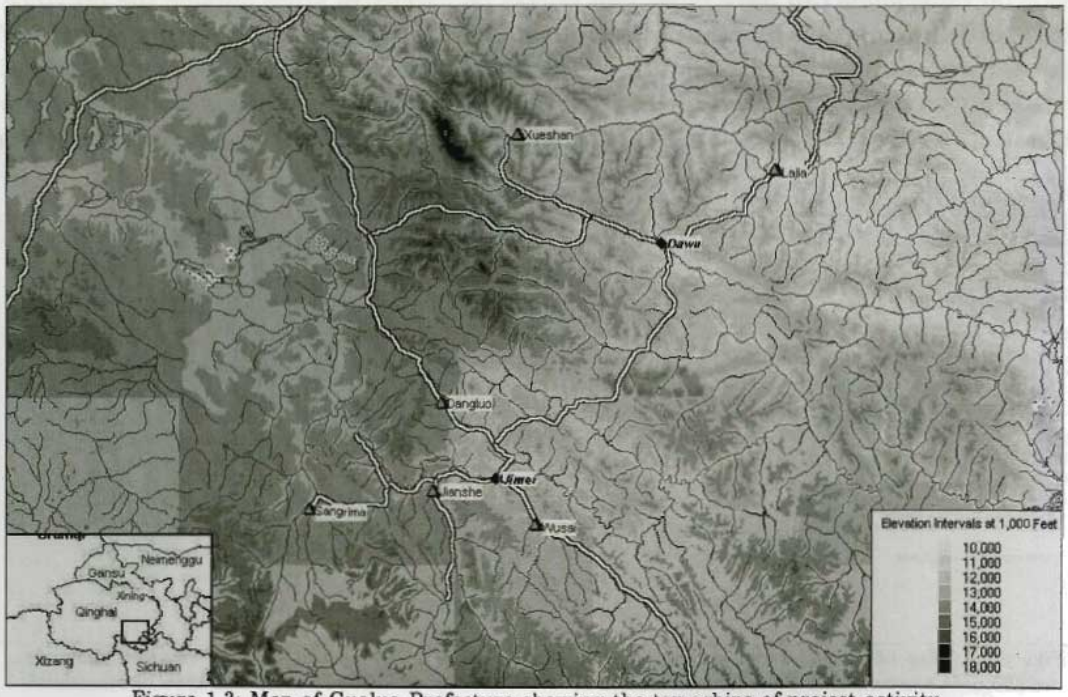


Figure 1.3: Map of Guoluo Prefecture showing the townships of project activity

The PMU worked with the BAH to design and implement activities. These units included the central, prefecture and county level grassland stations and veterinary stations; the provincial academies (Qinghai Academy of Animal Science and Veterinary Medicine); and the Huang Yuang School of Animal Husbandry. The Lanzhou Normal University, Qinghai Meteorological Bureau and the North-West Plateau Institute of Biology in Xining were also involved with specific activities. The role of the EC experts was not only to transfer technology and design field trials, but also to disseminate (new) ideas for development approaches. This network of institutions was coordinated by the PMU to contribute to the Concluding Project Seminar.

This document is not meant to be an evaluation of how the project has been executed. The European Commission and the central Chinese government's Ministry of Foreign Trade and Economic Cooperation (MOFTEC) have conducted an evaluation which has been reported on separately.

1.3 Further Reading

This document is made up of a series of review papers prepared by EC experts involved in the project. These reviews are based on the following three sets of documents: more than 80 workshop papers (in Chinese) produced for a workshop held prior to the seminar; more than 40 consultants' reports produced by consultants who had visited the project; and incidental documents gathered in connection with the seminar and during seminar discussions.

Workshop papers: The project staff and researchers of related instiutes prepared for the seminar by writing summary reports on research and experiments done over the course of the project. This series of research papers and activity reports was presented and discussed by the participants of a workshop which preceded the seminar. These papers are to be published in Chinese under the title: 'QLDP Workshop Papers on Livestock and Rangeland Improvement in Qinghai'. To give non-Chinese speakers access to this material, English translations of abstracts of these papers have been made and are available at the Bureau of Animal Husbandry in Qinghai.

Consultant's reports: These reports were prepared by visiting EC experts between 1996 and 2000. They have been summarised and a list of them is given in Annex 1. Full versions of these reports in Chinese and English are available at the Bureau of Animal Husbandry in Qinghai.

Chapter 2

STOCK TAKING: RANGELAND AND LIVESTOCK RESOURCES

2.1 The Rangelands, Land Degradation and Black Beach

A REVIEW OF RESEARCH REPORTS AND DISCUSSIONS
EDITED BY DENNIS SHEEHY

Rangeland importance

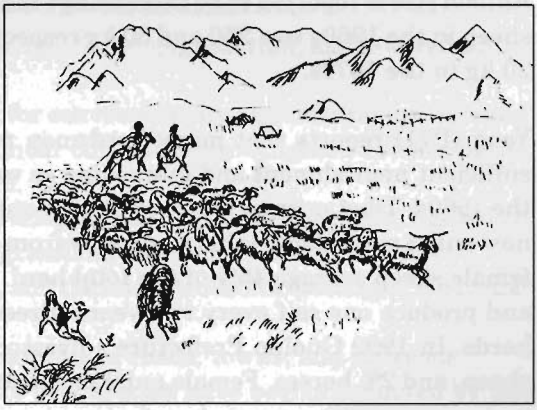
The Qinghai-Tibetan Plateau stretches over Qinghai, Sichuan, and Gansu provinces and the Tibetan autonomous region of China (Liu P33), (Table 2.1). Throughout the plateau, the dominant land type is rangeland which is used for livestock production. The main rangeland areas of Qinghai Province are alpine meadow vegetation around Qinghai Lake and south-eastern Qinghai. The total area of rangeland in Qinghai is approximately 36.5 million hectares.

Table 2.1: Distribution and area of degraded grassland in the Qinghai-Tibetan Plateau

Province	Grassland area (million ha)	% Degraded	
		1980s	1990s
Tibet	66.4	18	30
Qinghai	31.7	29	31
Sichuan	14.2	27	33
Gansu	16.1	44	49
Total	128.4	21	33

(Adapted by Liu and Zhou from Wang et al.)

The south-eastern monsoon and the high pressure of Siberia dominate the plateau's climate and have important implications for livestock production and rangeland management. The climate is divided into warm and cool seasons and the mean annual temperature is between 5.9 and 0 °C Precipitation increases from the northwest region (<300 mm/year) to the southeast region (>500 mm/year) (Wang et al. P63).



Desertification is reported to be a serious problem that is increasing in Qinghai Province. Annual precipitation is reported to have decreased by 10 mm in most areas of the province per decade since 1961 although use of 'cloud-seeding' techniques increased annual precipitation during the 1990s. Between 1960 and 2000 ambient air temperature is reported to have increased by between 0.2 and 0.3°C per decade, whilst the incidence and duration of winds at speeds sufficient to cause erosion and sand storms have also been increasing. The human population of Qinghai Province increased from 1.48 million in 1949 to 5.12 million in 1999 (Wang P62).

Although each factor unilaterally affects stability of the topo-edaphic-vegetation complex that has developed over millennia to form current ecosystems, the interaction among factors is having a significant and accelerating negative impact on ecosystem stability (Wang P62).

Rangeland Livestock Production

Total livestock numbers in Qinghai Province reportedly increased by 118% between 1987 and 1997. Meat production increased over the same period from 113,800 tonnes to 198,400 tonnes (Liu P33). Wang et al. (P63) consider livestock production to be traditional, backward, and monotonous. They report that the Plateau rangelands are overstocked; with, for example, the Yushu area of the plateau being 35% overstocked.

Li (P27) identified three classes of herder households in Qinghai Province's Guoluo Prefecture. The three classes were: poor households with 20 or less livestock per capita (mostly yak); middle level households with between 20 and 120 livestock (mixed sheep and yaks); and wealthy families with more than 120 livestock. Many families suffered labour shortages, which was identified as a primary cause of poverty. The same paper points out that wealthy households have tended to participate fully in the rehabilitation of pasture and in improving the feed resource. However, middle income families wish to participate in government programmes but often lack sufficient funds, whilst poor families receive welfare and generate most of their income from activities other than livestock production. According to Yang (P71), poor herders wish to have more animals while wealthy herders wish to increase the proportion of females in their herds.

Impact of rangeland degradation on livestock production

There are some indications that degradation of the rangeland resource base is beginning to seriously impact livestock production. Herders on the plateau believe that the area of rangeland has contracted and is now inadequate to sustain their animals. Although the herders know that the deterioration of the grassland in general is due to too large a number of livestock, they view pest infestation as an additional, important cause.

Animal size is reported to be decreasing (Yang P71). The average weight of yak and Tibetan sheep in the 1960s was 250 and 30 kg respectively, compared to average weights of 125 and 20 kg in the 1970s.

Yang (P71) reports that many herdsmen relate increased livestock mortality to lack of sufficient nourishment and inbreeding as well as to increased amounts of winter snow. In the 1960s, Tibetan ewes matured at 48 months and produced two lambs per year; whereas now only a single lamb is born and only from ewes in the best condition. Currently, breeding female sheep average 45% of the total herd. Female yaks currently mature at seven years and produce one calf every two years. Breeding female yaks account for only 30% of the herds. In 1999 Guoluo Prefecture's livestock herd consisted of 35% cattle and yak, 53% sheep, and 2% horses. Female animals made up 49.6% of the total herd.

A survey of 1,643 demonstration households in Guoluo Prefecture indicated that: 1) both poor and wealthy herders wanted to build fences, 2) a lack of seeds and cultivating skills

prevented herders from planting forage and fodder, 3) most herders did not want to spend money on animal shelters or else thought shelters would decrease animals' resistance to cold, 4) herders were interested in building houses after receiving grassland contracts, 5) most herders did not view animal disease as the main limiting factor of livestock production, and 6) most herders were poor and said they needed a loan to be able to improve their livelihoods (Yang P71).

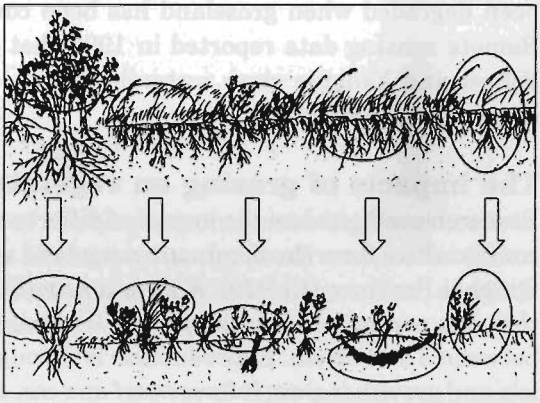
Rangeland condition

Liu (P33) report that 27% of the total grassland area had become degraded by the 1980s. During the 1990s, the total degraded grassland area had increased to 33% (Table 2.1).

Wang et al. (P63) report that over 16% or seven million hectares of the Qinghai-Tibetan Plateau is 'barren' land. This type of land has become known as 'black beach'. In Qinghai Province humus and nitrogen loss was reported as 310 and 7,121 kg/ha in soils lightly impacted by rodents, 915 and 21,365 kg/ha/yr in moderately impacted soils, and 1,759 and 40,357 kg/ha in heavily impacted soils.

The causes of degradation

Liu (P33) report that the ecological quality of the rangeland environment has degraded due to causes which include: herders' ignorance of the situation; poor management of the rangeland resources; snow disasters; persistent over-grazing; desertification; and rodent damage. These factors are preventing sustainable livestock development.



Human activities other than livestock grazing that have had a major impact on rangeland degradation.

- The extensive harvesting of fuelwood from Cypress, Diversiform Poplar, and Rose Willow forest). This has significantly increased sand dune formation and forest degradation, and lowered water tables.
- The destruction of extensive areas of forest for conversion into agricultural use. Around 0.66 million ha of grassland was brought under cultivation in Qinghai Province in the 1950s. Most of it has since been abandoned.
- Exploitative utilisation of grassland to develop livestock production. This has led to overgrazing and extensive degradation of grassland resources[1].
- Other human activities such as gold mining, and the uncontrolled harvesting of medicinal herbs.
- Infrastructural development such as the building of roads, towns, and railroads.
- Natural checks to the population growth of pest species have been eliminated by the killing and capturing of their natural predators[2] (Wang et al. P63).

[1] Livestock numbers have increased to over 20.9 million; 2.7 times more than in 1949.
[2] Reportedly, 15 to 20 % of animal species in Qinghai Province are in the 'threatened' category.

Erosion from wind and water and frost heaving further degraded the rangelands and have created a favourable rodent habitat.

Degradation impacts

A major impact of degradation on rangeland has been the loss of species diversity. Wang et al. (P63) indicate the three degrees of degradation not only by ground cover, but also by the number of different species found. The degree of degradation was considered small, if 86% of the soil was covered, in which case 18 species were found. Moderate degradation occurred at 46% coverage with 9 species, and serious degradation at 1% coverage by 5 species.

The grass yields of Dari, Maduo, Maqin, Quemalai, and other counties are reported to have decreased by between 50 and 80% between the 1980s and the 1990s. This decrease is believed to have been caused by over-stocking (Wang P62).

The vegetative production of 'black soil' type rangeland averages 400.5 (FW) kg/ha. Plants poisonous to livestock now comprise between 60 and 80% of the species found in black soil areas (Ma et al. P43).

In Maduo and Maqin counties, degraded grassland covers 1,266 sq.km of which 80% has been degraded when grassland has been covered by sand from destabilised sand dunes. Remote sensing data reported in 1995 that desert expansion in the source region of the Yellow and Yangtze river watersheds was expanding at annual rates of 20 and 2.2%, respectively (Wang P62).

The impacts of grazing on vegetation

Research conducted on the impact of different livestock stocking rates showed that *Kobresia* communities form the dominant rangeland vegetation type in the southeastern counties of Qinghai Province (Li P29). *Kobresia humilis* is a grasslike (*Cyperaceae*) herbaceous plant that is a perennial tussock species. It starts to grow in late April and grows to heights of between 3 and 15 cm. Reproduction is through vegetative multiplication. Although yield is low and growth is slow, it forms turf and can endure intensive grazing pressure, and usually becomes the dominant species.

In QLDP grazing trials, several different stocking intensities (0, 2, 4, and 8 SU/hm^2) were used to determine the response of *K. humilis* ramets to different grazing intensities. Plots were grazed between October and December and again in May of the following year. Results indicated the following.

- Tillers and aboveground biomass decreased with an increase in stocking rates. This indicated that grazing in the autumn reduced nutrient storage and spring grazing on the same plants reduced nutrients further, especially at stocking intensities of over 2 SU/hm^2.
- The number of flowering tillers/ramets decreased as grazing intensity increased while vegetative tillers initially increased under light stocking, decreased under moderate stocking, and then increased under heavy stocking intensity.

- As the number of clonal ramets increased, vegetative tiller numbers decreased and reproductive tillers increased
- This indicated that under heavy grazing pressure the plant tends toward vegetative reproduction rather than reproduction from seed as a way of competing with other plants and withstanding high grazing intensities (Li P29).

Dong et al. (P13) studied the impact of three stocking intensities of yak on frequency and cover of plants in an alpine meadow above 4,000m elevation. The three different treatments were light, moderate, and heavy grazing by four yaks. The results from these plots were compared with a non-grazed control area. The frequency and cover of plants were measured in 1998 and 1999. The study area was a fenced off area of degraded grassland. It was found that the stocking intensity had a notable effect on plant frequency and cover. Although the plant cover increased under the three stocking rates, the type of herbage present increased in different proportions. Light grazing (less than normal grazing intensity) increased plant cover (of the soil) in the first year. Under moderate and heavy grazing intensities, the plant cover increased only after the second year of controlled grazing. Under light and moderate grazing intensities, the cover of grasses and weeds decreased while the cover of sedges increased. Under heavy grazing the cover of grasses and sedges decreased while the cover of weeds increased. The study indicated that controlled grazing at light and moderate stocking rates would maintain grass and sedge composition and the yield of alpine grasslands.

2.2 The Climate

A REVIEW OF PAPERS AND OF DISCUSSIONS OF THE WORKGROUP ON RANGELAND BY NICK HODGSON

The Qinghai-Xizang (Tibetan) Plateau is one of the largest contiguous highland areas in the world. It extends over 2,000 km from the Himalayas in the southwest to the Qilian Mountains in the north-east. The plateau covers a total area of 2.5 million sq.km, of which Qinghai Province occupies about 720,000 sq.km.

Most of Qinghai Province is at an altitude of between 3,000 and 4,000 metres, with peaks reaching 6,800 metres. The province can be subdivided into the Qilian Mountains in the north-east, which have reasonable levels of rainfall and fertile cultivated valleys; the Qaidam Basin, an enclosed arid basin at an altitude of between 2,600 and 3,200 metres within the main plateau structure; and the Qingnan Plateau where the main area of alpine rangeland occurs.

Climate variability and climate change

The natural rangeland of the high plateau is characterised by a cold dry climate with long winters. Typical annual average temperatures range from -5°C to around zero, reaching a maximum of 10°C in July and a low of -15°C in January.

The length of the growing season ranges from a maximum of 200 days to a low of 150 days. Low water availability is a serious constraint to plant growth.

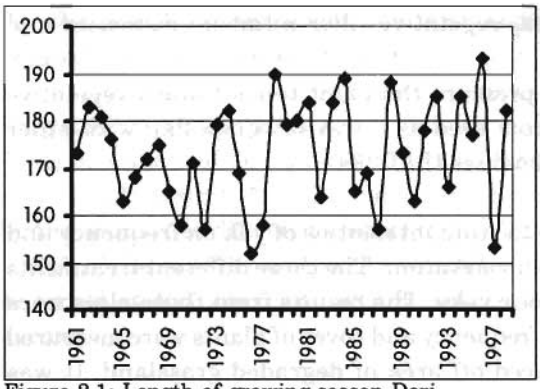


Figure 2.1: Length of growing season Dari meteorological station – Jimei

Land use in this harsh climate is further constrained by wide variability in the length of the growing season (Figure 2.1). An extreme example of this can be seen from Dari where in 1996 there were 193 growing days whereas in 1997 there were only 153; a difference of around 30% over two consecutive seasons.

Rainfall and temperature are also extremely variable. These factors, together with wind speed, cloud cover, and radiation, all affect plant growth.

The clearest index of potential growth conditions is actual evapotranspiration (ETa). The cumulative evapotranspiration for a growing season can serve as an index to measure the plant growth over a particular year. The loss of water through transpiration relates to water intake and growth in a plant. For example, the transpiration ratio denotes the amount of water used to produce one pound of dry matter on a plant.

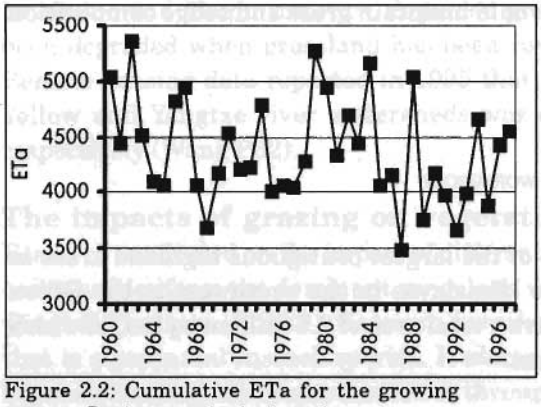


Figure 2.2: Cumulative ETa for the growing season, Dari meterological station

An evaluation was carried out by the Qinghai Bureau of Meteorology using data on evapotranspiration and rainfall to give actual evapotranspiration. Examination of the data that covered the period from 1960 to 1998 showed that the variability of average evapotranspiration had been at the high level of 30% (Figure 2.2).

There has been considerable discussion within the project about the impact of climate change on the plateau environment. There are some indications that annual average temperatures have been rising at about 1°C every fifty years, with the mean summer temperature rising at a rate of 1°C every hundred years.

Zhang Guosheng et al. (P77), in their paper on the effect of climate change on grassland degradation have stated that the annual mean temperature is increasing year by year in the source area of the Yellow River (Maduo County), with a particularly significant rise in summer temperatures.

Total precipitation is also increasing at a rate of 1.3 mm per year. However most of this is as winter snow, rather than growing-period summer rains. The impact of increasing winter precipitation is reflected in the increasing human toll of winter blizzards.

The same authors also considered that there has been a 14-year cycle of summer precipitation with climax years falling in 1961, 1975, and 1989. The figures showed low precipitation

periods between the climax years, with the year 2000 as a low summer precipitation period. The authors developed a drought index, based on temperature and precipitation, that indicates a cycle of higher and lower precipitation years.

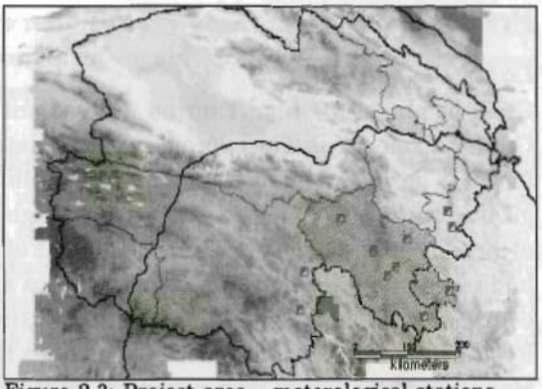


Figure 2.3: Project area – meterological stations

The authors also cite as supporting evidence the drying up of lake systems in the upper catchments. Water levels have dropped by up to two metres in some lakes and "up to one thousand lakes have disappeared completely." There is concern of the possible impacts of this on the Yellow River system and the downstream cycle of droughts and floods.

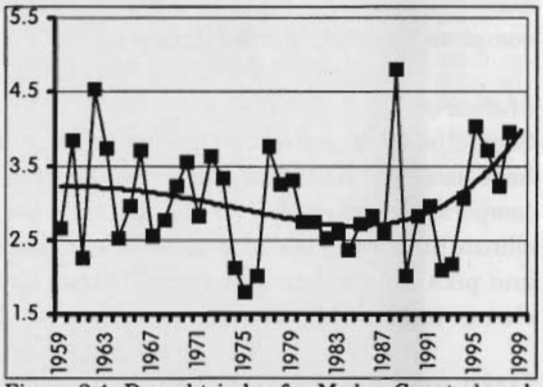


Figure 2.4: Drought index for Maduo County based on temperature and precipitation

A similar conclusion is reached by Zhang et al. (P77) in their discussions on the effects of climate change on rangeland ecology. They looked at precipitation and other factors for each of the seasons and the flood season.

The increase in dry season (winter and spring) precipitation and the decrease in wet season (summer) precipitation is considered to be leading to a situation of summer droughts and winter snow disasters. The authors say the trend is a move from "a large disaster every ten years, a middling one every 5 years and a small one every three years" to "a large disaster every 5 years, a middling one in every three years and a small one every year."

In the short and medium term it is the annual variability of climate that is most significant to the development of rangeland systems. If livestock systems are able to cope with the annual variability, then they are also likely to have the resilience and flexibility to adapt to long-term changes.

2.3 Changes in Vegetation Index, 1982-1999

SUMMARY OF A STUDY BY ANITA PERRYMAN

Introduction

Any policy and research concerned with rangeland improvement requires a good understanding of the dynamics of rangeland productivity. There is growing concern that in south-east Qinghai changed land-use practices and changes in climatic conditions are increasing land degradation, reducing the productivity of the rangelands and threatening the livelihoods of its inhabitants. However, no study had directly assessed the dynamics of vegetation in this area. QLDP and the Meteorological Bureau of Qinghai undertook such a study, which was executed by Anita Perryman, Yang Yinglian, and Xu Weixin. A more detailed report of its analyses is available from QLDP.

Previous studies

Land degradation

Chen et al. (1998) report on an assessment of the condition of the land in Dari County, Guoluo Prefecture. They compared 1985 data on rangeland grade and type maps with data for 1997 derived from NOAA and TM satellite images, which had been calibrated against a ground survey. They noted a decrease in high grade pasture and also concluded that the area of usable pasture had decreased, as the area of black beach land (eroded and degraded patches) had increased. By analysing stocking rates and carrying capacity data they concluded that overgrazing had not been the main contributing factor to pasture degradation. They hypothesised that global warming had been the key factor causing land degradation in Dari. However, their study was based on only two years of data, and so these years could be unrepresentative years when exceptional conditions occurred. The study reported here was carried out partly to build on the study carried out by Chen et al. by using a more historically complete, remotely-sensed data set.

Meteorology

Some studies suggested that land degradation had been caused by climatic change, whilst others have disagreed with this conclusion. Xu et al. (2000) suggested that there has been a rise in temperature and rainfall for Qinghai since the mid-1980s. Zhang et al. (1998) say that the drier climate has contributed to grassland degradation by compounding the problems of overgrazing and pika infestation. However, Thomas (2000) found that there had been no significant change in annual or seasonal potential evapotranspiration for Maduo in Guoluo Prefecture.

Data and methods

Normalised Difference Vegetation Index (NDVI) images often serve as a good indicator of vegetation dynamics. The aim of this study was to interpret a set of satellite images spanning the period from 1982 to 1999 to assess whether the productivity of rangeland had decreased or if falls in productivity were due to other factors, principally shorter growing seasons. These indicators were interpreted in conjunction with meteorological data to assess the impact of climatic and weather effects.

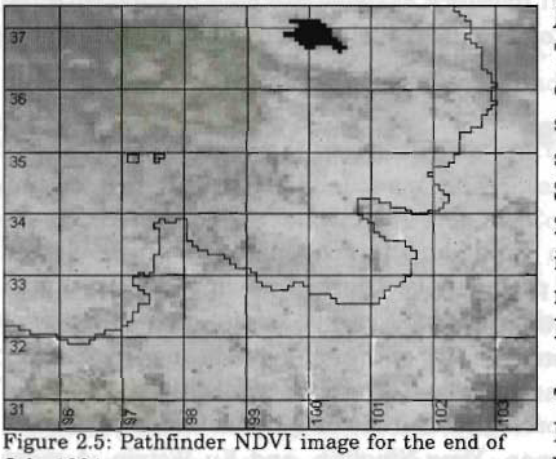


Figure 2.5: Pathfinder NDVI image for the end of July 1984

NDVI images

The image sets used in this study were ten-day vegetation images from the NOAA satellites (the Pathfinder AVHRR land data series), for the period from July 1981 to September 1994 and January 1995 to June 2000. These were downloaded from the internet (daac.gsfc.nasa.gov). Their spatial resolution is 8 by 8 km. Figure 2.5 is the Pathfinder NDVI image for the end of July 1984.

The Pathfinder data set includes Normalised Difference Vegetation Index (NDVI) images. Vegetation absorbs red light strongly for

photosynthesis, whilst the plant cell structure reflects away near infrared radiation. This dual reflectance response is uniquely characteristic of vegetation. The NDVI method uses this response to discriminate and describe vegetation.

NDVI values range from –1 to 1. Values above about 0.05 indicate the presence of vegetation, and the higher the index the more vigorous the photosynthetic activity. Water and bare soils give lower index values and so can be distinguished from vegetation. Topographic and cloud shadows (which reduce the reflectance values) are partially compensated for as the normalised difference is used. Diseased, dead, dying, and dormant vegetation are not detected. This makes NDVI a good indicator for the examination of growing seasons and production.

Figure 2.6 shows a region of about 800 sq.km and shows the boundary of the study area — Qinghai Province. Qinghai Lake is the dark area. The vegetation index values are shaded from black (NDVI value of –1) to white (NDVI value of 1). In Figure 9 active vegetation takes values from about 0.1 upwards increasing with the vigour of the vegetation growth. Lighter areas indicate higher NDVI values where vegetation is growing more vigorously. The darker area in the north-east of the image (Figure 2.6) is the Qaidam Basin desert area. This area clearly has less growing vegetation than the south-east of Qinghai.

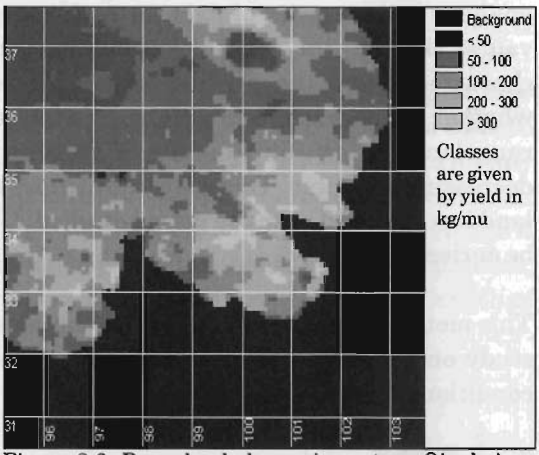


Figure 2.6: Rangeland classes in eastern Qinghai

Area covered

The region examined in this study covers parts of south and east Qinghai Province, bounded to the north by latitude 37.6 N and to the west by longitude 95.1 E, covering an area of approximately 350,000 sq.km or just over half of the province. The average annual precipitation of this area is about 500 mm, with the majority occurring in the summer. Precipitation varies from less than 50 mm in the Qaidam Basin area to about 700 mm in the eastern river valleys. Annual average temperature ranges from –6 to 4°C. The growing season usually runs from mid-May/late June to late September.

The area ranges from 3,000 to 5,500m in elevation. There is a band of lower land at 3,000m in altitude across the northern part of this area through the Qinghai Lake area, but generally the terrain slopes from west to south-east. The southern area is pastoral whilst the north-east is more agricultural.

Rangeland classification

A classification of rangeland was developed according to the information on the basic productivity of grasslands which can be picked out from satellite data. A rangeland grade map was produced for 1993 to 1995 using NOAA AVHRR data which were available at the

Bureau of Meteorology's Remote Sensing Centre in Xining. This map was derived from daily vegetation index images produced at a spatial resolution of one km. These data were composited to remove cloud contamination and were accumulated through the season. Five main sites and several seasonal sampling sites, chosen to represent the different vegetation type across south and east Qinghai, were used to collect field data. At each site five to ten $1m^2$ samples were selected from within the 10 km^2 main sampling sites. The vegetation in these squares was harvested and weighed every ten days during the growing season. From this data the output yield in kilogrammes per mu (1 km^2 = 1,500 mu) was calculated and the rangeland grade map calibrated.

Basic approach

The methodology used was similar to that used by Tieszen et al. (1997b). This method analyses a time series of data for each rangeland class to determine the profile of NDVI values through the season. Various measurements are then extracted to measure the characteristics of the growing season. These measurements are then examined to assess whether the characteristics of the growing season have changed over time for each class of rangeland, to test, for example, if growing seasons are getting shorter or production is decreasing over time. This allows any trends to be identified to see if an increase in degraded land has occurred over the period studied. If this is found, then the rate of change can also be derived.

This methodology does not allow for the causes of degradation to be established. A parallel study on the meteorological conditions was carried out to assess the impact of weather conditions on rangeland vegetation.

Time series analysis

Six hundred and seventy-one Pathfinder NDVI images were uncompressed and re-projected. The study region was extracted and the real NDVI values retrieved.

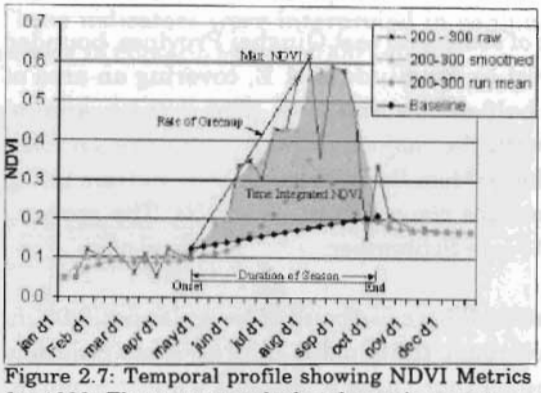


Figure 2.7: Temporal profile showing NDVI Metrics for 1983. The raw, smoothed and running mean profiles are shown. Various NDVI metrics are labelled

Time series' profiles were generated for each year of data for the rangeland classes showing NDVI values through the year. The green season or rather the growing season can clearly be seen by the rise and fall in NDVI values. It was only possible to extract full sets of measurements for years with complete data. Incomplete years (1981, 1994, and 2000) were excluded. The timing and NDVI values at both ends of the season were recorded (Figure 2.7).

The maximum NDVI over baseline and the timing of this peak in greenness were recorded. The maximum range in NDVI values was also extracted. The rate at which the green-up[3] and green-down occurred was calculated in

[3]The rate of green-up is the amount of change of DNVI per month between the onset of the green season and the season peak NDVI.

NDVI units per month. The time-integrated NDVI (accumulated NDVI over baseline for the growing season) was calculated. This quantity was taken as an indicator of seasonal productivity.

The measurements were tabulated for each rangeland class for each year. Graphs of the evolution of measurements from 1982 to 1999 were generated. Trend lines were fitted to data and the significance of trends was determined. The level of correlation between measurements was examined.

The measurements metrics for length of green season and accumulated NDVI (productivity) were considered most likely to reveal overall rangeland condition. Significant decreases in these two measurements over time would indicate progressive rangeland degradation.

Meteorological study

The Bureau of Meteorology carried out a study on climatic change to investigate how changing climatic patterns may have influenced rangeland vegetation. This was done to complement the remote sensing study. It reviewed the normal variability and looked for any changes in climatic and annual growing conditions in the project area, based on the evaluation of actual evapotranspiration rates using data from 1960 (where available) to 1998. While it was found that there has been considerable variation of precipitation and evapotranspiration, however, the study found that there have been no significant trends in either the length of the growing season or in actual evapotranspiration. This information was used to help evaluate the results of the remote sensing study.

Results and discussion

Results and discussion of time series' analysis

Temporal profiles and NDVI measurements were extracted from the time series for each rangeland class.

Graphs showing the evolution of measurements from 1982 to 1999 for length of green season and accumulated NDVI (productivity) are shown in Figures 2.8 and 2.9.

These graphs show that there has been considerable variability between years. However, no significant trends are evident for any rangeland class for either the length of green season or accumulated NDVI.

The other NDVI measurements were also examined. These also showed variability

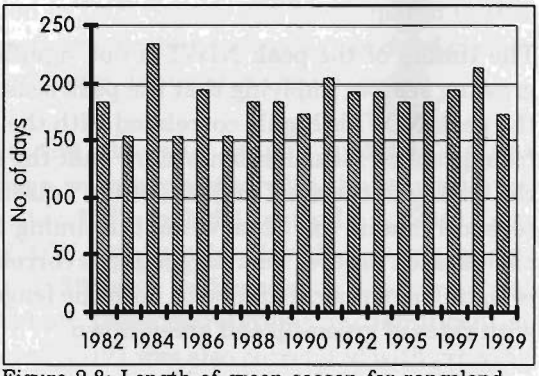


Figure 2.8: Length of green season for rangeland class 200 – 300 kg/mu

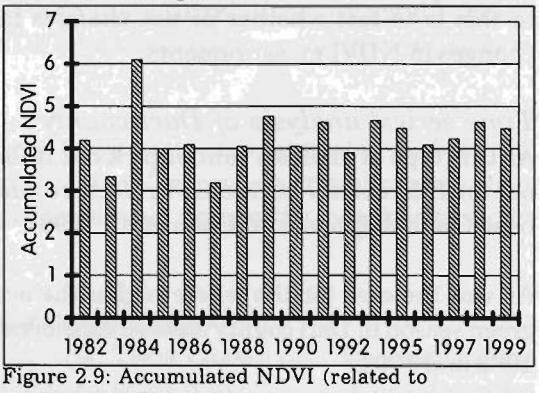


Figure 2.9: Accumulated NDVI (related to productivity) for rangeland class 200 – 300 kg/mu

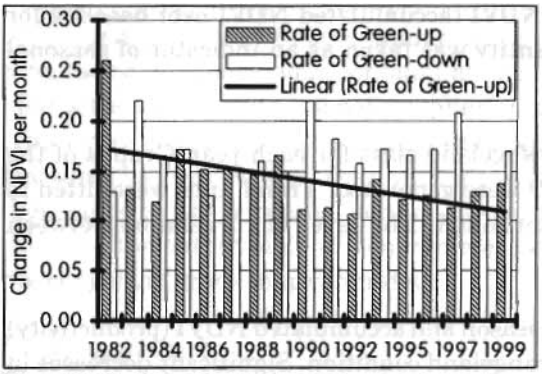


Figure 2.10: Rate of green-up and green-down in class 200 – 300 kg/mu

between years, but for most measurements no significant trends were found. The exception was the rate of green-up which showed a decrease in later years for all rangeland classes (Figure 2.10). This trend was significant at the 0.05 level. However, it appears that, for all rangeland classes, this trend is heavily influenced by the particularly rapid green-up in 1982, a year when the season started particularly late. When this year is removed the significance of the trend disappears from each class. The correlation between the timing of the onset of greenness and the rate of green-up was examined. The correlation coefficient for rangeland class > 300 kg/mu was 0.7823, which is significant at 0.001. This correlation indicates that when the season starts later the greening up occurs faster.

These data indicate that, although there is a lot of variability between years, there are no significant trends to indicate an increasing amount of degraded land in eastern Qinghai. This analysis was conducted using rangeland classes that are widely distributed across the eastern half of Qinghai. The results show that, on average across each of these classes, there has been no significant change in the amount of degraded land.

The timing of the peak NDVI is not significantly correlated with timing of onset of the growing season, implying that the peak season is not delayed by a late start. The timing of the peak NDVI is highly correlated with the rates of green-up and green-down (while data from graphed measurements show that the timing of the peak NDVI is less variable than the timing of the start and end of the season). This may imply that the basic shape of the season remains the same while the timing of the start and end effectively truncates the basic season profile. This suggestion is corroborated by the fact that the accumulated NDVI is significantly correlated with both the length of season and the maximum NDVI, but not with rates of green-up and green-down.

No reasons for any changes or lack of changes can be tested with this analysis. The exception to this is to test whether or not changes in the meteorological data are correlated with changes in NDVI measurements.

Time series' analysis of Dari county

As this type of analysis cannot pick out isolated areas of degraded land it was also carried out for Dari county in Guoluo Prefecture, an area identified as particularly subject to black beach land degradation (Chen et al. 1998).

As was the case for the whole region the accumulated NDVI (productivity) and length of green season in Dari county showed considerable variability but no significant trends between 1982 and 1999.

Comparison to previous study

A comparison was made with the results of Chen et al. (1998) on decreases in high grade pasture.

The NDVI time series was examined for changes between and around 1985 and 1997, the dates used in the study by Chen et al. The accumulated NDVI values show a clear drop in accumulated NDVI for each class from 1985 to 1997. However, when the accumulated NDVI for each year in the Pathfinder time series is examined, the conclusion of Chen et al. that land has become degraded is not supported. Figure 2.11 shows the accumulated NDVI for each year of the time series for Dari County. It can be seen that 1985 was an extreme year within these seventeen years, while 1997 was more normal.

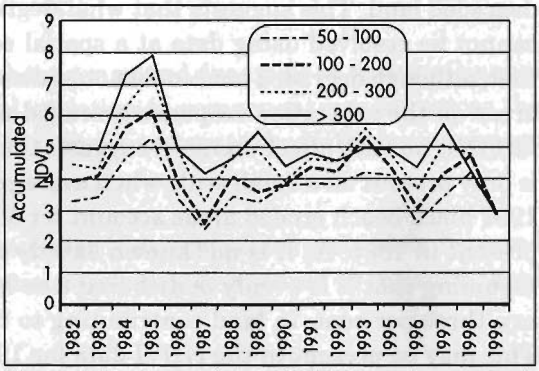


Figure 2.11: Accumulated NDVI for each rangeland class in Dari county

Incorporation of meteorological data

For future rangeland analysis vegetation data, derived through remote sensing, it is useful to increase the understanding of how meteorological data relate to the NDVI measurements. However, it is difficult to directly compare data derived for each rangeland class with the meteorological station data as the rangeland classes are dispersed across eastern Qinghai. However, the data for the meteorological station in Dari County can be compared in this way. Dari's meteorological station is located on the borderline between rangeland classes 200–300 and > 300 kg/mu, and so both of these classes are used in the analysis.

The amount of precipitation that fell in the growing season and the actual evapotranspiration (ETa) for the growing season were correlated with the accumulated NDVI (productivity) measurements for Dari for 1982 to 1998 (excluding 1994). The rangeland class 200-300 kg/mu accumulated NDVI was correlated with growing season precipitation (correlation coefficient, r = 0.4586) and with growing season actual evapotranspiration (r = 0.4365). With df = 14 both these correlations are significant at 0.1. For rangeland class >300 kg/mu accumulated NDVI was also correlated with growing season precipitation (correlation coefficient, r = 0.6051) and with growing season actual evapotranspiration (r = 0.5730). With df = 14 both these correlations are significant at 0.05. Hence there is a relationship between NDVI accumulated over the growing season and precipitation and ETa.

No in-depth statistical analysis has been performed to determine the interrelations between the NDVI measurements and the meteorological data. However, an initial examination suggests that these data sets are related although they are not necessarily measuring exactly the same quantities.

Limitations of analysis and suggestions for further work

This analysis has used rangeland classes based on yield. These classes were dispersed across eastern Qinghai. To better interpret the data and to compare it to other data sets it may be

necessary to use different regions for analysis. The analysis was duplicated for Dari County, an area subject to severe land degradation.

The Dari analysis still did not find evidence of a significant increase in the amount of degraded land. This suggests that what degraded land there is is in isolated patches which cannot be resolved using data at a spatial resolution of only 8 sq.km. It was anticipated that, although degraded land could not be directly seen in this data, the influence of degraded areas on the vegetation response averaged across each 8 sq.km area would be found. The fact that no such affect was seen suggests that any increase in the amount of degraded land is only present on a small scale when averaged over a county. Chen et al. (1998) say that in 1997 black beach eroded areas account for 5.52% of Dari county — more than double that present in 1985. As it is not known exactly how this is distributed across the county, and assuming that it is evenly distributed (the least detectable configuration) then a drop of, say, three per cent, in land contributing to the vegetation index value should be present. This may be present in the NDVI data for 1985 and 1997 but the overall variability of the seasonal growth obscures any identification of a change of this order.

To refine this, analysis data of higher spatial resolution should be considered. A spatial resolution of 1.1 sq.km. NOAA data is available daily. This data can be collected, calibrated, the NDVI calculated, co-registered, and composited to replicate the Pathfinder time series, but at a much higher spatial resolution. These one km data are very suitable for investigating rangeland dynamics. However, the archive for this type of data only extends back to 1992 in Xining. This could be analysed but a longer time series would be required. Data of a higher spatial resolution are usually not available frequently enough for investigating the dynamics of the growing season and coverage for Qinghai may be sporadic.

As an alternative strategy, some consideration should be given to which are the best regions for analysing time series' data. While rangeland yield classes define regions where the vegetation is expected to respond relatively homogeneously, counties are more useful for comparing other data determined on a county or point basis. A detailed classification of severely degraded areas could be used to pin-point the analysis, although minimum sizes of regions would have to be determined to ensure that the analysis is still valid.

The statistical analysis of data reported in this paper has been fairly basic, mostly owing to the lack of time to expand the analysis. More complete and sophisticated statistical analysis of the data could provide more useful results.

Conclusions

The analysis of the Pathfinder data indicated that, although there is much variability between years, there are no significant trends in land degradation over the east of Qinghai as a whole or in Dari county.

There are problems with basing conclusions on data from just a few dates, which will give only a snapshot view. The results can be rather different when data from a longer time series are examined.

Meteorological data for the same period showed similar variability and a lack of significant trends. No in-depth statistical analysis has been performed to determine the interrelations between the NDVI measurements and the meteorological data. However, initial examination suggests that these figures are related although they are not necessarily measuring the same quantities.

The PCA showed that different information about rangeland dynamics in eastern Qinghai can be derived from this data set. The spatial variation in component images across the region are particularly interesting and should be complementary to the NDVI measurement data.

The Pathfinder data are of insufficient spatial resolution to detect isolated and widely dispersed patches of black beach erosion. A higher spatial resolution is required to monitor these data.

2.4 Livestock Production

A REVIEW OF PAPERS AND OF DISCUSSIONS OF
THE ANIMAL PRODUCTION WORKGROUP BY JOHN DAVIS

The QLDP project area in southern Qinghai has a cold harsh environment with most of it lying over 3,500 metres above mean sea level (masl). Due to the harsh climate and short growing season it is not possible to produce food crops and the population are dependent on livestock for their survival. The two main livestock species are yak and sheep. Some horses are kept for riding. The herders practice a transhumance pastoral system moving their livestock to higher altitudes (>4,000 metres masl) in the summer and then returning to the lower areas (3,500-4,000 metres masl) with the onset of winter. In some townships there is an intermediate stop in the spring and autumn. The inhabitants of the six QLDP project townships typically follow these practices.

Trends

It is widely thought that the livestock productivity per animal has decreased markedly over the last 20-30 years. Yang (P74) indicates that the carcass weight has decreased from 250 kg to 125 kg for an adult male yak and from 30 kg to 20 kg for sheep. However, it is difficult to be sure whether or not these figures are accurate. The decline is attributed to the deterioration of the grasslands caused by overgrazing and, in the case of yaks, also to inbreeding. Conversely official statistics indicate that there has been little or no increase in livestock numbers over the period in question. Statistics from the Bureau of Animal Husbandry (BAH) show that the maximum livestock population was reached in the early 1970s with a slight decline in numbers since then. This applies to the province, prefecture and the project counties. Goldstein (R1996) argues that the rapid increases in livestock numbers reported from the 1950s through to the 1970s are likely to have been over-stated for political reasons. After the privatisation of farms in the 1980s, livestock numbers may have been under-reported. Livestock statistics for the project area need to be treated with caution.

The ratio of yak to sheep

The ratio of the number of yak to the number of sheep is an indication of the degree to which the system has become commercialised. The figures in Table 2.2 indicate that a

Table 2.2: Livestock statistics: prefecture, county and project area 1997

Area	Human population	Yak (Y)	Sheep (S)	Ratio Y:S
Qinghai Province		4,217,100	13,728,600	1 : 3.3
Guoluo Prefecture	121,900	1.179,600	1,334,900	1 : 1.1
Maqin County	31,200	211,600	377,500	1 : 1.8
Dari County	21,600	208,600	236,100	1 : 1.1

Statistics are from those of the Bureau of Animal Husvandry (BAH)

higher proportion of yaks are kept in the project area than in the province as a whole. This is an indication of the project area's remoteness as the yak is more important for people's subsistence in remote areas. Dairy products are significant in the herders' diets. The yak also provides hair for making tents and is used as a pack animal for the move from winter to summer grazing. Because of the long interval between generations in the harsh environment, especially in Dari, yaks are more vulnerable to losses from snow disasters than sheep. The sheep population can be built up more quickly after such losses.

Grazing systems

Apart from the move from winter to summer pasture there are no formal grazing systems. However, families – and in the more remote areas, tent groups – follow definite grazing strategies. Areas are set aside for grazing in the late winter or late summer and often the flocks and herds are split up. The more vulnerable animals, such as especially lactating or pregnant females, are put on the better grazing land on fenced winter pastures and the stronger animals are taken to the far away and more difficult areas. During the winter the herders adopt an opportunistic approach. When the weather is fine the animals are taken to higher areas, and when it is bad they are kept closer to the homesteads.

Yak production

The yak is the foundation of the way of life of the people in the project area. It is well adapted to the harsh conditions of the Qinghai Tibetan plateau and is able to respond to the variability and scarcity in levels of available feed. The cows only produce a calf every second year in southern Qinghai, although in areas with a higher feed availability annual breeding is the norm.

The yak has many useful attributes. Its ability to survive the very cold conditions is partly due to the composition of the hair, which consists of a coarse outer coat and an inner coat of much finer hair. Both parts of the coat are useful to humans. An adult animal produces approximately one and a quarter kilogrammes of hair of which just over half is the fine inner down. The coarse hair is traditionally woven to make the tents in which the families live. The hair is harvested in early summer.

Because of its adaptation to high altitudes, it is the most useful pack animal in this environment and is used both for riding and carrying loads.

Calving interval and lactation

Within one lactation a cow is milked over two summers. In the intervening winter, milk production drops to a lower level and is only sufficient to feed the calf. This no-milking

period is important for the survival and growth of the calf. In the second summer the cow responds to improved nutrition and the animals are again milked. Figure 2.12 shows that the milk yield, after feeding the calf, is just under one litre per day. In the second summer the calf gets less milk and is only given access to the mother's milk -- important to stimulate milk letdown. In the second summer the yield for human consumption is approximately 80% that of the first summer. The two year calving interval does not entail a large drop off in milk yield for human consumption.

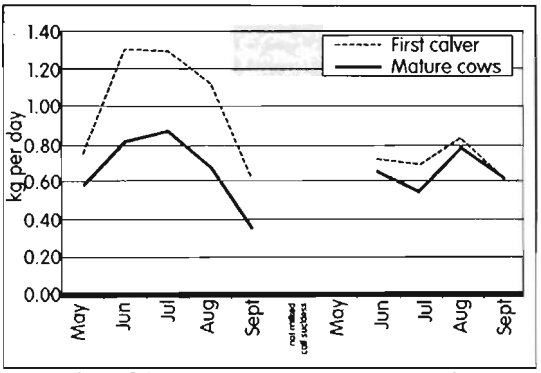


Figure 2.12: Milk yields after feeding the calf

Figure 2.13 shows the importance of the second summer when the cow is not feeding a calf. The animal is able to regain body condition before the next breeding cycle. If cows calve every year then the second calf is often born late in the calving season. This has its disadvantages.

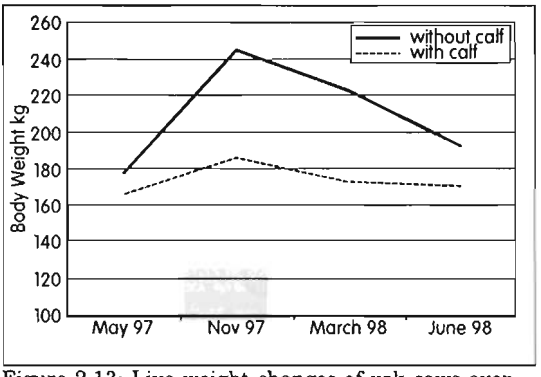


Figure 2.13: Live weight changes of yak cows over reproductive cycle

Weights at different ages are given in Figure 2.14. Growth rates are slow due to the poor nutritional status. The lack of sufficient and good winter grazing significantly reduces growth, and often live weight, in all winters except the third (which was between months 31 and 36). To examine weights at different ages, a limited number of yaks was slaughtered and dissected. A pack yak over 10 years weighed 370 kg with a carcass weight of 210 kg. Middle-aged animals, 5-7 years old only weighed 200 kg live weight and had a carcass weight of 110 kg.

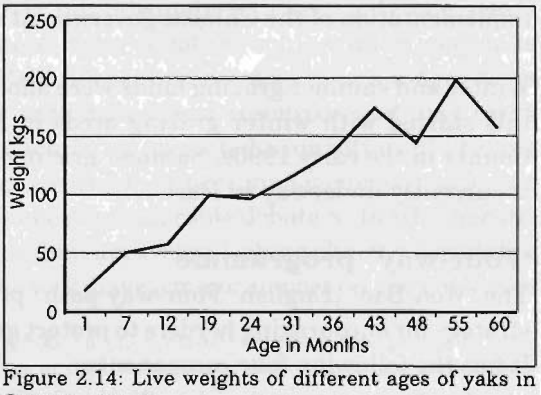


Figure 2.14: Live weights of different ages of yaks in Guoluo county

Sheep production

Sheep are kept for meat and wool. In the project area 45-48% of the flock are adult females. The lambing percentage is 75-80%. However, it is reported verbally by herders that only 70-80% of the lambs survive. Adult mortality rates are 6-8%. As with the yaks, the mortality is higher in the more remote Dari County. The sheep on average yield 1–1.5 kg of fairly coarse quality wool.

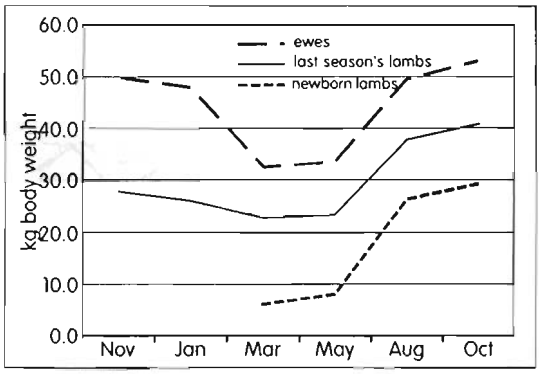


Figure 2.15: Live weight changes of sheep

Figure 2.15 shows the seasonal live weight changes of ewes, the previous year's lambs and the lambs born in the year of recording. The animals loose substantial weight over the winter, although when considering the figures for the ewes it must be remembered that by the end of the winter they will have given birth to their lambs.

Live weight at slaughter of males for mutton production is in the region of 45 kg with a carcass weight of approximately 20 kg.

The stress that yak and sheep face in winter because of insufficient feed is all the more dangerous if the animals have not been able, the preceding summer, to build up body reserves. Although insufficient winter feed is a serious constraint to production and survival, good summer grazing can mitigate the effects of winter.

2.5 Livestock Policies

A REVIEW OF PAPERS AND DISCUSSIONS OF THE ANIMAL PRODUCTION WORKGROUP BY JOHN DAVIS

Government livestock policy for the Qinghai rangelands has the twin objectives of protecting the environment and maximising livestock production. The principal method proposed to achieve this is for each herder household to become a small family ranch. This programme has a number of components.

Allocation of livestock and land

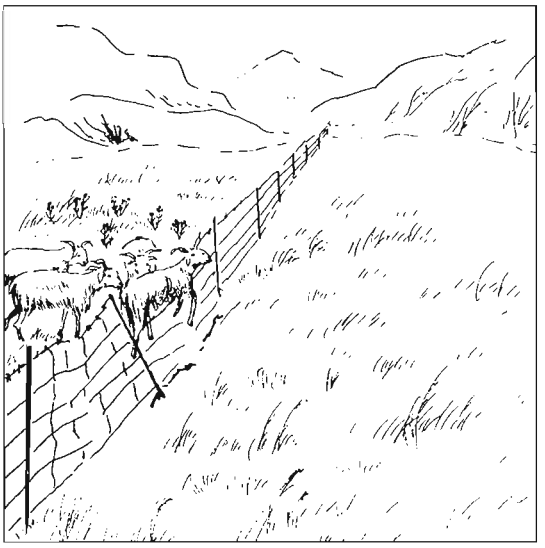
Livestock were allocated to individual families between 1983 and 1986 as part of the implementation of the Chinese government's 'family responsibility system'.

Winter and summer grazing lands were allocated to individual families. In the project area this started with winter grazing areas in Maqin County in the mid 1980s and in Dari County in the early 1990s. Summer grazing has only recently been allocated in Maqin and is currently underway in Dari.

'Four-way' programme

The 'Wen Bao' (English: Four-way path) programme is the Chinese government's major strategy for encouraging herders to protect grassland and intensify their production system. It has the following four components.

- Fencing[1] a 500 mu area for late winter feeding
- Making hay for supplementary winter feed by growing a plot of oats over 10 mu
- Building a 60 sq.m animal shelter for protection of livestock in winter, especially for the young lambs
- Construction of a permanent dwelling house on the winter pasture for the herder and their families.



Protection of the environment

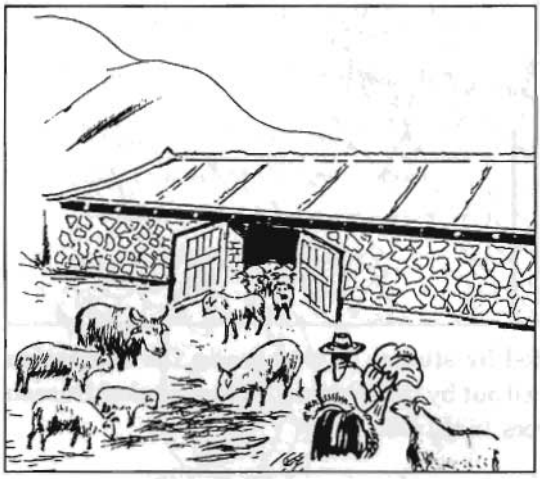
It is generally believed that the rangelands are degrading rapidly and that the principal cause of this is overgrazing by both large domesticated herbivores and by the pika and other rodents. This hypothesis has been tested by studies of changes in the vegetation index promoted by QLDP. These are being carried out by the Qinghai Meteorological Bureau in conjunction with the UK's Natural Resources Institute.

The rationalisation of stock numbers with the available feed resource is a principal aim of recent government policy along with poisoning campaigns against pika and *lagomorph* pest species. The availability of feed has been assessed by rangeland surveys which have been carried out by Qinghai Academy of Animal Science and Veterinary Medicine (QAASVM) approximately once every 10 years over a limited number of sites for each rangeland type. The productivity of each of these sites has been assessed. Recent climatic studies (Wang et al., P62) have shown that there are wide variations between years. The length of the growing season can vary by as much as 30% in different years. A study carried out on actual evapotranspiration (ETa) — the best measure of plant growth potential — has also shown variations from year to year of the same magnitude (Wang et al., P62).

It is crucial that livestock management systems take this annual variation and the dangers of snow disasters (every 5-10 years or so) into consideration. The possibility of losing large numbers of stock due to unusual weather conditions has to be taken into account when evaluating a rangeland's carrying capacity. It is not adequate to assess only one year's carrying capacity as the re-population of a herd, after a catastrophic winter, may take longer than regeneration of feed resources. Most herders do seem to take a longer term perspective, balancing animal numbers with anticipated feed resources and may carry excessive stock only for short-term reasons such as an expected acquisition of grazing rights. This is considered by some as proof of opportunism or poor management, but in fact it is a more realistic long-term view. There has been considerable debate as to whether the pasture areas of southern Qinghai are a 'non-equilibrium system' where climatic variability and extreme weather events, such as snow disasters, have a major impact on the growth in

[1]The initial fencing programme involved the enclosure of a 500 mu (33 hectares) area of winter grazing to leave as a strategic reserve until the late winter when animals are at their weakest and snow disasters are more likely to occur. In the second phase of the programme fences are used to demarcate each herder's grazing land.

livestock numbers and the type of vegetation. The project's consultants' opinions have differed on this point. Conditions do not show the very high degrees of variability found in the classical non-equilibrium systems in the arid tropics. However, the climatic variability and the occurrence of snow disasters indicate that the herder strategy of taking a long-term approach to the optimum number of livestock is substantially correct.



Maximising livestock production

The productivity of the rangelands is often only viewed in terms of meat production; and livestock are not seen in the wider context of supporting the people's way of life. Prices for meat changed very little over the five years of the project. Little account has been taken of the importance of butter and dried cheese in the herders' diet. The role of the yak in providing transport and in providing hair for making tents has also not been taken fully into account.

The government policy is to keep the same number of yaks, more sheep, and fewer horses. The herders are encouraged to have a higher proportion of productive females and to allocate the best grass to young males and more milk to the male yak calves to enable them to be marketed earlier to maximise meat production at the expense of other products.

Chapter 3

THE SOCIOECONOMIC SITUATION OF HERDERS IN GUOLUO PREFECTURE

A REVIEW OF RESEARCH CONDUCTED UNDER THE QLDP BY SYLVIE DIDERON AND MARIE-LOUISE BEERLING

3.1 Introduction

The 1992 feasibility study for the Qinghai Livestock Development Project recommended that a socioeconomic component be incorporated. The study recommended that the project fully take into account the socioeconomic changes taking place in the area. These include: population growth and movements, changes in grazing systems, and possible marginalisation of the Tibetan minority. Even though the project had a technical focus, it was considered essential to have a full understanding of social issues, in order to have sustainable and replicable results.

At the start of the project in 1995, a socioeconomic monitoring and evaluation component was introduced under the supervision of foreign consultants. A baseline socioeconomic survey of herders' households was carried out and sample households were selected to monitor the impact of the project. This information was to be complemented by household income and expenditure surveys and a farm management survey. Another objective was to identify socioeconomic constraints to development, and to suggest ways to eliminate these through project extension and training activities.

Work on the socioeconomic baseline survey began in 1995 (Dideron R1995; Dideron and Wangdan R1997) and a monitoring framework was designed (Dideron R1996). Later on in the project the initial ideas on long-term monitoring were dropped and the emphasis was shifted to more extension-oriented measurements of impact (Zachernuk R1998, R1999). Additional socioeconomic information was gathered by Gates's rangeland stock-taking mission (R1996), Goldstein's social evaluation study (R1996), field work carried out by the extension and training consultants (Matthewman R1996; King R1998, R1999), the participatory resource planning workshop at Jianshe (van Wageningen R1998), and reports on weaving (Dunsmore R1998, Beerling R2000).

The five years of socioeconomic investigations and project monitoring and evaluation work have focussed mostly on poverty issues (socioeconomic stratification; causes and consequences of poverty; and changes in socioeconomic stratification) and herders' perspectives (perceptions of constraints; attitudes towards government interventions; and responses to project activities). The situation of herders has been compared with overall social trends, while impact measurement has largely focused on the effects of the project's extension efforts (see Chapter 5).

3.2 Agro-ecological Zoning, Demography and Sampling

Physical features

The project area consists of a series of high plains which are each surrounded by mountains. Together they form a watershed from which the waters eventually accumulate into the Yellow River. This river has already reached a considerable width at the point where it is crossed by the S 101 road at Lajia township. The many mountain streams create valleys that gradually widen towards the main roads.

Due to high elevation and low average temperatures (<0°C) crop production is not possible in most of the project area (Lajia being the exception). The economic mainstay of the area is extensive semi-nomadic livestock production.

Guoluo Prefecture

The project's initial socioeconomic baseline survey (Dideron R1995) used official statistics to make an inventory of agro-ecological and socioeconomic indicators for Guoluo Prefecture. Data on topography and climate, land use, population, administrative units, livestock numbers, prices for livestock and livestock products, infrastructure, and government services were gathered to inform the selection of the pilot project townships.

Guoluo Autonomous Prefecture is made up of six counties. The 1994 statistics report a population of 122,000, with 89.5% Tibetans, the remainder being Han Chinese and Mongol, Hui, Sala, and Tu minorities. Of the total population, more than 77% live in rural areas; 10% in the prefectural capital Dawu (Maqin county) and 12% in county headquarters. The two project counties — Maqin and Dari — together make up 44% of the total population of the prefecture. Maqin has a population of 31,224 and Dari 21,666. Seventy per cent of Maqin's population and 95% of Dari's are Tibetan.

The project townships

The project townships were selected to represent a cross-section of township types (Table 3.1).

There are significant differences between the townships. These are caused by a combination of variation in the length of the grass growing season from 90 to 200 days due to variations in temperature and snowfall levels; varying quality of grassland and whether or not pastureland has been allocated to individuals; the level of remoteness (access to inputs, marketing facilities), and the level of implementation of the Four-way programme. Townships also differ in the way regulations and policies have been applied. The townships are relatively

Table 3.1: Characteristics of the six project townships as of October/November 1995

	Wusai	Jianshe	Sangrima	Dangluo	Xueshan	Lajia
Utilisable land (total)	75%	80-90%	59%	80-90%	87%	56%
Management system	Group and individual	Group and individual	Tent groups	Group and individual	Individual (extended family)	Individual (extended family)
No. animals/hh	79	140	141	71	287	165
Sheep/yak ratio	0.53	1.4	1.24	1.4	2.32	1.07
Housing	>50% houses	50% houses	Tents	50% houses	100% houses	100% houses
Fencing	43%	30%	NA	30%	60%	85%
Shelters	>50%	20%	NA	20%	46%	12%
Oat growing	small plots	small plots	NA	small plots	50%	100%
Marketing facilities	Good	Relatively good	Poor	Relatively good	Good	Very good
Average annual income	550 yuan*	c. 700 yuan	706 yuan	c. 700 yuan	3046 yuan	1493 yuan

* There are 8.28 yuan to a US dollar.
NA not available

autonomous as most budgets are raised within the townships. Some townships are more prosperous as they have more resources at their disposal. Differences between townships are expressed in variations in taxes, quota regulations, land allocation rules, service provision, poverty alleviation programmes, and salaries of local leaders and service providers (Zachernuk R1998).

The project's townships have a variety of herd management systems. These range from group management in Sangrima township to groups coexisting with fences inherited from the collective system in Jianshe, and groups of relatives cooperating and migrating simultaneously in Wusai, to strict individual management in Xueshan and Lajia. Where pastureland has been allocated late, herders still tend to operate in groups and share pastures and work, especially where there are no fences.

Socioeconomic stratification

To assess the socioeconomic status of different herder households, a way of ranking the prosperity of households was developed. This ranking system was based on herd size and composition. Herd size is the most important indicator of wealth as in the Tibetan pastoral system, animals provide security for the reproduction of the household, and are also the main form of accumulating wealth. The number of animals owned is an expression of the relative wealth of a household. Officials also view it is the main criteria of relative wealth. It is estimated that 25 yaks (of which at least 30% should be productive females) are necessary to ensure a household's subsistence. This number of animals requires one man and one woman for management and milking. Ten animals are considered the absolute minimum for survival. The proportion of sheep to yaks is a further indicator of prosperity. Poor households usually have a pure yak herd with no sheep. In the six project townships the average ratio varied from 0.5 to 2.3 sheep per yak .

The stratification system distinguished between three types of household: those unable to meet subsistence needs; those able to meet subsistence requirements but unable to save; and those able to meet subsistence requirements and make savings. The study classified households into the six categories from 1a to 3b (Table 3.2).

Table 3.2: Household prosperity categories

	Category 1 (poor)	Category 2 (average)	Category 3 (rich)
Sub-categories	1a: less than 10 animals very poor and vulnerable 1b: 10-20 animals poor, difficult conditions	2a: more yaks than sheep (typical for Dari) 2b: more sheep than yaks (typical for Maqin)	3a: sheep/yak ratio 0.77 3b: sheep/yak ratio 1.4
Characteristics	• average hh size of 4 • < 20 animals • barely meet subsistence needs • very poor • only yaks	• average hh size of 7 • 20 to 120 animals • can meet subsistence needs • average income • mixed herds	• average hh size of 7 • 120 animals • ample income allows savings • invest in livestock production • mixed herds
Constraints	• vulnerable to accidents • insufficient labour • no savings capacity • reliant on off-farm income	• not enough savings capacity to make investments • little access to credit	• limited area of land and productive capacity
Stated priorities	• to improve diet • to increase livestock numbers • to increase off-farm income	• to improve grassland & fences • to reduce black beach • to build animal shelters • to grow oats	• to continue grassland improvement • to improve living conditions: housing, solar generators

This categorisation can be further refined if the number of animals (or, ultimately, the number of sheep units[1]) per person is taken as an indicator instead of number per household. This is considered to be a better system, but it is not universally applicable because the actual level of 'rich' and 'poor' differs very much from one township to another.

This ranking reflects the physical and economic conditions in each township. For example, the poorest households in Xueshan have more than 25 animals per person, a level which exceeds that of average or even rich households in other townships (Dideron and Wangdan R1997). This issue is discussed in Section 3.4.

3.3 Herders' Living Conditions

Habitat and way of life

Except for the county headquarters, almost the entire population of the project area lives in the rural areas and engages in livestock keeping. The settlement pattern is extremely dispersed. In the winter season (October to May) the herders usually stay in their winter pastures relatively close to rivers, main roads, and township headquarters. Owing mainly to government programmes that promote permanent winter dwellings, clusters of houses have emerged in the winter grazing areas over the last 15 years. In the summer months (May to September) the herders move to the summer pastures which are usually situated on higher plains or in narrower valleys. The habitat pattern becomes most dispersed in the summers with families usually living more than a day's journey from each other. The summer dwellings are traditional tents woven of yak hair.

[1] 1 adult sheep represents 1 sheep unit (su); 1 yak is considered equivalent to 4 sheep in terms of feed consumption, therefore 1 yak = 4 su; 1 horse = 5 su (Goldstein 1996: 1 yak = 5 su, 1 horse = 7 su)

The average household size is slightly over five persons. Tibetans, as a minority people, are exempted from 'the one-child policy'. A household is usually a nuclear family (father, mother, and 3-6 children), but many other forms of cohabitation occur including multi-generational households and extended family households. The proportion of female-headed households may be as high as 20% (Zachernuk R1999). The not unusual out-migration of male household heads in poor households leads to this situation.

Life is very basic for most plateau dwellers: they live off what their animals provide, with few outside inputs. Their diet consists mainly of home-made dairy products (milk, cottage cheese, yoghurt, butter, and meat) which are supplemented by roasted barley, tea, potentilla roots, and, in the richer households, bread and sugar. Trade is very limited and very few households sell butter or milk. The isolated living conditions preclude commercial activities. Outside of the county headquarters there are no markets or fairs where products can be exchanged.

Practically the entire population of the project area adheres to the Buddhist religion. Religion is visible everywhere with prayer flags, altars, and prayer wheels in the homes and lamaseries. Many young men become monks and so do not work as herders. Religious ceremonies are the main occasions during which people meet.

Livestock and land

The main production factors of the Tibetan livestock keepers are livestock and land. The few households (1-10%; see Dideron and Wangdan R1997) that do not have animals are very poor. There are hardly any alternative sources of income.

Since decollectivisation in the early 1980s, individual families have become responsible for the management of livestock and land (Goldstein R1996). These assets remain formally the property of the state, which has allocated numbers of livestock and areas of grazing land to herders on a 50 year lease-contract basis. To pay for their leases, herders have to deliver a quota of animals and animal products to the government against fixed (low) prices. The government in turn provides certain services to the herders at regulated prices such as. veterinary services and commodity items like flour and oil.

The allocation of animals was done between 1983 and 1986. The animals belonging to the cooperative (the former 'production brigade') were divided according to household size, with each household receiving the number of animals deemed enough for their subsistence. How many animals each household eventually held depended on how rich the cooperative was, and whether the household had any animals of their own. (In the Communist era it had been at the discretion of each township to allow families to keep some animals as private property. In Xueshan and Lajia households had been allowed to keep as many animals as they wanted, while in Sangrima only one yak cow per person was allowed.)

The allocation of land occurred simultaneously in some counties and townships, while in other counties it happened later (1986-93). It was done on the basis of animals allocated earlier, and sometimes it partly took into account the surplus acquired in the intervening

years[1]. The winter/autumn pastures were allocated first, and the summer pastures (much) later. Records of the areas of land are kept at township headquarters and are known by the association/cooperative leaders; however, the herders themselves often seem to be unaware of the amount of land they hold (Gates R1996). There is active encouragement of fencing, mostly of winter pastures, but also for summer pastures. By the end of 1995, more than 170,000 mu of grazing land had been fenced in Dari county, and the target was that 80% of the 3,889 households in the county would have their grazing land fenced by the year 2000 (Goldstein R1996). By the end of 1999, 2.14 million ha (6.8% of used pasture in the province) were reported to have been fenced (Xung, P67).

Activities and livelihood systems

Yaks are essential for family survival. It is only after the number of yaks is sufficient to cover the basic subsistence needs that a family will also consider keeping sheep. Sheep are never milked; they are mainly kept for their wool and for selling.

There are hardly any off-farm activities in the project area. The only non-livestock related activities are caterpillar fungus and *Potentilla* root collection and some hunting. Very few Tibetans derive income from trading or handicraft production.

Women do the milking and milk processing and look after young animals, collect dung, and do most of the housework. Wool processing and weaving is also women's work. Men herd the animals and look after the feed (grass cutting, grass planting, fodder crop production, feeding animals). They are also responsible for animal health care, meat processing, skin preparation, and leather work. The summer is the busiest period for women, while the men are busiest in winter. Children are engaged in farm work from the age of seven (Dideron R1995; King R1999; Beerling R2000).

Position of women

Apart from investigations into women's work loads, little in-depth information was collected on the position of women in Tibetan herder society. Most information was derived or deducted from other sources.

Dideron (1995 R1997), Zachernuk (R1999), and Beerling (R2000) report that women have a relatively independent status in Tibetan society. This is probably related to the fact that Tibetan culture is influenced by a matrilineal kinship system. While inheritance generally follows patrilineal lines, it is not unusual that, in the interests of safeguarding the family property, the female line is actually followed (Dideron R1995). Sometimes a young couple will install themselves in the wife's home (matrilocal). Beerling noted the relatively high degree of independence of young women. They can have their own separate dwelling, choose their own partner, and often have one or two children before marriage. Divorce seems to be quite frequent, although describing a woman as a divorcee may be another way of saying she was never actually married.

[1]The fact that allocation of land did not always happen at the same time as allocation of animals caused some families to attempt to increase their livestock numbers in the mean time, in order to have increased claims at the time of land allocation. Eventually this was only partly taken into account and households received land basically according to the number of animals they had in 1985.

The number of female headed households (FHH) is probably more prevalent than is officially recognised. Using official township statistics, Zachernuk (R1998) found a proportion of between 7 and 20% (average 14.3%) FHHs and believed that this was probably an underestimate. Six out of 51 households in the socioeconomic survey were female headed. Almost half of the FHHs were classified as very poor (< 10 animals per capita). The lack of labour is the main constraint for FHHs. Another constraint they have is that they find it difficult to attend training sessions as often as men do, and they do not have easy access to inputs (they often need the help of relatives to get veterinary treatment for their animals). Women are more tied to the home and generally less mobile than men.

Nevertheless the overall impression is that women are important and enjoy a relatively autonomous status. They seem to have a freedom of expression and can be producers, income earners, and decision-makers in their own right. However, the tendency (also in QLDP) to view women consistently as 'herders' wives' rather than as economic actors in their own right is not conducive to women's advancement.

3.4 Issue I – The Structure of Poverty

Poverty as a relative concept

Analysis using the above wealth ranking categories, showed that poor households made up between 30% and 52% of all households in the project area (Dideron and Wangdan R1997; Zachernuk R1998, R1999). Goldstein (R1996) reported that 73% of the households in Jianshe were poor whilst there were no poor households in Xueshan. Official data suggest that the 117 families in Dangluo township (32%) are exempted from taxation because they are considered too poor (Matthewman 1996; Zachernuk 1998). Dari is a nationally recognised poverty area and benefits from central government poverty alleviation funds.

Local perceptions of what is poor and what is rich are always relative. Herders in Wusai and Jianshe said that for them, 'rich' households were those with more than 20 animals per person and 'very poor' households were those with less than five animals. In Sangrima, households which have 30-70 animals per person were thought of as 'rich' whilst households with between five and fifteen livestock per person were viewed as 'very poor'. In Lajia, Xueshan, and Dangluo the people did not even mention the category 'very poor'. In Xueshan, the poorest households have more than 25 animals per person, which is more than what is considered as average or even rich in other townships (Dideron and Wangdan R1997).

Origins of poverty

Animals were equally distributed at decollectivisation in the early 1980s; however, by 1999 major differences in wealth – as measured by the number of livestock — had come about. Dideron (R1995) gives the following causes of socioeconomic differentiation.

- Access to livestock and grassland. Livestock numbers were allocated according to household size and grazing land according to herd size. Changes in household size and composition since then may have created the need for more animals to sustain households' subsistence requirements. However, the number of livestock a family can keep is limited by the amount of accessible grazing land they have.

- Labour availability. A minimum amount of labour is required to care for livestock. Notably the number of yaks that can be kept (the subsistence animal par excellence in the project area) is limited by the number of female family members. Households lacking male members, or with disabled persons, have difficulties in caring for their herds.
- Access to off-farm income. The major off-farm income source is the gathering of caterpillar fungus for sale. In some areas this resource is being depleted. Also, some households lack the labour power to go out and gather it. Other income-generating opportunities are impeded by limited skills and knowledge.
- Climatic disasters, accidents, and disease. The impact of climatic disasters, accidents and disease are often a consequence of poverty with smaller herds being more vulnerable. Such events lead to further impoverishment by, for example, herders incurring further debts to replace their herds. There is large climatic variability in the project area with frequent snow disasters and droughts.

Another determining factor mentioned by Dideron is a household's start-off position. Present day animal wealth is a result of how 'rich' a cooperative was at the time of the allocation of animals, and on how many of its own animals a family had at that time. Wealth was already unequally distributed before decollectivisation.

Goldstein (R1996) mentions population growth as a reason for concern. As children mature, marry, and establish their own households, the pastureland given to a household at the time of privatisation will have to be divided into smaller units. There is no way for new households to acquire more pastureland. Goldstein refers to this as trans-generational fission. To compensate for this herders try to improve the productivity of their pastureland, but it is difficult for them to attain the economic level of the original households. This can lead to herders trying to overstock their pastures. If this is not possible they will be forced to accept a lower standard of living.

Herders and local officials themselves cited the following factors that caused poverty (Dideron and Wangdan R1997).

- The lack of adequate good quality grazing land
- The harsh climate, with a short growing season and great variability in climatic conditions and frequent natural disasters
- Large household sizes with too few animals
- Poor management abilities of the herders
- Female-headed households, (overburdening of women and children and insufficient labour)
- Lack of access to off-farm income
- Trans-generational household division

Although labour availability is missing from this list, it is obvious from other sources (Matthewman R1996; King R1998; van Wageningen R1998) that labour force constraints are among the major causes of poverty and that female households (HH) are more affected. Dideron's analysis shows that the number of animals is closely linked to the active labour force in a family, a lack of labour keeps a family from herding more animals. A mixed herd requires more labour than a single-species' herd. While yaks are the mainstay of a family's

subsistence, the number of yaks that a family is able to keep is limited by the availability of women to look after them. One woman can handle a maximum of ten female yaks. A young couple with small children can hardly manage to keep the number of yaks required for their subsistence.

Consequences of poverty

Differences in animal wealth and income, as shown in Table 3.3, imply that the constraints and, therefore, the needs of the different wealth categories are fundamentally different. The income generated by 31 households, representative for the socioeconomic stata defined in Table 3.2, is summarised in Table 3.3.

No major constraints seem to exist for rich households (Goldstein R1996). Their livestock enterprises are secured as most have winter fencing and animal shelters, and they are able to invest in summer fencing, grassland improvement, and oats pens. Other preferred investments are a house, household equipment, clothes and jewellery, and a pilgrimage to Lhasa. Such households do not purchase animals, but sell them to pay for the investments (Dideron R1995). They are more commercially oriented (Zachernuk R1998).

The basic constraint for the 'average household' is money for investment. The priority of these households is to improve their grassland and livestock production by practising forage cultivation and by building fences and shelters. As they lack access to credit their only way to generate more income is to increase livestock numbers, which is, however, constrained by a shortage of grazing land.

For poor households, the main constraints are the lack of subsistence means, investment, labour, and cash. The priority for poor households is to satisfy their subsistence needs for food and clothing. They attempt to achieve this by increasing the number of animals they keep. Also, they look for income-generating opportunities, but are constrained by lack of labour. Sometimes they lease their land to richer herders and work for others. However, the vicious circle of poverty, vulnerability, and limited opportunities often hinder them.

Table 3.3: Summary of household models (Dideron 1995)

Categories (see Table 4)	1 (poor)		2 (average)		3 (rich)	
Sub-categories (see Table 4)	1a	1b	2a	2b	3a	3b
Total number of livestock head	10	20	120	120	250	250
- of which yak	10	20	68	50	141	104
- sheep	0	0	52	70	109	146
Value of production before taxes/fees	607	3,413	16,004	14,413	33,184	29,980
Value of production after taxes/fees	567	2,733	14,476	12,943	30,016	26,922
Off-farm income in yuan	2,500	3,000	2,000	2,000	2,000	2,000
- Total net income for the household	3,067	5,733	16,476	14,943	32,016	28,922
- Total net income per capita	767	1,433	2,354	2,135	4,547	4,132
Cash income per capita	2,640	4,380	10,095	10,000	18,786	18,640
Composition of cash income:	660	1,095	1,442	1,430	2,398	2,390
- from yaks	5%	32%	46%	35%	52%	38%
- from sheep	0%	0%	34%	46%	38%	51%
- from off-farm activities	95%	68%	20%	20%	11%	11%

Because the prevailing view is (wrongly) that poverty stems from laziness, ignorance, and lack of interest, the poor come to feel ashamed of their situation which further undermines their position. Many poor households are female-headed.

One notable trend from the project area is the marginalisation of the poor. The poor come to be ignored in various ways, Between 1997 and 2000 the proportion of poor households among demonstrator households went down from 3 to 0% (personnel communication Laurens Wester). This does not mean that there are no longer any poor households, but that they are being overlooked by the extension services. The poor are even underrepresented in the project's monitoring sample. Any monitoring exercise should take a representative cross-section of households. However, the project's monitoring sample had more better-off households. Of the 51 households, only 11 fell in the poor category, 8 in the average category and 32 in the rich category (Dideron and Wangdan R1997; Zachernuk R1998). Attempts should perhaps have been made to have equal proportions of all three categories.

The gap between the poor and the rich will increase unless structural action is taken to stop the poverty spiral. Zachernuk's mathematical household model predicts that under unchanging circumstances, in about ten years time (c. 2008), poor families will have a negative income of almost 3,500 yuan (Zachernuk R1998).

Solutions to poverty - perspectives of herders and others

To cope with poverty herders:

- maximise their herd sizes, to reduce their vulnerability to disaster;
- pool their resources by keeping family herds together even after parents die–they operate on an extended-family basis in tent groups to share labour to manage the grasslands and herds;
- improve the feed resource by protecting the grasslands (fencing), improving grassland productivity (sowing, rodent control, and fertilisation), and by using alternative feed (fodder, barley flour);
- procure access to more pastureland by migrating to other areas (Sechuna, Maduo) or by renting grazing lands; and
- herd, weave or build fences for others, and pursue other types of non-farm income. (Their access to many alternative income sources, however, is limited by their low education level).

The herder's coping strategies are, however, often regarded as 'irrational' or 'traditional' by outsiders, who fail to see that they are forced to follow these strategies for the lack of any alternatives.

The government offers assistance through relief programmes such as: exemption from taxes, the five guarantee system, the establishment of poverty communities (as in Wusai), work for welfare schemes, poverty alleviation programmes, and subsidised loan schemes (Four-way programme). However, many of these packages do not help the poor because they cannot afford to join them. For example, the Four-way programme is too expensive for the poor to join. Fencing 500 mu of grassland, constructing a 60 m^2 animal shelter, and planting

10 mu of oats costs approximately 17,000 yuan which presupposes a savings' capacity of 3,400 yuan per year over five years. This is way beyond the capacity of the poorest herders.

Extension activities are supposed to take account of poor households by selecting a certain number of poor households as demonstrator households, and by including low external input technologies — such as hand tilling for oats cultivation. However, the mainstream package gets nearly all the attention and is taken up by those herders who can afford it. The number of poor households participating in extension schemes remains negligible.

It was suggested that QLDP promote poverty alleviation by launching a revolving fund for animals. The idea was to help the poor get out of poverty by supplying them with animals. A suggestion was also made to establish a pilot weaving project to help create income-generating opportunities for women. Unfortunately neither of these has been instituted.

So far, little structural improvement of the poverty situation has been achieved. However, the perspectives outlined by Gates (R1996), Goldstein (R1996), and Zachernuk (R1998) leave little doubt that a structural solution to poverty urgently needs to be found, if only because this must form an essential part of a structural solution to resource degradation. It is also clear that viable poverty-alleviation strategies can no longer be defined unilaterally, but have to be developed in dialogue with the herders and must be based on their own coping strategies.

3.5 Issue II – Managing a Marginal Resource

Range degradation: constraint or construct?

The issue of the availability of good grazing land is closely linked to the poverty debate. For the herders in Guoluo prefecture, limited accessible pasture land is a major constraint. The consensus is that this situation is getting worse.

In the many interviews with herders conducted during QLDP's socioeconomic and extension work (Dideron R1995; Gates R1996; Goldstein R1996; Dideron and Wangdan R1997; Zachernuk R1998; Matthewman R1996; Moorehouse R1997; King R1998; van Wageningen R1998), the herders highlighted rangeland degradation and the formation of black beach landscapes and the depredations caused by rodents and drought as the main causes for their deteriorating resource base. It is difficult to assess which is cause and which is effect; as there is a complex of factors that interplay in a vicious circle. However, what has been lacking in this analysis has been the human element. The herders themselves seldom mention overstocking or keeping too many animals as the cause of the diminishing resource base (Matthewman R1996). This is because animals are so vital to their survival and it is inconceivable to them that there could ever be 'too many' animals.

Interestingly, local officials likewise say that, despite erosion, rodents, and black beach, the carrying capacity of the rangelands has not yet been exhausted (Matthewman R1996; Goldstein R1996). The concept of destocking is utterly alien and is not seen as a solution to the problem, but as an attack on herders' livelihoods.

However, academics, policy-makers, and extension staff strongly believe that the causes of grassland shortage are overgrazing and overstocking, and that they reflect irresponsible use of the range resource by the herders (Xiong, P67).

There are clearly conflicting views. The herders mention mainly 'natural' causes; whilst the authorities blame the herders for causing the problem and think that their production system should change.

A third view, held by some outside experts, is that the government has been instrumental in rangeland degradation. Gates (R1996) holds that consistent pressure from central government to increase production led to 'four decades of overstocking'. The fact that production aspirations were not coupled with any concern for the condition of the rangeland led to devastating results. Government policies contributed to the disruption of the traditional nomadic system with its built-in flexibility that allowed for differential grazing and the spread of grazing pressure. Goldstein (R1996) argues that the introduction of the family responsibility system (decollectivisation) and the reduction of transhumant movements to winter and summer pastures have led to increased and more concentrated grazing.

The fact remains that the family responsibility system has not only privatised the rangeland, but also individualised the herding system in Guoluo. This has caused a fundamental change in the relationship between herders and the rangeland. Some observers consider this as the imposition of a new model: private subsistence ranching. Goldstein has said that "This policy actually transforms the Tibetan herders, who were originally open-range pastoralists, into subsistence ranchers." The system has moved towards an American style ranching system when it is clear that the Qinghai-Tibetan Plateau lacks many of the features that allow American ranches to operate successfully.

Strategic choices

The present situation is far from the traditional open, communally-managed, pastoral system characterised by frequent seasonal migration in line with the needs of the animals and the condition of the rangeland. The in-built flexibility mechanisms, which are essential for sustaining extensive livestock production on marginal grazing land, no longer exist (Gates R1995; Goldstein R1996). The new system has fundamentally changed the old pattern by ruling out mobility and free access to land. This has made differential grazing practically impossible, and makes it difficult for households to adapt the amount of land to their needs.

In the face of weaker animals, lower milk production, more casualties from disease, decreasing fertility, and large losses in case of snow disaster, they have deployed a range of coping strategies.

The traditional strategy of mobility — to seek greener pastures elsewhere — has not quite disappeared. Particularly in Dari, herders practise seasonal migration to Maduo or to Sichuan provinces. Other strategies include the renting and buying of more land. The more efficient use of resources is achieved by splitting herds and sharing land and tasks with other herders in tent groups. More directly management-oriented strategies include deferred grazing, which is made easier by fences; hay cutting on natural grassland; and the strategic planting

of oats and barley. Reseeding and rodent control were already carried out before the introduction of such government schemes. Herders have also consciously adapted their herd structures to their production conditions (Zachernuk R1998). Since decollectivisation in the mid-1980s, herders in the southern townships have reverted to a higher yak-to-sheep ratio (Zachernuk R1999).

Re-orienting the production system is one of the options. Zachernuk's analysis of trends since the mid-1980s suggests that some herders have embarked on the government-traced path that leads to private ranching (Zachernuk R1998, R1999). They have built fences and shelters to protect their grassland and implement rotational grazing. Other indicators of this trend are a higher sheep to yak ratio and a higher proportion of female animals in the herds. This strategic option is only, however, open to richer herders who have a surplus to sell. These happy few are the epitome of the new Guoluo subsistence rancher. The majority of herders are still forced to stick to the traditional production system because they are poor.

Where the strategies fail

Apart from planting oats, there is no ready answer to the problem of grassland shortage and degradation. Most herders cannot afford to destock and become a rancher. However, access to good grazing land is becoming an ever more serious problem.

The key issue is that of 'control'. The government, assumes that the carrying capacity of the area is exhausted, and so is trying to bring the number of animals into balance with the feed resources through its three- four- and five-way policies[1]. The herders who have to live in this marginal environment with its harsh and unreliable climate want to secure their livelihood and seek to control their risks by maximising their herd sizes. They feel the government policies are of no help to them.

Both are trying, but failing, to control the situation. The government's policies lack a scientific base. Data on the volume of the feed resource are lacking and no ways have been employed to take account of geographic and temporal variability. There has been no adequate monitoring system to verify whether degradation has increased and at what rate, which has precluded a proper analysis of cause and effect. As a result, no extension policy on grassland management exists and no concrete advice on stocking rates or grassland protection is available (Matthewman R1996; Zachernuk R1998).

The herders have more confidence in their own knowledge and invention than in any if the government's policies or interventions. Interviews conducted by Goldstein (R1996) and Dideron and Wangdan (R1997), and to some extent King's participatory rural appraisal (PRA) work (R1999), have shown how herders react to government service provision and interventions with frustration and scepticism. At the Jiangshe Resource Planning Workshop, herders showed little confidence in government efforts to control rodents. Government efforts to restore grassland were also considered with scepticism, and as being too expensive

[1] "control flock by grass production and keep balance between feed and animals"; "increase the number of sheep, maintain the number of yaks, reduce the number of horses"; "one allocation, four fixings, five unifications"; see Xiong (P67).

for individual herders (van Wageningen R1998). This leaves the herders with little else to do but to continue with their traditional coping strategy of maximising livestock numbers to circumvent climatic hazards.

Enhancing control

With the help of QLDP ways are being sought for both the government and the herders to enhance their 'control'. This is happening on the government's side by support for rangeland research, the introduction of monitoring systems based on remote sensing and GIS, and by encouraging an integrated perspective on the problems of rangeland management.

The herders are being assisted to develop reliable technologies aimed at reducing the loss of animals from unpredictable climatic hazards. If the herders have more control over animal productivity and mortality, they will soon see that it is no longer necessary to keep so many animals to maintain their subsistence. The system's rationality can change and develop in other directions.

To find out where enhanced control and the associated development interventions could lead, a mathematical model representing a household economy was developed (Zachernuk R1998). The model showed that continuing the present production systems as it is would result in a wider gap developing between poor and rich herders with the income of poor households even becoming negative. It also indicated that:

- keeping the current number of animals constant by selling off the increases would result in a widening gap between poor and rich households, although the poor household would not end up with a negative but with a small positive net income;
- manipulating the tax structure would not change the situation significantly;
- improving veterinary care for poor herders would mean that a poor household would have four more sheep and 1,022 yuan less net income — these households would only break even when the sheep price was 250 yuan, the main gain would be a lower degree of risk; and
- improving veterinary care for the average herders means that average herder households, could expect an increase of 2 yaks and 15 sheep with a drop of 2,554 yuan in net income — at current animal prices this would represent a net gain of 2,196 yuan.

The model also suggested that investments in fencing could reduce mortality rates. However, it is unclear whether or not this is a realistic assumption. If, for example, the lamb mortality goes down from the present 32 to 28%, and the calf mortality rate from the present 21 to 13%, then the gain will be 45 yuan. If mortality rates are further reduced, then the gain will be higher. This calculation does not take into account other advantages of fencing such as weight gain of adult animals, economy in terms of labour, and better relations with neighbours.

Technology can help to enhance control over rangelands and eliminate hazards in livestock raising, but the socioeconomic impact is not automatically a positive one. Lack of attention to socioeconomic initiatives will lead to an ever widening gap between the rich and the poor. Technological initiatives must go hand in hand with socioeconomic policies aiming at the more equitable distribution of wealth.

3.6 Issue III – The Politico-Administrative Context

An issue common to both the poverty and the rangeland management debate is that of existence of norms to which herders are subjected. These are defined on the one hand by culture and religion, and on the other by the policies and laws instituted by the administrative authorities. The herders have to make their decisions and make a living within these boundaries.

The hierarchical administrative system of counties, townships, herders associations, and herders' cooperatives, all impinge upon herders' lives. Policies implemented by these bodies include:

- livestock-related and general taxation, levies, and quotas;
- five-year plans and other central-level policy priorities, such as 'development of the west';
- minority policies and relief policies in poverty alleviation programmes;
- environmental policies — these are relatively new but forebode dramatic impacts on herding; and
- population and migration policies.

The extension and the market environments also directly influence herders.

The herders hardly figure at all as active stakeholders in these formal institutions. Rather, they have to abide by their decisions which are seldom made with herders' interests in mind. This often forces them to operate within the narrow margins of what is permitted and what is not. Finding holes in the fabric of the law has become a part of their way of life. Inter-county migration, long-term renting of grazing land, interference with fences, sticking to herding groups rather than individual ranching, are not so much signs of opposing government policies as attempts to adapt a basically incompatible normative environment to the requirements of semi-nomadic herding. The Tibetan herders are accused of being 'reluctant' to accept government decisions, and of being unwilling to understand the rules and laws. The herders' perspective is that they do this out of necessity, as the existing rules do not allow them to safeguard their own interests and to continue their extensive semi-nomadic livestock production.

The herders are not involved in the formulation of rules and regulations, laws, policies, and five-year plans. These laws and policies can be described as essentially being "about them but without them". Hence, Tibetan herders have to operate within a normative environment that does not reflect their values, interests, and priorities, and that is at times contrary to them.

The limits to autonomous decision making

The herders have a variety of coping strategies but official interventions constrain rather than help them to implement these strategies. The privatisation policy is a case in point.

Major policy developments over the last few decades have been the abandonment of the collective production system, the introduction of the family responsibility system, and the

privatisation of pastureland. Although these policies have had a profound impact on the lives of the herders, the herders have not been consulted about their introduction. The policy of shifting the responsibility for production to individual households is suitable for crop-growing areas but not for the herding areas, as extensive livestock production on marginal land can derive substantial benefits from communal resource use. Although they are hesitant to discuss this issue openly, herders, and especially those who are poor and have not (yet) benefited from the Four-way programme, would have preferred another, more open, system (Goldstein 1996). The implicit constraints the new policy imposes on the free movement of assets (land and livestock) have been discussed earlier. The fifty-year leases and the inflexibility of the rules are perceived as major problems and may in the long run be major impediments to efficient herd management.

Privatisation of pasture land has done little to solve the grassland problem whilst poverty alleviation policies have not helped the poor. Extension has not been geared to the poor. The markets are still distorted by government interventions in pricing and purchasing, while deficient infrastructure and remoteness prevent herders from freely trading in the market. Recent environmental projects, such as the Three Riverheads' project, have been put forward by central government with national rather than local interests in mind. It is unsure whether or not this programme will improve the situation of the herders. The central government's idea to create 'livestock-free' zones (by moving herders to other areas) epitomises the baseless concept that herders are the source of degradation when scientific fact shows that grazing actually helps to keep ranges healthy.

There are a number of other examples of where the institutional environment imposes constraints on autonomous decision-making.

- The rigid top-down structure which, although it may be a good way to pass instructions and information from the top down to the grass roots, can also be a filter that keeps information away from the grass roots. This is an issue because of the remote and dispersed habitat of the herders who are therefore not able to independently access information themselves and have to rely on others to keep them informed.
- Government control of the management of animals, stocking rates, and the use of rangeland is exercised through cooperative, association, and township leaders. The timing of transhumance movement of livestock is determined by these leaders. Also, Goldstein quotes some township officials who are aware that they have the authority to intervene in case they perceive overstocking has occurred (Goldstein 1996). However, local government has never limited the number of livestock, although the idea of restricting the number of animals per family, as is already the policy in Tibet, has occasionally been discussed at local government level.
- The rigid structure of extension is not conducive to the involvement of herders. Only a small part of the herder community is actually served by extension services.
- The statistics that herders are obliged to supply to officials about their farms are often inaccurate (Zachernuk 1999). This hampers planning.

Given the unhelpful official policy framework it is not surprising that Tibetan herders sometimes behave in a recalcitrant way towards government officials and government rules. The official environment at best does not help the herders, and at worst limits and restrains

them in the implementation of their survival strategies. Rules and regulations imposed by outsiders often have such opposite effects.

The problem can be solved either by improving the legitimacy of the normative environment by enhancing local people's participation in decision-making, or by reducing the strictness of the norms, so that violation becomes less of a necessity.

Greater flexibility in applying the norms is necessary to avoid completely estranging the Tibetan herders from the state system. This would reduce mutual distrust and social unrest, and would help to create an atmosphere of solidarity. It would create the basis for a situation in which parties can collaborate for a better future. Imposing the norms by force will only make things worse.

Can the herders be brought in?

The Tibetan herders are a negligible minority amongst China's population of 1.3 billion. Their traditional extensive mode of production is viewed as being of little relevance where more than 95% of all meat consumed is pork and poultry produced in intensive production systems. Beef and mutton from extensive production systems account for less than 5% of national consumption.

The participation of Tibetan herders in the mainstream of development has lagged behind, due to their low levels of education and participation in representative bodies. Tibetan herders are widely considered as 'traditional', backward, and uneducated. In policy development forums there is little understanding of the predicament of the herders. The majority of Chinese, who are overwhelmingly crop growers, have little affinity with extensive livestock keepers and little appreciation for the values of their production systems. There is a general lack of faith in the traditional migratory grazing systems; which are considered 'irrational' and harmful because they are believed to cause range degeneration (Richard 2000). Such dichotomies need to be recognised and resolved, lest they result in increasing polarisation between the herders and the authorities.

The problems seem to be growing. Besides the need to improve rangeland by implementing management measures and conservation practices, there is also a need to change regulations concerning land holding, tenure, taxation, and marketing (Gates 1996). Fences and shelters will not create a stable equilibrium if the problems of high population growth, lack of alternative employment opportunities, and restoration of degraded pastures are not tackled simultaneously (Goldstein 1996).

The population, environment, food security, and employment problems that China is facing are national scale problems. They cannot be solved without a thorough policy framework. For these policies to be effective they must be formulated in consultation with a cross-section of Tibetan herder society.

As it is clear that the Tibetan herders must be 'brought in' and consulted the main question to address is how best to do this? What options exist given that the herders distrust the government and disregard its rules, whilst the government lacks faith in the herders?

Creating trust is a precondition. This requires the two sides understanding each others' motives and perceptions. Further socioeconomic studies of the herders' perceptions, and forums where technical and socioeconomic experts can discuss each others' work, will contribute to a better understanding. Participatory rural appraisal (PRA) should be adopted as the basic methodology for technology development and extension. But more important than meetings and methodologies is a willingness to listen to each other and to respect each others' views.

Language has been a major barrier preventing mutual understanding between Chinese and Tibetans. Chinese officials should learn the Tibetan language as the Tibetans would have more faith in officials who speak Tibetan.

A system of bottom-up planning needs to be adopted to allow marginal groups, such as Tibetan herders, to participate in decision-making processes. QLDP's Jianshe Resource Planning Workshop provided many learning experiences that can be useful in the development of bottom-up planning.

3.7 Conclusion

The role and place of socioeconomic work in QLDP

Poverty, the herders' concepts of the causes of rangeland degradation, the herders' reactions to government policies, and the government systems' attitude to herders have been the main socioeconomic themes in QLDP.

Yet, the incorporation of a socioeconomic component in QLDP has been officially viewed as an alien concept that was imposed by the donor and implemented by European consultants. The Bureau of Animal Husbandry had no socioeconomic expertise among its staff and viewed talking with the herders as of only limited use. They saw their real role as being to increase animal productivity. Five years of socioeconomic research have done little to convince the decision-makers in BAH that socioeconomic investigations need carrying out to improve the efficiency of their task. In many ways the socioeconomic work has failed because it has been carried out in relative isolation, by foreign consultants. The Chinese counterpart was from outside BAH, and there has been little sense of Chinese 'ownership' of this work. There has been little integration of the results of the socioeconomic studies into other aspects of the project. The socioeconomic work has reflected the poor relationship between the Tibetan herders and the authorities: it has lacked legitimacy because the partners have not been fully involved.

Poverty and distribution of animal wealth

Poverty is a big problem and a major challenge for all involved in the development of the Qinghai-Tibetan Plateau. However, so far there has been little reduction of poverty in the project area. Suggestions have mostly remained at the recommendation level. What needs doing is to:

- develop extension packages for poor herders and female-headed households that take into account their lack of finance and labour;

- develop low cost technologies that require few external inputs to reduce labour requirements and relieve drudgery; and
- investigate what types of credit are needed and manageable by poor households.

At a structural level it is recommended to:
- investigate alternative income-generating opportunities for all Tibetan herders. Within one or two generations the livestock sector will be unable to support the growing population;
- promote education and skill development;
- develop and stimulate the processing and marketing of livestock and livestock products; and
- facilitate flexible land legislation and allow the free movement of assets.

Animal wealth is unequally distributed with the poorest 20% of Tibetan herder society having only 2-5% of all animals whilst the top 20% own more than half of all animals. These increasing levels of inequality mean that more and more people are sliding into poverty, which makes the implementation of anti-poverty measures ever more urgent. This also has implications for the implementation of range management measures. The bigger stock owners make greater demands on the range resources and are therefore more likely to cause degradation than the small stock owners. It is economically rational to target range management policies at the herders with the most animals.

Women herders

The number of female herders and female-headed households has probably been underestimated. They are ignored as they are not regarded as a target group by the extension agents, the BAH, or the QLDP. These organisations only talk about 'Tibetan herders' wives'. Yet, in some cases they are producers and decision-makers in their own right. They suffer from specific constraints with a lack of labour being the most prominent one. Programmes are needed to offer assistance to women herders. This is quite different from attempts to build the capacity of women as weavers.

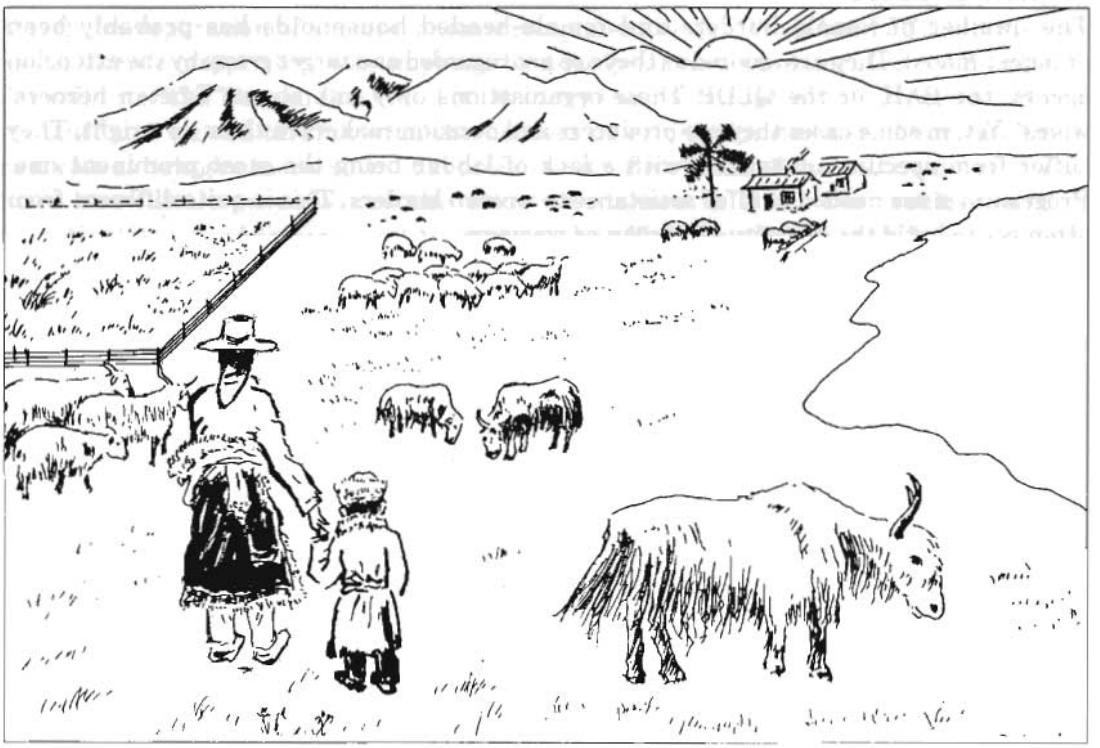
Future developments - do socioeconomic insights help?

The government's policies lack a scientific basis. Its premises have not been objectively determined and assumptions have not been explicitly declared. The government has used dubious calculations of rangeland carrying capacity. The problem is that basic data on the volume of the feed resource is lacking and no mechanism exists to take account of geographic and temporal variability. There is no adequate monitoring system to verify whether black beach is increasing and whether or not snow disasters have become more frequent and the climate is changing. It is therefore impossible to properly analyse causes and effects, and hence very difficult to make a realistic long-term grassland development policy. As a result, no extension policy on grassland management exists and concrete advice on stocking rates or grassland protection is not available (Matthewman 1996; Zachernuk 1998). Nevertheless the government does impose policies, the soundness of which is justly questioned by the herders.

The herders have more confidence in their own knowledge and invention than in the government's policies and interventions. The herders feel frustration and scepticism with

the government's service provision and interventions (Goldstein 1996; Dideron and Wangdan 1997; King 1999). Some herders are critical about privatisation, saying that it has only worked for the benefit of herders who have enough land. However, privatisation is a fact, and most are in favour of fencing to control, protect, and improve their land. Planting oats is rather positively viewed although it has only been implemented by the better-off herders (Dideron and Wangdan 1997). The herders have little confidence in government efforts to control rodents and restore grasslands, as they are viewed as too expensive for individual herders to carry out (van Wageningen 1998). The opinion on shelters is not unanimously positive; some herders feel the standard design is not good and others feel that providing too much protection makes their animals lose their resilience for surviving the harsh conditions (Dideron and Wangdan 1997). Herders have little contact with the extension services at county level, and there are not many grassland technicians involved in extension work (Matthewman 1996; King 1999). The veterinary services have been appraised rather critically (Dideron and Wangdan 1997).

The main challenge for the future is to bring the herders and government officials together. This will be a difficult task but they have one main interest in common: the need to safeguard the common resource base. The new policy to 'develop the West' may serve as the first test ground. The idea is that western China benefits from enhanced economic investment, whilst eastern China is able to release some of its pressure of overpopulation. Can this policy be the win-win situation that it is advertised to be?



Chapter 4

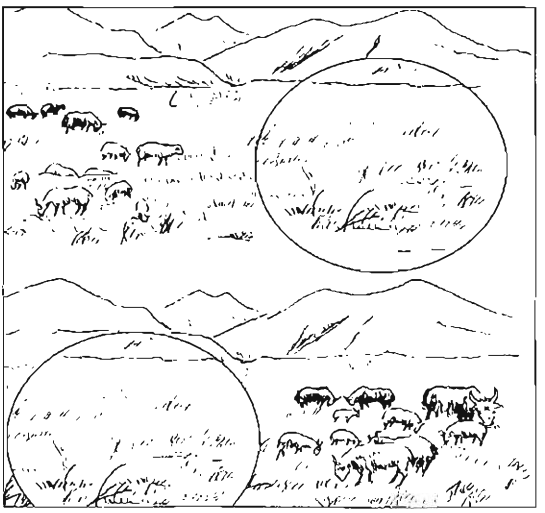
TECHNICAL INTERVENTIONS BY THE PROJECT

4.1 Rangeland Rehabilitation

A REVIEW OF RESEARCH CONDUCTED UNDER QLDP BY DENNIS SHEEHY

The majority of research on rangeland rehabilitation has been oriented towards developing techniques to rehabilitate black soil type degraded rangeland (commonly referred to as 'black beach'). According to Li (P30), the term 'black beach' first appeared in a 1976 report of the Bureau of Animal Husbandry. The Tibetan term for 'black beach' is sanaheta. The same author reports that 'black beach' only occurs at elevations of between 3,600 and 4,500m in areas affected by a combination of human activity and environmental factors. Black beach formation follows a sequence of sedge degradation, rodent burrowing, wind and water erosion, sedge mortality and increased amounts of bare ground, root shearing by frost heaving, and continued wind and water erosion. The paper describes the different levels of degradation and maps out the sequence of vegetation community changes in terms of changing species' composition, decreasing vegetation cover, and increasing cover of bare soil.

There are two theories regarding the formation of 'black beach' landscapes. The comprehensive factor theory sees over-grazing and rodent damage as the main factors initiating damage to *Kobresia* rangeland communities. Wind erosion of the damaged area begins with eroded away sand being blown on to and covering adjacent areas. This, together with frost heaving, destroys the vegetation until only bare soil remains. The climatic change theory believes that global warming has caused the formation of black beaches through a sequence of increase in temperature, degradation of vegetation communities, soil erosion, and decreases in precipitation. Supporters of the comprehensive factor theory maintain that the decline in *Kobresia* communities has occurred too rapidly to have been caused by climatic change (Ma, P44).



Ma (P44) reviewed research that has been carried out since 1970 to find ways of rehabilitating black beach. Experiments have addressed reseeding techniques and the suitabil-

ity of species for revegetation. Approximately 20 species of grass have been found to be suitable for seeding black beach degraded grasslands. The best suited species have been *Elymus nutans* and *E. breviaristants*. In 1985, a review of previous research recommended that seriously degraded grasslands should be re-vegetated, whilst moderately degraded grassland should be disk-harrowed to loosen soil to allow natural regeneration. The recommendations for lightly degraded grasslands are that livestock grazing should be controlled. *Kobresia* spp., which make up most of the natural vegetation cover of alpine grasslands, have been successfully used to reseed degraded grasslands; however it has been less suitable as a rehabilitation species because of its low germination rate and slow development (Ma, P44).

Black soil type deteriorated grassland is mainly sandy loam and sandy soil over grit soil. The gritty soil only supports plants that are toxic to livestock and a few grasses. Coarse organic matter of the original meadow surface soil is 10% and contains 50-54% moisture. The surface soil of the black beach black soil type has 4% coarse organic matter and its moisture-holding capacity is only 4-18%. Li (P20) points out the benefits of rehabilitating 'black soil types'.

Most of the alpine meadow rangelands of Guoluo Prefecture are degraded. There are reportedly 2.86 million hectares of degraded grassland (49% of total usable grassland) in this prefecture (Li et al., P24) and black beach covers 1.23 million hectares of this. The total area of grassland reportedly degraded through pika and *Microtis* infestation is 2.56 million hectares (44% of usable rangeland). Ma et al. (P43) have estimated that the area of black beach rangeland in Qinghai Province in the 1990s was 2.13 million ha.

Systematic rehabilitation

The rehabilitation of grassland that has less than 30% vegetation cover, but with deep soils on relatively level topography, involves consecutively disking, harrowing, sowing seed of adapted perennial grass species, fertilising, and finally rolling. Rehabilitation by seeding should begin in May and June. The application of fertiliser is necessary during the plant growing season.

Two rehabilitation methods have been developed for areas with thin black soils where slopes make machine operation impractical and vegetation cover exceeds 30%. If vegetation cover is more than 50% and toxic weeds dominate the site, rehabilitation needs to involve fencing out large herbivores, controlling rodents, and the control of toxic plants by applying herbicides. On black soil slope sites with a vegetation cover of between 30 and 50%, rehabilitation should involve fencing, rodent control, reseeding, and fertilisation. Broadcast seeding should be carried out between May and June and animal hoof action can be used to set seed. Fertilisation is necessary for successful stand establishment and needs to be applied in subsequent years (Li, P24).

Black beach rehabilitation using these methods has a productive stand life of between five and eight years. Maximum yield is reached in two to three years and then decreases. After eight years, stands need to be revisited and re-treated if stand productivity is to be retained. The average annual yield of fodder over the eight-year life of the stand is 6,660

(DW) kg/ha. Pasture rehabilitation costs over the eight years of stand life use have been calculated by Li (Li, P24). The establishment of sown pasture is estimated to cost yuan 3,596/ha and semi-sown pasture yuan 352/ha. Assuming that sown pasture has an average annual yield of 6,660 kg/ha over eight years, it would accrue an economic value of yuan 10,656 (8 years x 6,660 kg/ha = 53,280 kg x yuan 0.2/kg = yuan 10,656). Therefore the benefit obtained from a combination of sown and semi-sown pastures over the eight-year life of the stand would therefore be yuan 1,621/ha.

Testing species adaptability

Shi et al. (P58) tested ten varieties of oats to determine their capacity to increase hay yields under plateau conditions. The three oat varieties, Qinghai 444, Bayan 5, and Xuan 18, were found to have significantly higher yields than the control (Bayan 3).

Ma (P44) reported on results of trials of 25 introduced plant species. Eleven species of grass and two species of legume did well in the Guoluo environment, whilst six species of grass and one legume species proved moderately suited, and three species of grass and one species of legume were unsuitable. Most species introduced from other areas of China appeared to have the potential to rehabilitate black beach.

Shi et al. (P58) reported on tests of 21 perennial grass species seeded in various mixtures to determine their over-winter survival potential and productivity under plateau conditions. Three grass species (*Elymus nutans* Griseb, *Elymus sibiricus*, and *L. perisicum* Boiss) that use above-ground seed reproduction strategies appeared well adapted. Eight grass species that use below-ground vegetative reproduction strategies also appeared to be well adapted. Stands of mixed grass species improved community structure and increased herbage yield more than stands of single grass species. The authors also suggested that germplasm of grasslike plants (*Cyperaceae*), which dominate turf communities, be tried out.

Black soil areas below 4,000m in elevation with slopes of less than 10 degrees were selected for rehabilitation. The application of fertiliser is necessary to ensure stand establishment and high biomass yields. Also, pest species must be controlled and the plant species used in seeding should be locally adapted. It is also crucial that site management continues after initial rehabilitation (Ma, P44).

The benefits of the rehabilitation of black beach include: 1) increase in above-ground biomass, 2) reduction in negative impacts associated with the severe physical environment (wind desiccation, wind speed reduction), 3) reduction in wind and water erosion, 4) reduction in soil moisture loss, 5) reduction in pest species' impacts, and 6) increased socioeconomic benefits to herders. The rehabilitation of degraded grassland and the prevention of further degradation are of vital importance for both improving pastoral livestock production and stabilising the environment (Li et al., P23)

Control of livestock grazing

Fencing can be important for rehabilitating moderately and lightly degraded black soil grasslands. Fencing allows herders to control livestock grazing to provide an opportunity for native forage species to restore their vigour (Ma, P44).

An enclosure trial was undertaken to study the effect of stopping livestock grazing on deteriorated alpine meadows. The yields, frequency, and cover of four classes of herbage (sedge, grass, palatable forbs, and poisonous forbs) were measured. Two years after fencing had excluded livestock grazing the plant cover had increased by 11%, the herbage yield of sedges, grasses and palatable weeds had increased by 65%, whilst the yield of poisonous weeds had decreased by 23%. Dong et al. (P12) suggest that fencing and control of livestock grazing can be used to improve deteriorated grassland. Ma (P41) notes that grass and grass-like plants had invaded deteriorated black beach grasslands that had been fenced to exclude livestock (Ma, P41).

Weed control

Four herbicides were tested to determine their effectiveness in controlling noxious and toxic plants growing on black beaches in which livestock grazing had been controlled. The mixed herbicide (80% metsuiifuron -methyl + 20% tribenuron-methyl) was most effective in controlling weeds after two years of treatment. The dry matter of beneficial species increased by 235%, the yield increased by 136%, and vegetation cover increased from 60 to 95%. Conversely, the dry matter of toxic plants decreased by 735%, their yield decreased by 87%, and the coverage of these species decreased from 90 to 10%. Three genera of toxic plants were completely controlled. The benefits in terms of increased dry matter for livestock were much greater than the costs of application (Ma, P42).

Improved fertility

Urea fertiliser was applied to deteriorated black soil type grassland in eight different treatments ranging from 0 (control) to 262.5 kg/ha. Urea fertiliser applied at the rate of 150 kg/ha provided the best results. After two years of treatment, the total aboveground biomass and biomass of high quality herbage was 827 kg/ha (53% higher than the control) and 584 kg/ha (106% higher than the control), respectively. More work is needed to determine the best timing for fertiliser application (Ma, P41).

Ma et al. (P42) have reviewed techniques for the rehabilitation of areas of black beach. They recommend establishing a seasonal livestock industry in which yak calves and lambs are fattened on sown perennial pastures as a technique for increasing the production of livestock and encouraging natural regeneration of grasslands. The basis for this suggestion is the high gain achieved by young animals over the relatively short grazing periods of the summer forage-growing season.

Recommendations

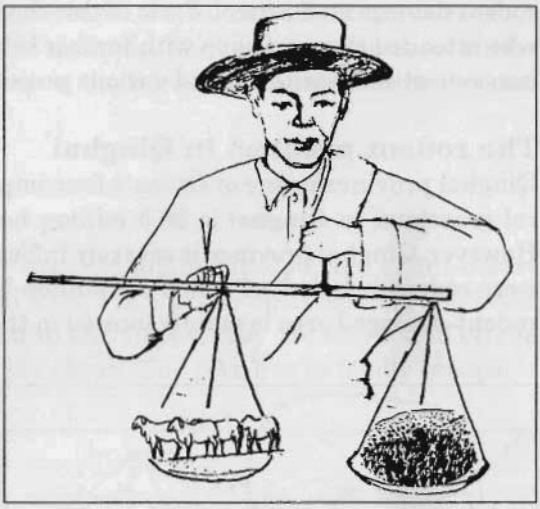
Livestock management and support

Liu and Zhou (P33) have developed the concept of an ideal Rangeland Livestock Industry System (RLIS). This would see an ecological system of livestock production based on the balance of energy transfers between soils, vegetation, and grazing animals with forage being the connecting link. If such a system was established as the basis for livestock production, they believe that the total vegetation productivity of Qinghai rangeland would increase by between 3.6 and 7.2 times.

Liu and Zhou (P33) recommend developing sustainable livestock production systems using RLIS as a guide to 1) developing an infrastructure that includes regulatory mechanisms, proper

stocking rates, rangeland monitoring, rotational grazing, exclusion of livestock from degraded areas, and the revegetation of degraded areas; 2) increasing the use of grown fodder and crop by-products; and 3) organising herder livestock production units into family ranch operations.

Wang et al. (P63) assert that, by applying a set of optimum livestock production models, an ecological balance can be obtained between livestock needs and the grassland. The balance can be obtained by: 1) establishing a stable and highly productive artificial grassland to maintain feed and nutrient balance seasonally for livestock, 2) optimising seasonal animal production by using natural pasture for fattening young stock to create a fast turnover; 3) using hybrid livestock instead of native livestock, 4) developing a scientifically based rangeland monitoring and evaluation system, and 5) by developing scientifically based livestock production models that are a synthesis of traditional and innovative methods.



Li (P27) supports implementation of the government promoted Four-way programme of fencing, forage, and oat planting; animal shelter construction; and house construction, as a way for all families to overcome poverty.

Recommendations for overcoming livestock management problems in the project area include:

- using the grassland law to manage and protect the grassland — including preventing cultivation and the digging up of medicinal herbs;
- improving rodent control by concentrating control efforts in areas where populations are forecast to be high;
- controlling overstocking and overgrazing by extending grazing time on summer and fall pastures and reducing the time spent grazing winter and spring pastures;
- improving the effectiveness of techniques to rehabilitate degraded grasslands;
- finding ways to increase funding for rehabilitation and organisation of grassland use, including interest-free loans to herders, using poverty alleviation funds for grassland rehabilitation, and raising funds at provincial and local levels to implement improved management;
- developing ways to increase animal off-take rate through animal production mechanisms; and
- expanding household livestock production to include other animals.

As well as these measures the government should promote the establishment of alternative economic opportunities other than herding livestock.

4.2 Control of Rodents on Rangeland

A REVIEW OF DISCUSSIONS AND CONTRIBUTIONS TO THE WORKGROUP ON RODENT CONTROL, EDITED BY NICO VAN WAGENINGEN

Shortly before the Concluding Seminar, a separate expert meeting was held on the issue of rodent damage and control. Parts of this chapter have been written by the visiting experts[1] who attended the workshop with further information added by the editor, drawing on discussions at the workshop and various project sources.

The rodent problem in Qinghai

Qinghai province is one of China's four important grazing areas. The total area of natural grassland in Qinghai is 36.5 million hectares, of which 31.6 million ha are usable. However, Qinghai province is severely infested with rodents. In 1998 about 8.2 million ha were rodent infested, of which 6.8 million ha were classified as 'severely damaged'. The rodent-damaged area is mainly located in the south of Qinghai, accounting for 81% of the total area damaged by rodents in the province. The main pest rodent species are *Ochotona curizoniae*[2] or plateau pika and *Myospalax baileyi* or zokor. Other rodent species are the Daurian pika (*Ochotona daurica*), Plateau pine vole (*Pitymys irene*), and the Himalayan marmot (*Marmota himalayana*). The total area damaged by the pika in the south of Qinghai is 4.4 million ha, or 64% of the total damaged area in the province. The area damaged by the zokor is about 0.8 million ha (12% of the total damaged area).

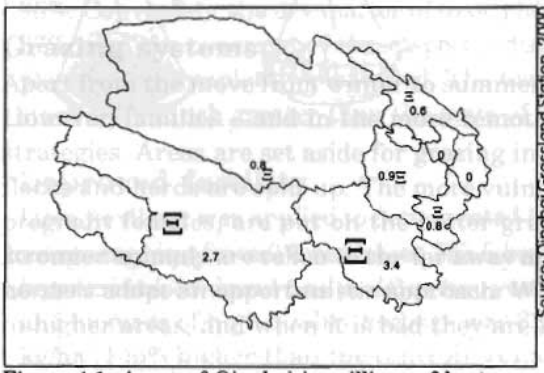


Figure 4.1: Areas of Qinghai in millions of hectares known to be colonised by pika

Nearly one million ha of Dari and Maqin counties (Guoluo prefecture) are colonised by large populations of pika. The area damaged by pika amounts to 74% of the total degraded area of rangelands in Dari and Maqin counties.

According to the calculations of Fan Nai-Chan (P14), there are at least 600 million pikas and 150 million zokors on the grasslands of the Qinghai-Tibet Plateau. It is estimated that they consume 50 billion kilogrammes of fresh grass each year, which is equivalent to the food intake of 30 million Tibetan sheep. The rodents compete with yaks and sheep for grass. They dig and destroy vegetation, and this causes soil erosion, a reduction in ecosystem biodiversity, and changes in the microclimate, which all lead to a reduction in the livestock carrying capacity. A large area of grassland has been degraded beyond the point at which it can regenerate by itself, radically changing the ecology of the environment in which animal husbandry operates.

[1] The workshop took place in Xining from 26 July to 31 July, 2000. The visiting experts are mentioned in Annex 2. Special mention is made here of Dr Pech, Dr Byrom, Dr Fan Naichang, Dr Wu Xiaodong and Dr Ma Yong.

[2] Pika is not a rodent but belongs to the order *Lagomorphae*

Posamentier (R1997) says that the habitat of pika is open land with short vegetation and therefore the occurrence of pika should be seen as an indicator of degraded rangeland and not as a cause. The areas invaded were already suitable as pika habitat.

From the end of the 1950s a number of Chinese research institutes and experts have studied these rodents. This has led to various control methods. The two main institutes studying rodents in Qinghai are the Grassland sections of the Bureau of Animal Husbandry, and the North-West Plateau Institute of Biology.

Ecology and damage of Plateau Pika

THIS SECTION IS FROM FAN NAI-CHANG (P14)

Pikas mainly inhabit the alpine steppe, steppe meadow, alpine meadow, and alpine desert steppe at elevations of between 3,100 and 5,100 masl. Pikas prefer open habitats and avoid dense shrub or thick vegetation. In areas of shrub and steppe, they are only found on the grassland around the shrub, and never enter the shrub. The pika live in family groups.

Figure 4.2: Ochotona curizoniae or 'Plateau pika'

Pikas have two types of burrow system. Simple or temporary burrows are shallow and short and are mainly used in summer. They usually have only one or two surface openings. The other type is the complex burrow system which occupies larger areas. The average length of the tunnels is 13m, with a maximum of up to 20m. The average depth of the burrows is 33 cm, but they may be up to 60 cm deep. The burrow system has many branches that are connected to form a complex network. There are on average six openings, although some have up to 13. The diameter of the tunnels is between 8 and 12 cm. There is usually one nest in the burrow system about half a metre below the surface. It is bedded with soft dry grass and fur from yak and sheep and is where wintering and breeding occur.

Pikas are typical herbivores. They feed on different plants and different parts of one plant selectively. Experiments have indicated that of 31 plant species available in their natural habitat, pikas prefer to feed on only 23 of them. These were mostly grasses, sedges, and legumes. Each pika consumes about 77 grammes of fresh grass per day, which is about 50% of its body weight. The grass consumption of 56 individuals of pikas is equal to that of one Tibetan sheep.

The pika is a diurnal non-hibernating animal. Its above-ground activities peak in the forenoon and afternoon. These peaks change with the seasons. In October the first activity peak occurs at 9 am and the second at 6 pm, while in July the activity peaks come at 8 am and 7 pm.

Close observation of marked individuals indicated that foraging is the dominant behaviour of pikas, comprising 63-78% of their total activity. Pikas have a special feeding pattern,

termed as pecking, as after feeding for a moment they look around or move a short distance, and then feed again. Their feeding frequency is 5.7±1.3 pecking bouts per minute.

Social behaviour between individuals comprises 13% of all their behaviour. The most frequent types of social behaviour are intimate and play behaviour. Aggressive behaviour has seldom been noticed, suggesting that there is a weak tendency for exclusiveness. Where appropriate food and space are available, pikas tend to live in high densities, causing damage to grassland.

Pika studies in Himahe in China suggest that the average lifespan of a plateau pika is 120 days. The longest lifespan recorded has been 957 days.

Pikas live in family groups and their home ranges are relatively stable. Males and females exhibit territorial behaviour. During oestrus, the female holds no territory, but the male monopolises the female and drives away other invading males. The neonates of the current year also sometimes drive away invaders once they reach adult body weight.

The average litter size is 4.7±1.3 and an adult female can produce between one and nine offspring per litter. Each year an adult female can produce between three and five litters.

Whilst feeding pikas damage grass roots and also damage the primary grass and soil layers by burrowing, damage is related to the density of the animals. On one hand, an increasing pika populations increases the area of grassland suitable for habitation by rodents, on the other hand, the habitat restricts the size of the population when it gets to the carrying capacity. When the population increases to the carrying capacity, the population ceases to increase, but damage to the grassland still continues, and the grazing intensity increases.

Review of recent research in Qinghai

QLDP's four-year research programme on rodent control worked with Qinghai's Bureau of Animal Husbandry (BAH). The work was strengthened by experimental studies and recommendations by the project consultants and other BAH staff. Trials and investigation were mainly carried out in Wosai, Jainshe, and Dangluo townships (Dari and Maqin counties). The following section details the findings of the research programme and comments from the workshop.

The extent of the problem in Dari

Aiqi Gong et al. (P4) report that an area of 501,300 ha of the three townships is infested by rodents, causing a loss of around 16.1 million kilogrammes of forage each year.

Workshop comments

Here there is much information on the distribution, abundance, and impact of the economically significant rodent species, particularly the plateau pika (*Ochotona curzoniae*) and the zokor (*Myospalax baileyi*). No information was provided to the workshop on the status of the other approximately 45 species of rodents, including 12 other pika species which occur in Qinghai. Although monitoring stations have been established in seven prefectures to

record changes in the abundance of rodents (see heading 'Population Monitoring and Forecasting'), it is a very difficult task to properly measure trends in rodent impact, and the sustainability of livestock grazing across huge areas of grassland. In future, remote sensing and GIS technology may be useful for broad monitoring.

The effect of rodents and livestock on herbage yield

A trial was conducted over three years to monitor the effect of the grazing of alpine meadow and resown pastureland by livestock and rodents (Aiqi Gong et al., P2). The result of grazing on herbage yield was as follows: no grazing: control; rodents graze freely, livestock grazing restricted: 45% yield reduction; and rodents and livestock graze freely: 58% yield reduction.

Workshop comments

The no-grazing control group made use of cages (exclosures) that excluded pika and yak from the experimental plots. The relatively small scale of the experiments meant that they were unlikely to represent a cross-section of major grassland types and ranges of levels of livestock grazing. The value of the experiments would have been improved by setting up replicated treatments and by measuring attributes of the pasture such as the biomass and the height and cover of palatable and unpalatable groups of plant species, as well as the abundance of pikas and the levels of livestock grazing.

Comparisons of rodenticides

Four years of rodent control trials compared the chemical poison 'Di Shu Na Yen' (sodium, chlorus, check translation) with the biological poison Botulin toxin C (Aiqi Gong et al. P3). Three different concentrations of the chemical were compared with one concentration of the botulism preparation. The result showed that a 0.09% concentration of the chemical and a 0.1% of the biological agent killed 95% of the rodents exposed to it. The biological agent is comparatively safer as it does not pollute the environment or the food chain and is recommended for use over large areas.

Workshop comments

There was some concern expressed about the experimental design as the timing of the assessment of population impact after baiting was not optimal. Botulin toxin C is a preferred lethal control agent in the grasslands because it does not affect livestock or predators. One problem is that it loses effectiveness at temperatures over 5°C. However a protective agent has been developed that maintains the performance of Botulin toxin C at temperatures higher than 5°C. Data from Qinghai and other provinces of China indicate that many 'rodent' species are susceptible to Botulin toxin C.

Population monitoring and forecasting

This study correlated a reproduction index with the capture rate. Regression analysis was used to forecast capture rates (an indicator for the rodent population) from a known reproduction index. Aiqi Gong et al. (P1) established that the reproduction index as estimated in April will forecast the capture rate in the month of September of the same year and of the next year. Similarly, September's reproduction index correlates with the capture rate of the following April. However, in this regression relation the number of factors is limited.

Workshop comments

The abundance of rodent populations was recorded over three years at nine monitoring stations in seven counties. In autumn of each of the three years the station staff recorded the extent of rodent infestation over the whole prefecture. Each station also used killed samples to collect monthly data on the demographic parameters for the major pest species. (It would have been better to have used live capture methods to monitor the abundance and survival of rodents, with a separate killed sample to measure reproduction.) The aim was to provide three and twelve monthly forecasts of the size of the rodent population. No data were reported to the workshop, although the paper referred to above did include the regression equations for making the forecasts. The predictions apparently have about 70% accuracy, but the predictive models require considerable improvement. For example, they fail to account for factors such as climate, the condition of the pasture, or the level of grazing by livestock. It was suggested that at least seven to eight years of data are required to establish the pattern of rodent population dynamics at the monitoring sites.

Control methods

An experiment compared bait application by machine with the traditional form of application by hand. Another experiment compared bait attractants with commercial, ready-made sterilants. The results indicated that, for rodent control over a large area, the machine-distributed bait is more economical as it saves time and labour, even though it requires an attractant added to the bait. The commercial sterilant did not work very well.

Workshop comments

Although aircraft and ground-based machinery can be used to distribute rodenticides, the project area's difficult terrain and climate necessitate that most rodent control measures are applied by hand. A trial has been conducted to measure the intensity of poison baiting required to effectively control rodents. This trial demonstrated that increasing the spacing of baited strips from every 25m to every 50m did not reduce the effectiveness of control. This led to recommendations to reduce the intensity, and hence the cost, of rodent control. Several types of attractants have been tested. This research is particularly relevant to the future use of control agents such as plant-derived sterility agents which pikas find unpalatable.

Research elsewhere

In many countries the focus is on integrated pest management (IPM). Viruses have been successfully used to reduce rabbit populations. Advances in gene engineering and immunocontraceptives hold great promise for the future.

Opportunities for development

A 'systems' approach to managing grasslands

The substantial findings from the research conducted over many years in Qinghai (Fan et al. 1999) needs to be made more widely available to policy-makers, technicians, field staff, and other people involved in grassland management. It is especially important to increase awareness of how to manage the total grazing system, which includes pasture, livestock, and rodents. Most attention is focused on managing rodents, with insufficient recognition

of the strong ecological interactions between the pasture composition and livestock and rodent species for each of the major grassland types.

Rodent community composition and population dynamics

Studies suggest that the suite of rodent species present in an area is related to the habitat type. Also, the population dynamics of each rodent species is affected by environmental factors such as the condition of the pasture and the climate. However, current strategies exclusively focus on the control of the main rodent species. The management of pest species and the conservation of non-pest species could be improved by increased recognition that the whole community of rodent species in an area will respond to changes in the habitat, due for example to grazing by livestock.

Monitoring systems

The current monitoring system provides the basis for the collection of data and the forecasting of pika population dynamics. However, the value of this could be significantly enhanced if additional information was collected on other key aspects of the grazing system such as pasture condition, the abundance of rodents other than pika and zokor, and the level of grazing by livestock. The rodents data will have little use unless the environmental conditions are also measured. Reliable field data will provide essential 'ground truthing' calibration and verification for any future remote sensing monitoring system. Improvements to the monitoring system may require additional training and support for field staff.

Province-wide rodent survey data should be combined with other types of research to produce maps of the distribution and the levels of damage caused by rodents. These would provide better information to enable policy makers to adjust measures taken to suit the differing ecological types. Measures could be fine tuned according to locality. Such maps need producing soon to allow each prefecture to improve rodent management.

Predictive models for rodent population dynamics

The models used to predict changes in the abundance of pikas could be improved significantly. This may require collaboration with specialist scientists from other research institutions in China or overseas. Better predictive models will help to determine when rodent control is necessary. Also, being able to forecast rodent outbreaks would help to increase the effectiveness of rodent control measures by ensuring they are applied before high population densities of rodents are reached. Such modelling exercises are being used to predict outbreaks of Brandt's vole (*Microtus brandti*) in Inner Mongolia in a collaborative project between the Institute of Zoology (IOZ), the Chinese Academy of Sciences, and CSIRO Wildlife and Ecology (Australia).

The province's nine monitoring and forecasting stations should be strengthened to collect more data on grassland vegetation, climatic factors and rodent populations. They should progressively set up a monitoring system based on a geographical information system.

Integrated pest management

Byrom (2000) describes a new approach to rodent management using integrated pest management (Singleton et al. 1999). It recognises the importance of basing control measures on

a good understanding of rodent ecology. These studies showed that in the project area further research is required on:

- compensatory responses following pika control which lead to increased survival or reproduction levels;
- the rates of re-invasion by pikas after control;
- the dependence of pika population dynamics on pasture conditions and climate; for example identifying the factors that determine the onset of breeding and survival over winter; and
- the value of controlling pikas compared to other measures such as managing livestock or re-seeding pastures.

Research should be conducted on a large enough scale to provide useful information for grassland management and experiments should include sufficient replication so that results are reliable. In addition, an ecological approach may find that there are conditions in which pikas have a beneficial impact on grasslands. An in-depth study based on work done until now should be carried out on the inter-relationships between rodents, livestock and grassland.

Rodent control technology

Rodenticides used to kill pikas also affect non-target species. Techniques that minimise the effects on other species, such as machines that place the baits in artificial burrows, however, increase the cost of rodent control. Research in Australia, and elsewhere, is developing a new species-specific, environmentally-benign method of sterilising pest species using an immuno-contraceptive vaccine that can be delivered using non-toxic baits[1]. Similar research is being carried out on Brandt's vole in Inner Mongolia. Immuno-contraceptive technology is only in the early stages of development, but there may be opportunities in the future for its application to pest species in Qinghai's grasslands.

Demonstration plots and management practices

Demonstration plots need to be established to show the effects of the Four-way programme interventions such as fencing, rotational grazing, adjustment of herd structure, and the reseeding of rangelands. Three to five areas should be set up covering 5,000–10,000 mu in different ecological zones.

Support for county and township

There is a need for improved support and facilities to county and township staff to allow for effective rodent control. The government should have relevant policies and ensure that adequate funding is made available to guarantee long-term, effective rodent control.

Suitable information towards herders

The knowledge of the herders about rodent control and grassland management also needs improving. A simply written and well-illustrated booklet should be produced. Such a booklet should be made to promote producers' skills.

[1] Details of the technique are described in Chambers et al. (1999).

Better cooperation between research, education and extension institutions
Qinghai province's large size and many types of grassland mean that the rodent pest problem is complex. Therefore for comprehensive rodent control the links between research institutes, universities, and extension agents should be strengthened to combine production, teaching, and research together to promote the effective control of rodents.

4.3 Cereal Fodders, Seeded Perennial Forage, and Rangeland Revegetation

A REVIEW OF RESEARCH CONDUCTED UNDER THE QLDP, BY ERIC LIMBACH

Herders have a difficult life in Guoluo province's harsh sub-alpine and alpine environments. Livestock production is hampered by low rangeland productivity on nutrient depleted soils, snow disasters in late winter and spring, no-to-little conserved fodders, and losses of young stock due to parasites and diseases. Scientists from the Qinghai Academy of Animal Science and Veterinary Medicine (QAASVM) have estimated that overgrazing by pikas has impacted the productivity and livestock production on 49% of the grazeable rangelands of Dari County and on 10% of the grazeable rangelands of Maqin County. Furthermore, black beach affects about 14% of the grazeable rangelands of Dari County and 29% of the grazeable rangelands of Maqin County.

These factors combine to render livestock production in Guoluo well below its potential. The livestock forage base must be improved to help herders to change to a more profitable livestock production system. A considerable impact on livestock health, survival, and production could be made by promoting the production of oat hay in sheep pens during the summer, by selecting adapted grasses to revegetate degraded sites, and by increasing revegetation efforts that have so far not gone beyond demonstrations.

This section reviews the accomplishments of QLDP to introduce improved oat hay varieties, to promote the growing of hay, to field screen improved forage grasses and legumes for revegetation, and finally gives recommendations for rangeland revegetation appropriate to Guoluo.

Cereal fodders for hay production

QLDP initiated a screening programme of cereal fodder varieties in 1996. These field trials were focused on hay production in herders' sheep pens and were enthusiastically carried out by QLDP personnel and scientists from QAASVM. They have been very successful (Jing, P16; Shi, P55; Shi et al., P58 and Yang, P70). Through QLDP's extension efforts, led principally by Yang Lijun, more than 2,200 herder households now grow oat hay for winter feed. Cereal fodder trials were extended from relatively low elevation sites at Xining (2,300m), intermediate elevation sites at Lajia (3,000m), and high elevation sites above 3,000m in Dari and Maqin counties to over 4300m at Sangrima in Dari County.

Introduction of new cereal fodder varieties

Table 4.3 lists the varieties of oats (*Avena sativa*), barley (*Hordeum vulgare*), and rye (*Seceale cereale*) that were screened as cereal fodder crops for growing in Guoluo. It was determined early on that neither barley nor rye did as well as the oat varieties; so further research and extension efforts focused entirely on oats. The growing season in most of Guoluo is generally too short and cool to produce seed from these fodder crops. Oat hay production, however, ranges between about 2,500 and 4,400 kg/ha at most sites, although a few sites were extremely productive, producing in excess of 6,000 kg/ha. At the lower to mid-elevations between Xining and Lajia, oat plants matured rapidly and made good seed production.

Growing oat hay in sheep pens

During part of the winter, especially during lambing season, sheep are kept in pens or corrals constructed of rammed-earth or sod-brick walls. The soils of these pens become well-manured and are high in nutrients. When sheep are herded to high elevation summer pastures, the pens lie dormant. These pens therefore offer protected, high nutrient sites for the production of oat hay in the summer.

Researchers carried out a number of experimental oat seedings in vacant sheep pens. Oats were grown in sheep pens by Jing (P17) in Maqin County (3,200-4,600m); by Li et al. (P28) at Dawu (3,719m); and by Yang (P72) at Lajia (3,650m) and Wusai (about 4,100m) and in a cultivated field in Xining (2,280m). According to the temperature and the length of the growing season, sowing rates ranged from 180 to 255 kg/ha and inter-row spacing from 10 to 20 cm between rows. Seeds were sown at between three and five cm (Jing, P17), three to four cm (Li et al., P28), and four to five cm (Yang, P70). The duration between planting and harvesting was 137 to 145 days at Maqin, 107 to 115 days at Dari, 134 days at Dawu, 150 days at Lajia, 140 to 170 days at Wusai, and 148 days at Xining. Generally, the frost-free period is about 120 to 130 days for areas where oats can be grown in Guoluo.

Table 4.3: Fodder cereals screened for hay production by QLDP

Name	Source	Name	Source
Oats, var. Aare	Fi	Oats, var. Canadian *	Ch
Oats, var. Kapp	No	Oats, Sweet	Ch
Oats, var. Katri	Fi	Xuan 18	Ch
Oats, var. Lena *	No	*Hordeum*, var. Strange	No
Oats, var. Veli	Fi	*Hordeum*, var. Tyra	No
Oats, var. YTA *	Fi	Ryecorn, var. Rahu	NZ
Oats, var. Wakieru	NZ	Spring Oats, var. Aberglen	Wa
Oats, var. Yongjiou 001 *	Ch	Spring Oats, var. Neon	Wa
Oats, var. Yongjiou 108	Ch	Spring Oats, var. Melys	Wa
Oats, var. Yongjiou 233	Ch	Winter Oats, var. Harpoon	Wa
Oats, var. Yongjiou 473 *	Ch	Winter Oats, var. Emperor	Wa
Oats, var. Qinghai 444 *	Ch	Winter Oats, var. Chamois	Wa
Oats, var. Bayan 3	Ch	*Seceale*, var. Norderaas tetra	No
Oats, var. Bayan 4	Ch	*Seceale*, var. Akusti	Fi
Oats, var. Bayan 5	Ch	*Seceale*, var. Anna	Fi
Oats, var. Bayan 6	Ch		

Sources: China (Ch), Finland (Fi), New Zealand (NZ), Norway (No), Wales (Wa)
*These six varieties were the best adapted and most productive of all the cereal fodders tested and are being used in the Oats Extension Campaign for Guoluo herders.

Typically, the sheep pens were shovelled or raked clean of the topmost layer of raw sheep manure. Then the underlying soil and manure were turned over and mixed by manual shovelling, were shallowly disked by small tractor or ploughed by yaks, and finally harrowed and levelled and then seeded (Jing, P17; Li et al., P28). The seed was broadcast at about 225 kg/ha for manual cultivation and 180 kg/ha in drill rows by tractor (Yang Lijun, QAASVM, personal communication).

Dry weight yields ranged between an equivalent of 1,140 and 8,907 kg/ha (Table 4.4). The latter value appears to be extremely high for oat production in Tibetan sheep pens in Guoluo. It is comparable to hay production under modern, intensive agriculture and is at the high

Table 4.4: A comparison of oat hay yields and nutrient content of improved oat varieties at sites in the QLDP area

Variety	Location	Site	Seeding rate (kg/ha)	Yield (kg/ha)	CP (kg/ha)	CP %	CF %
YTA[2]	Dawu	Pen	240	1140	na	11.2	na
YTA[2]	Dawu	Pen	180	**6002	2007	13.7	na
YTA[4]	Laj-Wus*	Pen	200	**5655	1758	na	na
YTA[5]	Dawu	Pen	na	**6640	2221	na	na
YTA[6]	Laj-Wus*	Field	188	2414	1837	11.9	28.0
YTA[7]	Lajia	Field	191	3783	na	na	na
YTA[8]	Lajia	Field	na	4770	na	na	Na
Lena[4]	Laj-Wus*	Pen	200	**5260	1794	na	Na
Lena[6]	Laj-Wus*	Field	188	2566	1682	10.8	27.2
Lena[7]	Lajia	Field	189	4484	na	na	na
Lena[8]	Lajia	Field	na	4970	na	na	na
Melys[4]	Laj-Wus*	Pen	200	**8907	2563	na	na
Melys[6]	Laj-Wus*	Field	188	4675	2102	12.3	23.0
Melys[7]	Lajia	Field	191	5885	na	na	na
Melys[8]	Lajia	Field	na	5283	na	na	na
Neon[4]	Laj-Wus*	Pen	200	**7844	2176	na	na
Neon[7]	Lajia	Field	191	5955	na	na	na
Neon[8]	Lajia	Field	na	4872	na	na	Na
QYJ 001[4]	Laj-Wus*	Pen	200	**5800	1837	na	Na
QYJ 001[1]	Dari	Field	250	4287	na	na	Na
QYJ 001[6]	Laj-Wus*	Field	188	4777	2314	11.8	29.0
QYJ 001[7]	Lajia	Field	202	**4844	na	na	Na
QH 444[1]	Dari	Field	250	5584	na	na	Na
QH 444[4]	Laj-Wus*	Pen	200	**4936	1246	na	Na
QH 444[6]	Laj-Wus*	Field	188	2871	1576	10.9	24.8
QYJ 473[1]	Dari	Field	250	4730	na	na	na
QYJ 473[6]	Laj-Wus*	Field	188	2823	1736	10.6	29.6
Bayan 3[1]	Dari	Field	250	3923	na	na	na
Bayan 3[7]	Lajia	Field	200	**8348	na	na	na
Bayan 4[1]	Dari	Field	250	4080	na	na	na
Bayan 5[1]	Dari	Field	250	5291	na	na	na
Bayan 6[1]	Dari	Field	250	3765	na	na	na
QYJ 108[1]	Dari	Field	250	3361	na	na	na
QYJ 233[1]	Dari	Field	250	4204	na	na	na
Xuan 18[1]	Dari	Field	250	5612	na	na	na
11Varieties[3]	Dari - Dawu	Pen	225-255	4730-5612	na	na	na

QH = Qinghai QYJ = Qing Yongjiu CP = crude protein CF = crude fibre
*Field trials at Lajia & Wusai
** These values were recalculated (multiplied by 0.3636) from the values reported by assuming that the reported values considered dry weight to be about 0.33 rather then 0.12. na = not applicable
[1] Shi Jianjun et al. (P58). [2] Li et al. (P28). [3] Jing (P17): only ranges in values were reported. [4] Yang (P70). [5] Li et al. (P28). [6] Shi et al. (P58). [7] Shi (P55). [8] Yang (P70).

end of such a production range. It appears safe to assume that oat production in sheep pens of Guoluo generally falls into the 1,000-4,000 kg/ha range in these studies, especially in high rainfall summers, like the summer of 1999.

Seed application rates and growth period

QLDP researchers have tested a variety of sowing techniques, sowing rates, and sowing dates. Li et al. (P28) investigated the yield of YTA oats and nutrient content using 60, 120, 180, 240, and 300 kg/ha sowing rates and a 107-day growing period (13 May–28 August) and one of 135 days (13 May–25 September). They determined that 240 kg/ha was the optimal sowing rate. The earlier (end of August) harvest date yielded a greater quantity of hay although it was not as nutritious as samples harvested at the mid-point between 28 August and 25 September. In a corroborative study, Li et al. (P28) demonstrated that 13 May was the best time to sow oats in sheep pens. Later sowing reduced the hay yields and the crude protein content.

In a similar trial Yang (P70) found that a seeding rate of 180 kg/ gave the highest hay yield (1,140 kg/ha). In this case the effects of competition for light at the higher sowing rates of 240 and 300 kg/ha caused lower leaf yields but taller plants. This also gave higher crude fibre yields and lower crude protein contents than the higher sowing rates.

In a separate study, Yang (P70) investigated the effects of hormone and fertiliser application, both alone and in combination, on the yield of hay. Interestingly, fertiliser had hardly any effect on yield compared to the high nutrient sheep pen control. However, growth hormone did increase yields but did not cause seed set and, ultimately, was not deemed appropriate.

Genetic characteristics of oat phenotypes

The isozymes of esterase of four introduced oats and six domestic oat varieties were investigated by Shi et al. (P55) using polyacrylamide gel electrophoresis. Isozyme biochemical characteristics are controlled at the gene level and the stability of esterase isozymes provides an effective means of determining genetic relationships between plant varieties. Six phenotypes were identified by comparing 16 bands of esterase isozymes. The 10 oat varieties were grouped as: 1) Melys and Neon phenotype, 2) YTA and Lena phenotype, 3) Yongjiu 108 and Qinghai 444 phenotype, 4) Canadian and Yongjiu 001 phenotype, 5) Canadian and Yongjiu 473 phenotype, and 6) Bayan 3 phenotype.

After being multiplied in Guoluo, the isozyme characteristics of the progeny of the four introduced varieties and Qinghai 001 did not change from the patterns of their parents. This genetic stability indicates that these varieties should breed true for at least four or five generations. It is important to classify the genetic characteristics of the about 600 oat varieties at QAASVM to better understand which varieties are related.

Seed production

Since 1996, the area in Guoluo producing foundation oat seed has increased from 225 ha to about 2,714 ha (Jing, P16). Growers are also producing seed on a further 12,540 ha (Jing, P16). This seed is supplied to Guoluo, Xinjiang, and Tibet. The most important oat varieties

include YTA, Melys, Lena, Canadian, Yongjiu 001, Yongjiu 473, Xuan 18, Bayan 5, and Qinghai 444. Oat seed trials were established in Xining (Yang, P72) and Lajia, Maqin County (Shi, P57). Their results are presented in Table 4.5.

The yields were higher and the days to ripening longer in Lajia than in Xining. The fact that the Lajia plots received 405g ammonium phosphate and 105g of urea while the plots in Xining were not fertilised largely accounts for differences in seed yields. On the other hand, the site at Lajia is at an altitude of about 700m higher, which helps to explain the slightly longer period taken for ripening for all varieties there. At any rate, these varieties demonstrated their seed production capacities and the seed of these varieties is being multiplied and expanded across southern and eastern Qinghai.

Table 4.5: Seed yields and ripening periods at Xining and Lajia for six oat varieties

Variety	Xining[1]		Lajia[2]	
	Yield (kg/ha)	Days to ripen	Yield (kg/ha)	Days to ripen
YTA	3560	102	4770	104
Melys	3750	118	5283	123
Neon	3600	117	4872	129
Lena	3630	115	4874	117
Yongjiu 001	3090	95	--	--
Qinghai 444	3630	101	--	--

[1] Yang 2000a
[2] Shi 2000

Adoption by herder households

The oat hay campaign has been extremely successful across the QLDP project area. About 2,318 herder households are now growing oats in sheep pens over about 515 ha (Yang, P71). These pens have produced an accumulated production of about 4,414,500 kg of oat hay, an average of 8,543 kg/ha for each household. The statistics' bureau of Guoluo assumes that one kilogramme of hay has a value of about 0.4 yuan. This valued the oat production to be equivalent to about 1,759,858 RMB. As production costs average about 1,147.5 RMB/ha the surplus value of oat hay produced in the project township has been about 1.1 million RMB, or about 500 RMB per household. Jing (P16) estimates that production of oat hay in sheep pens benefits herders to the extent of about 480 RMB per household. Unless oat seed becomes very expensive, the enthusiasm with which the herders have taken to growing oats for winter hay should continue.

Introduced perennial forages

Perennial forages are required in Guoluo for the revegetation of degraded rangelands, to arrest the erosion of soil on black beach and other severely eroded sites, and to improve the rangeland forage base for sheep and yaks. At present, QAASVM has over 700 types of perennial forage grasses in its seed collection, but few have been tested under field conditions at high altitudes. Between 1996 and 1999, QLDP and QAASVM introduced 72 varieties of improved forages grasses to Guoluo (Limbach R1998, R1999, R2000; Liu, P31; Shi et al., P58). These introductions included 18 legume varieties and 54 perennial grass varieties from within and without China (Table 4.6).

Table 4.6: Perennial grass and legume forage varieties introduced by QLDP

Scientific Name	Source	Scientific Name	Source
Agropyron dasystachyum	Ca	*Lupinus luteus*	Ca
Agropyron intermedium	Ch	*Medicago falcata*	IM
Agropyron longatum	Ch	*Medicago falcata*	Ch
Agropyron smithii	Ca	*Medicago sativa var. Able*	Ca
Agrostis alba	Ca	*Medicago sativa var. Anik*	Ca
Agrostis hugoiana	Ch	*Medicago sativa var. orsa*	Ge
Alopecurus pratensis	Cn	*Onobrychis sativa var. Remont*	Ca
Astragalus cicer	Ca	*Oryzopsis munroi*	Ch
Bromus inermus	Ge	*Phleum pratense*	Ca
Bromus inermus var. hakari	NZ	*Phleum pratense*	Ge
Bromus inermus var. tiki	NZ	*Phleum pratense var. Engo*	No
Dactylis glomerata	Ca	*Phleum pratense var. hja*	Fi
Dactylis glomerata var. haka	Fi	*Phleum pratense var. tammisto*	Fi
Dactylis glomerata var. tatu	Fi	*Phleum pratense var. tuukka*	Fi
Deschampsia caespitosa	Ca	*Phleum pratense var. vega*	Fi
Deschampsia caespitosa	Ge	*Poa alpina var. mantelsaatgut*	Ge
Deschampsia flexuosa	Ge	*Poa annua*	Ge
Elymus nutans	Ch	*Poa compressa*	Ca
Elymus sibiricus	Cn	*Poa crymophila*	Ch
Elymus trachycaulus	Ca	*Poa poiphagorum*	Ch
Festuca arundinacea var. retu	Fi	*Poa pratensis var. alpina*	Ca
Festuca fascinata	Ch	*Poa pratensis*	Ge
Festuca kirilovii 01	Ch	*Puccinellia tenuiflora*	Ch
Festuca kirilovii 02	Ch	*Roegneria pauciflora var. hylander*	Ch
Festuca ovina	Ca	*Stipa viridula*	Ca
Festuca ovina	Ch	*Trifolium hybridum*	Ge
Festuca ovina var. Karst	Ch	*Trifolium pratense var. jokionem*	Fi
Festuca ryloviana 01	Ch	*Trifolium pratense var. kolpo*	No
Festuca ryloviana 02	Ch	*Trifolium pratense var. pawera*	NZ
Festuca rubra var. America	Ch	*Trifolium pratense var. tepa*	Fi
Festuca rubra subspp. Rubra	Ge	*Trifolium pratense var. violetta*	Ge
Festuca rubra subspp. Rubra	Ca	*Trifolium repens*	Ge
Festuca sinensis	Ch	*Trifolium repens var. tooma*	Fi
Festuca rubra var. Tongde	Ch	*Trisetum flavescens*	Ge
Hordeum violaceum	Ch	*Vicia faba var. alfred*	Ge
Koeleria cristata	Ca	*Vicia sativa var. ebena*	Ge

Sources: Canada (Ca), China (Ch), Finland (Fi), Germany (Ge), Inner Mongolia (IM), New Zealand (NZ), Norway (No)

Tibetan Mixture (Ge): *Agrostis canina, A. gigantea, A. capilaris, Festuca rubra subspp. rubra, F. rubra subspp. Communtata, Poa alpina, Phleum pratense, Poa annua, Deschampsia flexuosa, Trisetum flavescens, Dactylis glomerata, Anthyllis vulneria, Lotus corniculatus, Trifolium hybridum, Trifolium repens, Achillea millefolium.*

It is not for lack of knowledge or access to adapted plant materials that rangeland revegetation is yet to happen in Guoluo. A number of varieties of perennial forage grasses have been identified as suitable for rangeland revegetation at high altitudes in Guoluo. Of the 54 varieties of perennial grasses screened in field trials or used in rangeland reseeding efforts, at least 12 have proved well adapted to Guoluo's environment. These varieties include exotic introductions from outside China and introductions from other regions of China. All of these varieties are of species indigenous to the Qinghai-Tibetan Plateau. They include *Deschampsia caespitosa, Elymus nutans, E. sibiricus, Festuca kirilovii, F. ovina, F. rubra, F. ryloviana, F. sinensis, Poa compressa, P. crymophila, P. pratensis var. alpinum*, and *Puccinella tenuflora*. The real obstacles to enlarging rangeland revegetation efforts in Guoluo

and Qinghai are the relatively high cost of mechanised reseeding operations and the availability of seeds. The seed production base of forage grasses has not been developed for large-scale reseeding operations.

Legumes are important for providing nutritious livestock forages that are high in nitrogen and crude protein. Furthermore, legumes that are inoculated with nitrogen-fixing bacteria, such as *Rhizobium* spp, help to enrich the fertility of the soil. However, hardly any of the legumes grown by Limbach (R1999, R2000) survived in the field, although two varieties of *Medicago falcata* did survive weakly and are persisting in a protected area at Dawu Seed Farm, Maqin Co. Yang (P73) also reported poor performance of legumes when sown at Lajia (3,700m) and Jianshe (4,100m). Dry matter yields have ranged from 40 to 410 kg/ha, averaging about 160 kg/ha. It is recommended that future legume introductions are limited to indigenous varieties collected on the Qinghai Tibetan Plateau.

Rangeland revegetation

This section focuses on rangeland revegetation to improve rangeland productivity and livestock production in Guoluo Prefecture in particular and Qinghai Province and western China, in general. Xung (P67) has reviewed range management and rangeland revegetation practices and policies carried out in Qinghai from the late 1950s.

A major caveat needs to be considered when considering rangeland revegetation. Restoring the productive capacity of degraded ranges is a major undertaking. It is expensive in terms of time, money, and manpower and is very risky. When the plant community has been degraded or transformed to a lower ecological-successional status, an ecological threshold has been crossed. This ecological threshold is a theoretical demarcation between plant communities of different successional status. It represents a dividing line between a more desirable plant community and a less desirable one. Degraded plant communities have a lower ecological status and provide poorer grazing. Once rangeland has moved over to the lower, less productive status, it is very difficult to return it to a more productive status. Direct manipulations, such as revegetation using modern equipment and rehabilitation techniques, are needed to restore a productive plant community. There will always be a risk that after all the effort and money invested the seeding fails.

A successful rangeland revegetation programme can produce the following benefits.

- Increased Forage Production - The seeding of desirable species into severely degraded ranges can increase forage production. However, reseeding is expensive and risky and should not be the first measure to be considered. A review of existing management and alternative options may suggest other ways of increasing forage production at less expense.
- Increased Forage Quality – Successful reseeding can lead to more palatable forage which has a higher nutrient content or a longer green growing period. Changes in management methods may be the most cost-effective means of accomplishing this goal.
- Increased Animal Production - This is a primary goal whether we are concerned with livestock or wildlife. Increased animal production translates into healthier new-born animals and lower mortality rates and greater prosperity for herder families.
- Control of Poisonous Plants - Poisonous plants may be routinely removed by pulling, spraying with herbicides, or burning provided that desirable species are present to re-

grow after the poisonous plants have been removed. If they are not present desirable species have to be seeded in. One of the main features of the overgrazed rangelands in Guoluo is the preponderance of poisonous species such as *Aconitum*, *Delphinium*, and *Ligularia*.

- Reduced Soil Erosion and Better Water Quality - Enhancing and promoting a denser vegetative cover will restore water quality on deteriorated watersheds. On severely eroded sites such as black beaches, soil stabilisation may justify restoration of the vegetative cover, with forage, and livestock production benefits being only the secondary consideration. For watershed improvement, the goal of revegetation should be to enhance the capture, storage, and slow release of water. A good vegetative cover aids the capture of precipitation by allowing it to infiltrate and be stored in the soil to be slowly released into streams. Enhanced watershed values also benefit wildlife and fish.

The counties, townships, and herders are sharing the costs of range revegetation projects in Guoluo. Once completed, the management of these restored rangelands needs changing to correct the problems that caused the original degradation. Part of this improved management strategy is already in place with implementation of the Four-way programme: Table 8 gives the perennial grass and legume forage varieties introduced by QLDP.

Reseeding of degraded rangelands

The successful reseeding of degraded rangelands requires considerable technical and financial inputs, good planning, and coordinated efforts. The following all need careful attention: site selection , selection of adapted plant materials, seedbed preparation, seeding techniques, fertiliser application, and control of rodents and weeds. After sowing the reseeded rangelands need to be continuously monitored and the grazing controlled. Reseeding efforts that initially appear to have only a low seedling density, such as one shoot in every one to one and a half square metres, can still be successful if plant reproduction and expansion occur in subsequent years. At present, the cost of reseeding degraded rangelands in Guoluo is about 120–150 yuan/mu (Ma Yushou, personal communication). This cost is considerably higher than in many other parts of the world. For example, the target costs for revegetation efforts in the Great Basin region of North America usually range from between 30 to 60 yuan/mu. One way of reducing the cost is to use a rangeland drill.

The rangeland drill

The rangeland drill has a number of features that make it superior to conventional seed drills for reseeding rangelands. (Note that direct seeding is variously referred to in the literature as 'inter-seeding', 'sod seeding', or 'over-sowing'). These features are as follow.

- Direct sowing: A no-till seed drill can seed directly into intact grassland sod, eroded soils or rough rangeland without prior mechanical preparation. The advantages are that it simplifies logistics and reduces the cost of reseeding. A chisel in the front of each planter unit opens a furrow in the sod, a delivery tube drops seeds into the furrow (with the depth band maintaining the proper planting depth) and a press wheel, behind, closes the furrow; fertiliser can be applied simultaneously with the seeds.
- Heavy duty design: The rangeland drill on the other hand is designed for use on rough, rocky terrain and hard, unploughed soils. It is stronger and more heavily constructed

than conventional seed drills. Each planter unit is separately hinged with a depth regulator band so that each planter unit works independently. Furthermore, end wheels on the back of the drill ensure that sod openers (see below) neither gouge the soil too deeply nor become airborne when working on rough ground.

- Less soil erosion: Direct seeding greatly reduces soil erosion problems associated with ploughing. It has the additional advantage of the seeding operation being performed in one operation.
- Cost effectiveness: A typical reseeding operation, using traditional agronomic techniques might consist of the six separate operations of woody plant removal, root-ploughing, harrowing, broadcast seeding, application of fertiliser, harrowing again, and roller packing. Direct seeding with a rangeland drill may require only one pass over the land. Consider the comparative costs in fuel and manpower between the two operations. At present, the cost of reseeding degraded rangelands in Guoluo is about 120–150 yuan/mu (Ma Yushou, personal communication). This cost could be reduced to perhaps 30–60 yuan/mu by using the rangeland drill.

Site selection

It is always best to choose revegetation sites that have the highest potential for recovery. Very degraded sites will often provide hardly any worthwhile returns on reseeding investment. A site's potential will often be indicated by the vigour or productivity of unpalatable plants growing on the site. Sites with high potential but current low production are the sites with the best potential.

Herbicides

Undesirable weeds can be eradicated by applying herbicides such as phenoxy herbicides (2,4-D or 2,4,5-T) or glyphosate 'Roundup'. Herbicides can be formulated to target either grasses or broadleaved plants forbs, shrubs, and trees. They can be sprayed or applied in the form of pellets. Spraying can be done from the air by plane or helicopter, or from the ground. Ground applications are usually done by 12–40 ft wide boom-sprayers mounted on tractors or caterpillar tractors or by hand-held pump, backpack sprayers. Application by backpack sprayers has the advantage of only effecting the target plants; but it is a very time consuming way of treating large areas.

Planting season

In Guoluo seeding is traditionally carried out early in the spring, whereas autumn seeding is practised on the rangelands of the Great Basin and in western Canada. Autumn sowing is preferable as it overcomes the following difficulties.

- When sowing is delayed until late spring or early summer, a significant portion of the growing season is lost for seedling growth, development, and establishment.
- The seeds of some species require stratification (cold period) to break dormancy and initiate germination.
- Seeds require a period of moisture inhibition to hydrate the seeds and initiate their physiological processes.

Autumn is the time when native seeds disperse and become part of the soil seed bank. Autumn seeding deposits seeds just prior to freezing and snowfall. This ensures that seeds

go through freezing and thawing cycles to break dormancy or other germination requirements. Autumn seeding puts the seed in place so that the following spring, as soon as conditions of warmth and moisture are optimum, germination and emergence can immediately proceed. This gives seedlings the whole growing season to grow, develop, and establish. Spring seeding may miss the period of optimum germination for various reasons, but often because the site is not accessible until after optimum conditions occur.

However, if ranges are seeded too early in the autumn, the emergent seedlings need to be well established before winter sets in or there is a risk of losing them to frost heaving. This may be one of the reasons why seeding is typically delayed until spring in Guoluo. Another reason given by researchers at QAASVM is that they have no control over the reseeded area in autumn and winter as at this time the researchers are outside the area.

Seeding rates

Seeding rates tend to be too high in Guoluo. Typically, herders sow oats at 12.5–15 kg/mu (154–186 kg/ha), (Grassland Experiment Report 1997). This may be a consequence of poor seed quality. If seed is mixed up with an equal amount of inert materials and non-viable seeds, then these high seeding rates make some sense. Furthermore, if germination rates are correspondingly low, say <33%, then seeding at 170 kg/ha will be equivalent to using only about 28 kg/ha of pure live seed. Seeding rates for rangeland revegetation efforts elsewhere are about an order of magnitude lower than in Guoluo, typically between 9–17 kg/ha with seed quality much higher as it contains less than five per cent of inert materials and more than 90% of the seeds will be viable. Seeding rates could be significantly reduced and the limited seed supply more economically used if harvested seed materials were mechanically cleaned to increase quality.

Causes of reseeding failures

The most common causes of reseeding failures are the failure of seeds to germinate, the failure of seedling emergence, and the failure of plant growth and development. Generally, failures can be attributed to the wrong choice of species, poor seed quality, improper seedbed preparation and seeding techniques, predation of seeds and emergent seedlings by rodents, and improper management following reseeding.

Germination and emergence fail due to poor seed quality, planting seeds too deeply, seed dormancy, soil crusting, low temperatures, drought and desiccation, insufficient soil moisture, wind and water erosion, seed predation, herbivory by rodents and insects, insufficient soil coverage of seeds, and poor seed quality.

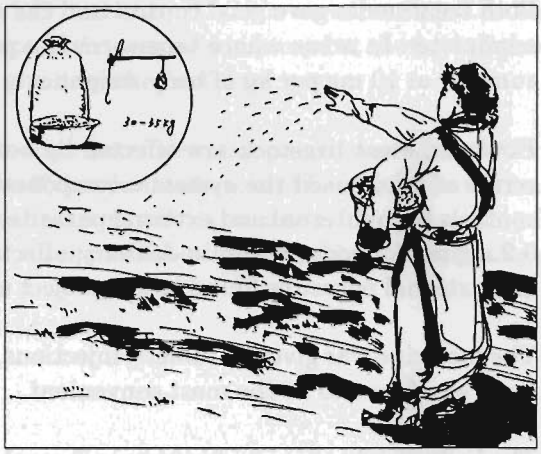
Seedling establishment may fail due to drought, frost heaving, competition from weeds, poor drainage, low fertility, desiccation, herbivory by rodents and insects, wind and water erosion, failing to inoculate legumes, and grazing too soon.

Proper seedbed preparation should include: 1) the eradication of pikas, 2) removal of competing plants (by ploughing and letting the seedbed lie fallow or by applying herbicides), 3) ensuring there is firm soil below the seeding depth, 4) disking and harrowing to pulverise

and mellow the topsoil, and 5) compaction by rolling or roto-tilling in the following seeding.

Seed may be either broadcast or planted in rows. Aerial broadcast seeding from a plane or helicopter can cover large areas of black beach on inaccessible steep mountain slopes.

The main problem with broadcasting seed is that the seed will not be covered for germination and the establishment of roots. However, some species do well when broadcast on to snow. With the spring snow melt they are carried down to the soil where they find very moist conditions suitable for germination. Planting in drill rows gives more control over seeding rates and planting depths. Drill rows are usually 15 to 40 cm apart. The wider the drill row spacing, the less the plants in adjacent rows will compete for soil water and nutrients.



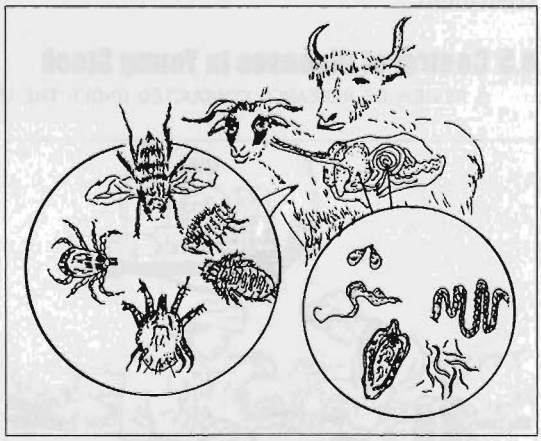
The job of revegetation is not finished when the new pasture or range becomes established. Established seedlings should only be exposed to grazing from the second year and a further year's deferrment is preferable. If the poor management practices that helped to previously degrade the site in the first place are not corrected, then the reseeding effort will be to no avail.

4.4 Control of Parasites in Sheep and Yaks

A REVIEW OF RESEARCH CONDUCTED UNDER THE QLDP, BY JOHN DAVIS

Parasite control

Investigations early in QLDP revealed that internal and external parasites caused a serious problem to livestock in southern Guoluo. Many of the livestock are infested, and since the privatisation of livestock and grazing land, the practice of parasite control is less rigorously implemented. The individual allocation of land has meant that many of the dip baths are no longer used because of access problems. Also, under the new system of individual responsibility, the government no longer supplies either anthelminthics or chemicals to control external parasites.



A series of trials was initiated by the project to study how best to control livestock parasites .One trial looked at the control of internal parasites using the standard anthelminthic, albendazole. It is relatively cheap and was found to give good control of common

internal parasites found in the project area with significant increases in live weight gain and a greater survival of treated animals. The following two treatments were tested:

- one double dose of 20 mg per kg of body weight at the start of the winter; and
- two doses of 10 mg per kg of body weight with the first dose at the start of winter and the second in March.

Both treatments gave good control and the single dose is preferred because it is easier to administer. In areas where tapeworm is a problem the animals should be treated in late summer at 10 mg per kg of body weight.

However, most livestock are affected by both internal and external parasites. A second series of trials used the systemic compound, Avermectin. This is more expensive but it controls both internal and external parasites. In the trial, the drug, when administered at 0.2 mg per kg body weight in January, effectively controlled most of the common internal and external parasites found in the project area, including warble fly in yaks.

The medicine was given as tablets, injections, aerosol sprays, and in suspension. The tablet form was found to be the most convenient.

The body weight gains and increases in wool yield were recorded for animals that survived the winter. Increases in survival rates were: 17.9, 1.8, and 4.3% for yearling lambs, ewes, and calves respectively. Increases in body weight were 4.8 kg, 2.9 kg and 3.4 kg for the different groups. Extra wool production was on average 0.08 kg per ewe.

Assuming that, on average, the cost of medicines was 0.4 yuan per sheep and 1.0 yuan for yak calves, whilst labour cost 30 yuan per day per 100 animals with veterinary charges of 0.2 yuan per animal; and if the animals are valued at 50 yuan per lamb, 150 yuan per ewes, and 200 yuan per calf with wool worth 5 yuan per kg, then the cost benefit of the treatment would be 1:6.47. The benefits are worth more than six times the cost of the treatment.

4.5 Control of Diseases in Young Stock

A REVIEW OF RESEARCH CONDUCTED UNDER THE QLDP, BY JOHN DAVIS

Field data show that in the prefecture as a whole approximately 10% of the calves and 25% of the lambs die each year or before reaching maturity? The main causes of death are diarrhoea and in some cases pneumonia. The death rates in Dari are worse than the prefecture average whilst those in Maqin are better than average. A series of trials was initiated based on work undertaken by QAASVM. Firstly, the presence of pathogenic organisms was investigated. Four strains of *E. Coli* were found plus *Salmo-*

nella and *Clostridium*. One rotavirus was identified in lambs. The sensitivity of the bacterial strains to various antibiotics was then tested. A mixture known locally as 'Xu lilin' proved most effective.

The effectiveness of Xu lilin was tested in the field. The administration of 20 ml per day for calves and three ml per day for lambs over the first three days of their life increased the survival rate by nearly 10% in calves and by 13% in lambs. Xu lilin was also found to be effective as a treatment for animals that became ill if it was administered at the rate of one ml per kg of body weight, with a double dose given on the first day.

Following the success of these trials, a large-scale extension campaign started in 1998. Training courses were held for government staff, herder leaders, and herder technicians. Medicines were made available during the lambing and calving seasons. The provision of short-term credit for the herders to buy the inputs will be important to the long-term adoption of this technique.

Chapter 5
EXTENSION

A REVIEW OF PAPERS PRESENTED IN THE WORKSHOP SUBGROUP ON SOCIOECONOMICS AND EXTENSION, PREPARED BY MARIE-LOUISE BEERLING

5.1 Contributions to Animal Husbandry Extension in Qinghai Province

Introduction

Animal husbandry extension in Qinghai province is carried out by the field staff of the Bureau of Animal Husbandry (BAH). The bureau has no separate extension service. Although veterinary and grassland technicians are sometimes called animal husbandry extension technicians (AHETs), extension in the sense of communicating messages and ideas to herders is not their primary task. Their main responsibilities are disease prevention and treatment, emergency control actions, the implementation and supervision of government programmes such as the Four-way programme and poverty alleviation programmes (subsidies and loans for fencing, pen building, winter shelters, distribution of grass seed, oat seed), and the collection of livestock census data. A review of institutions, present staff, present activities, and how extension is integrated with research is given in Matthewman (R1996).

Until recently 'extension' was used to describe the system of "passing on administrative instructions from a higher level to a lower level agency in our county" (Li and Wang, P21). Extension staff instructed the herders to carry out the initiatives identified by BAH and technical stations as being beneficial. This top-down approach worked to some extent in bringing the major livestock diseases under control. However, important changes are occurring that require a different, more persuasive style of extension to, for example, persuade herders to administer drugs to their livestock. These used to be available free of charge. Also the problem of rangeland degradation calls for an integrated approach in which cooperation with the herders is indispensable.

QLDP has supported training programmes to build up the extension capacity of BAH. Support was provided by outside experts (Matthewman R1996, R1997; King R1998, R1999; Van Wageningen and Sa, P58). The overall purpose was to make animal husbandry extension in Qinghai province more client-oriented and effective.

Extension education

Assessment

Matthewman (R1996) made an inventory of the existing situation. This included an assessment of herders' needs and the actual training level of field staff and their training needs and an appraisal of training institutes and their curricula.

It was found that there was considerable scope for improvement of the pre- and in-service training curricula for animal husbandry staff. They were strongly oriented towards animal health and production; and little attention was given to extension. There was a need to re-orientate current topics and add new topics on grassland management, animal nutrition, and extension. A participatory rather than the prevailing top-down approach was felt to be more suitable for delivering rangeland management extension messages.

It was recommended that all courses should add modules on 'information dissemination and extension methods'; 'communication methods'; 'rural information gathering'; and 'participatory planning'. Proposals were made for these modules to be incorporated into CASVM's (College of Animal Science and Veterinary Medicine) and HYSAH's (Huang Yuan School of Animal Husbandry) regular curricula. Matthewman also made suggestions for improving the in-service training of field staff and herder technicians.

Pre-service training

These proposals were further elaborated upon by subsequent consultancy missions (Matthewman R1997; King R1998) which led in 1999 to HYSAH adapting its current curricula. Li and Wang, both of HYSAH, have reported how awareness grew within the school that it could no longer ignore modern extension science. The impetus arose to integrate extension in all four major courses taught at the School (Li and Wang, P21). The incorporation of the new curriculum and associated teaching plan was facilitated by QLDP, which funded short-term and MSc training courses in extension science for several of the school's teachers.

The new course has been taught to final year students majoring in veterinary medicine, grassland management, animal husbandry and animal health, and livestock production since 1999. All new field staff will now have at least some notion of client-oriented extension. Preparations are underway to establish a Department of Animal Husbandry Extension to allow students to major in extension. No problems are anticipated with approval of the curriculum, teaching plan, and text books (per. comm., Wan Yongfeng), and it is expected that HYSAH will begin the training of fully-fledged extensionists from 2001 (Li and Wang, P21).

In-service training

The project provided training in modern methods of extension as in-service training for field veterinary and grassland technicians (King R1999). The training was both theoretical and practical. In the practicals the trainees worked with herders on various participatory rural appraisal (PRA) exercises. Both the trainees and the herders were enthusiastic about this new method. The field staff were convinced that it is a simple, effective, and useful methodology and wish to use it in their work (King et al. P18).

The basic principle behind PRA is that local people know a lot about their environment and this knowledge should be mobilised to analyse problems and arrive at solutions. It presupposes a willingness to listen and takes the priorities of the local people into account. A variety of tools is used to put people at ease and make them talk about their environment and their lives. Information about land use and land degradation can be collected from conducting mapping exercises and by walking along transects. A better understanding of the herders' lives and their labour dynamics can be derived from drawing up calendars and daily activity diagrams. The herders' opinions on government services, institutions, and programmes can be drawn up in Venn diagrams. Herders' problems and development priorities can be identified from ranking exercises (Sa and King, P54). There are many other PRA tools; and, as PRA is a flexible and dynamic method, new tools can be developed 'on the spot'. PRA methods do not always take more time than traditional ways of gathering data. They are intended to make extension work more efficient, and, by virtue of actively involving local people in the process, they are also more effective.

In 1999 sixteen field staff and two provincial staff from BAH and QLDP were trained in PRA methods. A further 56 staff were trained in 2000 (pers. comm. A. King). Seventy-four extension workers are now familiar with the basic principles of participatory approaches to extension. Also, 200 leaders and herder technicians from the six project townships attended a lecture on 'extension methodology, PRA and extension evaluation' from 1999-2000 (Wester Pers. comm). It is hoped that these efforts will mean that extension becomes more client-oriented.

Extension implementation

Extension materials

QLDP supported the development of a range of extension materials for use by BAH field staff (Wester R1999). The most notable was the 'Illustrated Handbook for Sheep and Yak Herders'. This was prepared with contributions from many researchers, field staff, and consultants. The booklet was made user-friendly; being small, easy to carry, with lots of self-explanatory pictures that cover the technical advice that is delivered during demonstrations and field days. The booklet serves as a reminder for herders who have attended demonstrations.

The handbook was produced as a concrete example of a client-oriented mass medium. However, it has been disappointing that so few herders have purchased it. Although extension staff see the book as simple, cheap, and very practical, the herders have been hesitant to buy it. One reason given is that herders feel they should not be paying money for information that originates from the government (van Wageningen and Sa, P59). It is good to keep in mind that in extension terms an uptake of 20% in the first year is quite good (personal communication, J. Groome).

The handbook was developed by first identifying the Tibetan herders as the users of the proposed publication (van Wageningen and Sa, P59). The book aimed to take into account their usual form of communication, their environment, and their problems. The topics were chosen to be relevant to the herders and only practical advice that the herders could feasibly follow was included. The topics were organised to link up with the main topics of

the extension programme, covering parasites, oats, and young stock diseases, plus some awareness raising on grassland management (van Wageningen and Sa, P59).

The text was kept to a minimum, with two editors cross-checking to ensure cohesion between Chinese and Tibetan. The field testing of messages and pictures revealed some interpretation difficulties, especially with drawings explaining abstract ideas, such as balancing livestock numbers with feed resources, deficiencies of micro-elements in feed, and timing of activities. Difficulties were also found with understanding the text where complicated or non-local terms were used such as with the names of parasites. The necessary adaptations were made and 6,000 copies of the book were printed. These were distributed to the counties for sale to herders at a subsidised price of two yuan each.

Use of new extension methods in the field

Sa and King (P54) have developed examples of how PRA techniques can be used in the field. However the authors are not convinced of the practicality of their application in QLDP, although it is clear that the herders must have an active role in extension activities (Sa and King, P54). The problem is that not enough experience has been gained with practical applications of PRA in the ongoing extension programme and more guidance is needed for field staff to integrate PRA into their regular work.

Xue and Lu of Guoluo Veterinary Station in their paper (P64) report experiences with new extension approaches, use the term 'participation style of extension' rather than PRA. They recognise that herdsmen should be encouraged to analyse their own problems through brainstorming and other types of exercise, and the herdsman's wish should be the working goal of extensionists. The same paper also describes how new extension methodologies have been used in their field work. Problem identification was done with herders as 'herdsmen know best the practical difficulties they confront.' This resulted in the priority for intervention being assigned to young stock diseases and parasite-borne diseases.

The extension messages have been designed as a comprehensive package to solve these problems. A layered system of training, demonstration, and extension has been used with the collaboration of administrative leaders and extension experts enlisted to increase the level of contact with herders. Xue and Lu also say that the extension agents should have a responsible attitude and should listen patiently to the herders' problems to enhance the herders' interest and participation. One-off training sessions on new extension techniques can only set the base and there needs to be follow-up training, preferably involving extension agents interacting with the herders to find out about herders' lives and problems. QLDP has encouraged extension agents to constantly reflect on their experiences as extension must be seen as a learning process that needs continuous reinforcement.

Extension organisation

The field work in the project area has become more structured. Extension campaigns are now planned as integrated packages to disseminate the main messages of parasite control, young stock disease control, and forage cultivation. Two teachers from the School of Animal Husbandry have been seconded to improve the quality of county-level extension training. The training system now incorporates group discussions with herders, demonstrations,

and herder feedback, while occasionally herders are invited to lecture in front of their fellow herders, and a herder study tour has been organised.

Links have been strengthened between research and extension. Research has become more problem oriented and focuses on the three priority research areas for herders (parasites, young stock diseases, and fodder shortage). QLDP has promoted and facilitated on-farm trials that involve both extension staff and herders (Wester, Pers. comm.). It has resulted in advice that is both adequate and appropriate at herder level. Also, the existing structure of relaying innovations from province and prefecture levels down to township and association levels has been reinforced.

Impact of the new methods

The new extension package has been working since 1997 to communicate techniques and benefits of parasite control, young stock disease control, and oat planting. Zhang (P80) has evaluated its impact by investigating the economic benefits experienced by the herders overall from the integrated package.

Zhang found that herders who have applied all three techniques have had higher young stock survival rates and lower adult mortality rates than herders who have not applied the techniques. The benefits accrued in terms of herd increase, valued at market prices, outweigh the cost of inputs such as labour, seed, antibiotics, anti-parasite drugs, and treatment fees against. It is calculated that the typical 'model' herder has made a net gain of 241 yuan per year[1] from adopting all three messages simultaneously.

This form of impact measurement is popular within BAH (Sa and King, P54 and Xue and Lu, P68, and many of the technical papers on animal health). However, it is of limited validity, since the calculations are based on simple assumptions that equate economic benefit with the cash value of surviving animals. This is an over-simplification as herders do not look at their animals as mere meat producers, but as multipurpose animals. Milk and dung are important by-products without which a herder family cannot survive, and these benefits have not been included in the calculations. Calculations of economic benefit should also account for other factors.

This approach was first attempted by Dideron (R1995) who proposed typical household models for each of the six socioeconomic strata using production and consumption data gathered from interviews (Dideron R1995). Zachernuk, on the basis of a more elaborate data base, used mathematical modelling to try and assess the impact of different strategies and policies on the development of household economics over a 10-year period (Zachernuk R1998).

5.2 Herders' Attitudes and Perceptions

Socioeconomic investigations

For their extension messages to be relevant and appropriate extensionists need to be well-briefed on the background situation of their target group. They need to know not only about

[1] This figure has been corrected as there was a calculation error in the original paper.

the physical and climatic conditions, but also about the herders' way of life, and their perceptions and attitudes. These factors must be taken into account to gain herders' confidence.

QLDP carried out many investigations to find out about the herders' lives and their perceptions and priorities. These took the form of socioeconomic studies (Dideron R1995, R1997; Zachernuk R1998, R1999) by interviewing herders in their homes (Matthewman R1996; King R1998; Goldstein R1996; Beerling R2000) and training (King R1999; Wester, Pers. comm.).

These studies indicate that 30 to 50% of herder families (depending on township) are hardly able to assure the subsistence of their families. One characteristic of such families is that they generally lack adequate labour. This seriously limits their economic scope. The yak is considered as the prime necessity of life. The herders aim to have as many animals as possible to ensure that they will still have a productive nucleus after snow disasters or drought. They are aware that the grassland has a limited carrying capacity, but, given that they need their animals for their own survival, they are not keen to reduce animal numbers. Rather than reducing their number of animals the herders look to seasonal migration to other areas, renting other land, the communal management of summer pasture, growing fodder or reseeding to address the limited carrying capacity problem. Awareness of this reality should make it possible for the authorities to work with the herders to find sustainable solutions to their multiple problems.

A workshop discussion paper argued that despite all the socioeconomic work, the distance between extension, research and policy, on the one hand, and the reality of the herders, on the other, still persists (Beerling R2000). This has led to misunderstanding of and the insufficient focus of extension efforts. Some officials still believe that herders are ignorant as they do not want to listen to sensible advice. These findings were confirmed in the workshop discussions. Force is still, at times, considered a highly effective extension method, and the idea that more sustainable solutions may be obtained if the herders' views are taken into account is difficult for some officials to accept.

Jianshe workshop

In September 1998 QLDP organised a participatory resource planning workshop at Jianshe (van Wageningen R1998). At this workshop herders, extensionists, and leaders sat together as stakeholders to discuss and evaluate the options for sustainable improvement of the townships' resource bases.

The workshop first sought feedback on BAH's interventions on animal disease and parasite control; oat planting; fencing; animal shelters; black beach control; rangeland regeneration; and rodent control. The following four themes were addressed at the workshop: improving animal production, stopping range degradation, improving degraded land, and increasing herders' knowledge. Participants were asked to describe the situation, analyse the causes and effects, propose solutions, and draft an action plan for each theme.

This was a new approach and, in spite of some concerns about the expense of this exercise (pers. comm. N. van Wageningen), it did prove to be a very valuable experience. It yielded some valuable insights into involving herders in developing improvement strategies.

Income generation through weaving

Herders frequently mention their lack of money as a constraint to making investments. The BAH's focus on enhancing livestock productivity to increase herders' income is not a feasible option for herders who live on or below the subsistence level. Such herders need to develop sources of income other than livestock production.

Cottage crafts offer one way of earning supplementary income. Weaving, which is traditionally done by women using yak fibre and sheep's wool, has good potential. QLDP supported weaving as an income-generating activity by providing two consultants (Dunsmore R1998; Beerling R2000). Their investigations showed that technically and commercially there was good potential for weaving. No socioeconomic factors were identified that would impede the further development of market-oriented weaving (Liu and Beerling, P32).

A workshop was held to train ten Tibetan weavers from two townships in new weaving techniques. Weaving is based on local knowledge and skills and fits in with what women want from their lives. The women weavers were encouraged to contribute to the planning and design of development activities by consulting them about how to set up a pilot project and by listening to their views on production levels and prices (Dunsmore R1998). A proposal for a pilot project has been prepared and submitted for funding (Beerling R2000).

This has been the only QLDP activity directly targeted at women. Otherwise the up to 20% of Guoluo prefecture households that are female-headed and mostly poor (Zachernuk R1999) have not been targeted by BAH's extension activities.

Discussion

Discussion during the workshop centred on PRA and its usefulness for animal husbandry extension in southern Qinghai, and the question of how well extension fits in with the situation of the herders.

PRA is a controversial subject within BAH. It has been largely misinterpreted as only involving talking with herders, and has not been seen as something that helps to achieve the BAH's main goal of solving the problems of animal productivity. It is also seen as taking up too much time. BAH staff believe that, although talking with herders is a good way to identify constraints, it is not useful to solve the problems of parasites, diseases, overstocking, and range degradation. PRA is viewed as difficult to use in the field. A need was expressed for new basic extension techniques that are simple, easy to use, and practical. The Herders' Handbook and Participatory Planning Approaches (Sheehy R2000) to range degradation were mentioned as examples.

The scepticism about PRA indicates the need for more practical guidance about how to use PRA tools in the field. The veterinary and grassland technicians do not see how PRA can assist them to carry out their everyday duties. Perhaps there was too much focus on diagrams, calendars, maps and matrices made during the training when the main issue was really 'more modern methods of extension'. PRA is just one such method. It was therefore suggested that rather than 'PRA', other terms such as 'client-oriented extension', 'target group oriented extension' or 'participatory style of extension' should be used.

Field staff meet a number of difficulties when trying to solve the problems of animal productivity. Although the problems are known and solutions exist, herders sometimes fail to show up at extension sessions, or do not apply the extended techniques. Workshop participants suggested that this was due to reasons such as the non-availability of drugs, lack of money to pay for inputs, little understanding of the benefits, unwillingness of herders to invest, and, on the extension side: insufficient explanation, not enough time and effort put into the extension effort and too many herders to contact. It was proposed that increased funding and better transport facilities for extension field staff would go a long way towards overcoming these difficulties.

A failure to consider the herders' priorities might also have led to the low impact of extension efforts. For example, some of the extension campaigns coincided with the highly profitable caterpillar fungus collection season. Extension programmes should be scheduled outside of the herders' busy times.

In conclusion it can be said that QLDP has brought a number of innovations to southern Qinghai's extension system. They have only been recently introduced and there has not been enough time to gauge their lasting impact. Their introduction needs to be better facilitated by increased government funding to provide adequate resources for field staff.

Also, it is crucial that extension messages are well developed and appropriate. These messages are mostly the outcome of scientific research; and therefore it would be beneficial if the researchers also became acquainted with PRA and how to use it to involve herders more in the design, execution, and evaluation of trials.

Chapter 6

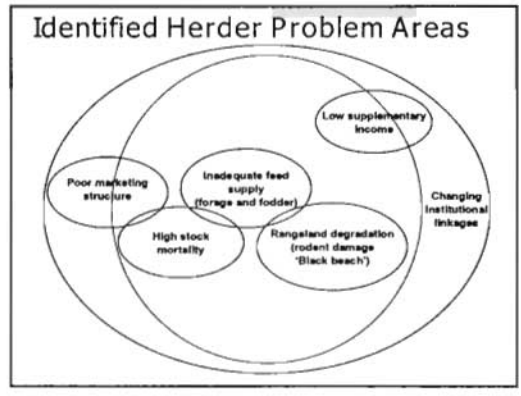
PRIORITIES FOR DEVELOPMENT

A summary of discussions of participants at the Concluding Seminar, reviewing past and future project work in the livestock sector of Qinghai Province

This summary follows slides used during the presentation and discussions.

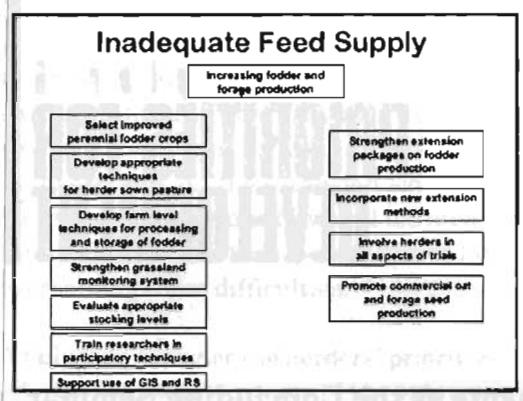
6.1 Overview of Discussions

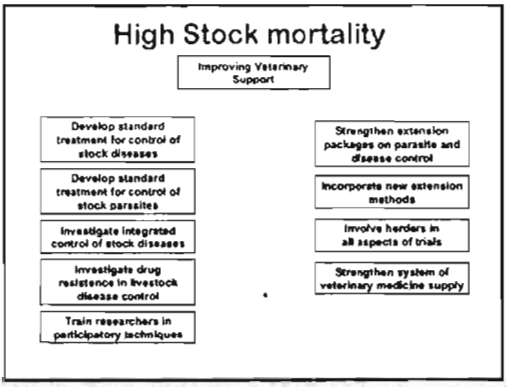
The 38 senior scientists, policy makers, and decision makers who participated in the concluding seminar represented the following organisations: at the national level, the Ministry of Foreign Technical Cooperation and the Delegation of the European Union; at the provincial level, the Provincial Government, the Bureau of Animal Husbandry (Leadership and various departments including the Academy, Finances, the Project Management Unit, the Grassland Station, Veterinary Station, and the School for Animal Husbandry), the Department of Foreign Technical Cooperation, and the EU team providing technical assistance; and at the prefecture level, the Prefecture Government and the Bureau of Animal Husbandry. This group was considered eminently suitable for such a task.

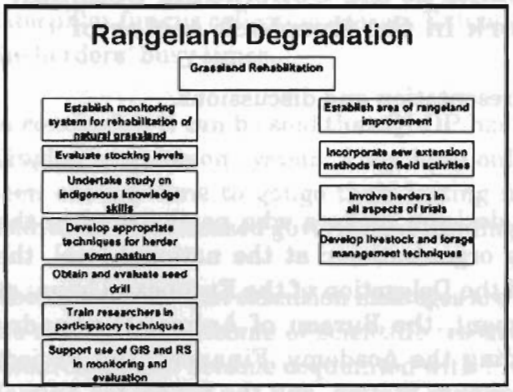


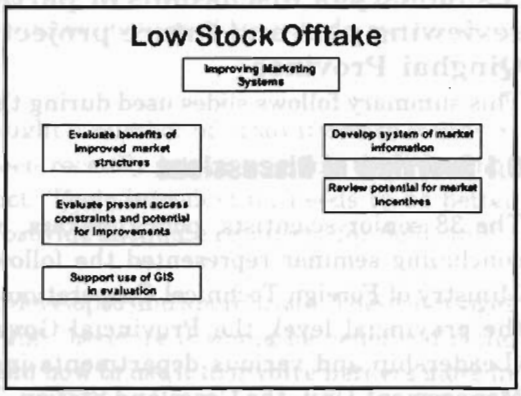
The meeting assumed that, with the growing interest in the West, the number of projects and programmes would grow. Both Government and foreign donors are mobilising funds for development of the rangeland ecological system. It is thus more than likely that development interventions in the area will continue and, in that context, the lessons learned from five years of QLDP work should play a role in the decision-making and planning of future efforts.

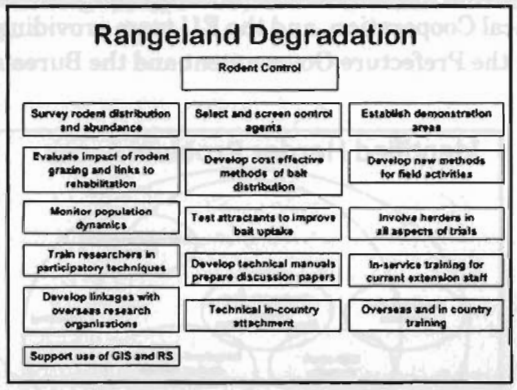
QLDP has been unique in that it has brought various specialist fields, which usually operate separately, under one umbrella. In this way, an integrated perspective can be taken of the basic issues at stake in the Qinghai Tibetan Plateau, allowing the problems observed to be placed in relation to each other. Any discussion about development options for the Southern Qinghai area will benefit greatly from this integrated perspective, because it makes it clear that the constraints are due to the interplay of many different factors.

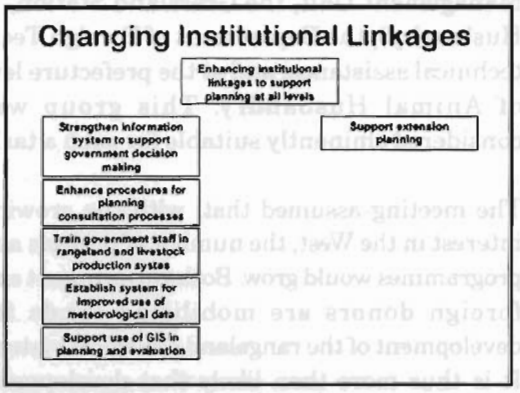

Inadequate Feed Supply
Increasing fodder and forage production
Select improved perennial fodder crops
Develop appropriate techniques for herder sown pasture
Develop farm level techniques for processing and storage of fodder
Strengthen grassland monitoring system
Evaluate appropriate stocking levels
Train researchers in participatory techniques
Support use of GIS and RS
Strengthen extension packages on fodder production
Incorporate new extension methods
Involve herders in all aspects of trials
Promote commercial oat and forage seed production

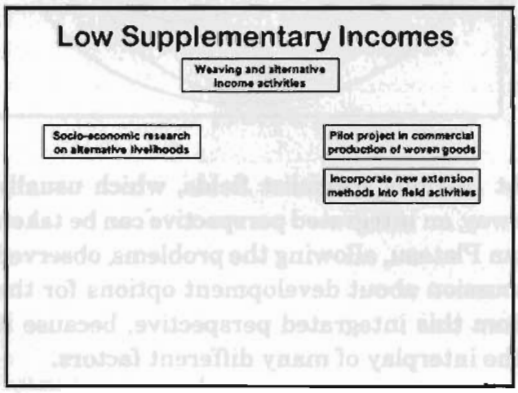

High Stock mortality
Improving Veterinary Support
Develop standard treatment for control of stock diseases
Develop standard treatment for control of stock parasites
Investigate integrated control of stock diseases
Investigate drug resistence in livestock disease control
Train researchers in participatory techniques
Strengthen extension packages on parasite and disease control
Incorporate new extension methods
Involve herders in all aspects of trials
Strengthen system of veterinary medicine supply

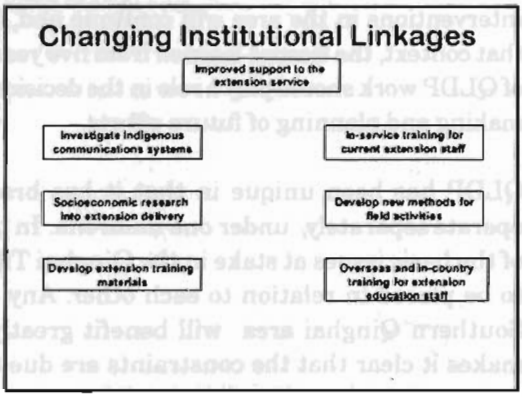

Rangeland Degradation
Grassland Rehabilitation
Establish monitoring system for rehabilitation of natural grassland
Evaluate stocking levels
Undertake study on indigenous knowledge skills
Develop appropriate techniques for herder sown pasture
Obtain and evaluate seed drill
Train researchers in participatory techniques
Support use of GIS and RS in monitoring and evaluation
Establish area of rangeland improvement
Incorporate new extension methods into field activities
Involve herders in all aspects of trials
Develop livestock and forage management techniques


Low Stock Offtake
Improving Marketing Systems
Evaluate benefits of improved market structures
Evaluate present access constraints and potential for improvements
Support use of GIS in evaluation
Develop system of market information
Review potential for market incentives


Rangeland Degradation
Rodent Control
Survey rodent distribution and abundance
Evaluate impact of rodent grazing and links to rehabilitation
Monitor population dynamics
Train researchers in participatory techniques
Develop linkages with overseas research organisations
Support use of GIS and RS
Select and screen control agents
Develop cost effective methods of bait distribution
Test attractants to improve bait uptake
Develop technical manuals prepare discussion papers
Technical in-country attachment
Establish demonstration areas
Develop new methods for field activities
Involve herders in all aspects of trials
In-service training for current extension staff
Overseas and in country training


Changing Institutional Linkages
Enhancing institutional linkages to support planning at all levels
Strengthen information system to support government decision making
Enhance procedures for planning consultation processes
Train government staff in rangeland and livestock production systes
Establish system for improved use of meteorological data
Support use of GIS in planning and evaluation
Support extension planning


Low Supplementary Incomes
Weaving and alternative income activities
Socio-economic research on alternative livelihoods
Pilot project in commercial production of woven goods
Incorporate new extension methods into field activities


Changing Institutional Linkages
Improved support to the extension service
Investigate indigenous communications systems
Socioeconomic research into extension delivery
Develop extension training materials
In-service training for current extension staff
Develop new methods for field activities
Overseas and in-country training for extension education staff

A discussion about priorities hence becomes both more complicated and more realistic. Being aware of the interconnectedness of the different constraining factors makes it more difficult to choose a single path for improvement. The findings from QLDP have only reinforced the conclusion that a development strategy for the Southern Qinghai region must be based on a multi-pronged approach where research, extension, and the facilitation of enabling activities collaborate to achieve a result. This was the challenge with which the Seminar participants were faced.

The discussion on Priorities for Future Interventions was started with an outline of the overall objective: Supporting the Herder. Within this objective, four separate elements can be recognised: the herder, local management, research, and extension.

At herder level, many problems have been identified (a slide was shown'Identified Herder Problem Areas') some of which are situated at farm level and/or in the herding area, while others are situated wholly or partly outside the herding area. The various problems overlap.

For each of the six main problem areas identified at herder level, an analysis was made of how improvements could be achieved. These were listed on the eight slides given on the previous two pages.

The problem areas where thus studied and possible interventions identified. These included: for High Stock Mortality (Improving Veterinary Support); Inadequate Feed Supply (Increasing Fodder and Forage Production); Rangeland Degradation (Rodent Control and Grassland Rehabilitation); Low Offtake (Improving Market Systems); Low Incomes (Promoting Weaving and Other Alternative Income Sources); and Enhancing Institutional Performance and Linkages.

The result was a list of theoretically desirable interventions, altogether 50 in number, which was then subdivided into three focus areas: research, extension, and enabling activities (a slide was shown 'Integrated Interventions').

The Seminar participants were then asked to score each of the proposed interventions into one of three priority classes, A, B, or C, in which A stands for 'highest priority', B for 'medium priority', and C for 'less important'. Discussion with fellow participants was encouraged. It was interesting to observe how most Chinese finished their task quickly while the foreign TA group took a much longer time and lively discussion to complete their scoring. In the final analysis all answers were taken together without subdivision according to the participants' backgrounds.

The results, after weighting the As with a factor 4, the Bs with a factor 2 ,and the Cs with a factor 1, were as shown in the last table.

The following points have led to relatively long discussions.

- The high priority given to research into appropriate techniques for pasture management and disease control
- The high priority given to the role of research in support to decision-making, planning, and policy formulation (information systems, monitoring, planning procedures)

	Number of participants scoring this activity's importance as . . .			Weighted score
	High (factor=4)	Medium (factor=2)	Low (factor=1)	(n*factor)
Research activities				
Develop appropriate techniques for herder-sown pastures	18	5	7	89
Investigate mutual integration of control methods for treatment of livestock diseases	13	13	4	82
Strengthen information systems in support of government decision making	13	12	5	81
Enhance procedures for planning consultation processes	14	9	6	80
Monitor stocking levels	15	6	8	80
Carry out socioeconomic research on alternative livelihoods	14	7	9	79
Evaluate present market access constraints and the potential for improvement	9	15	5	71
Establish a monitoring system specifically for the occurrence of 'black beach'	10	10	10	70
Develop a standard integrated treatment for control of common intestinal parasites	8	14	8	68
Establish a monitoring system of quality changes of grassland	9	9	12	66
Investigate breed improvement	10	6	9	61
Investigate occurrence of pathogen resistance against currently used drugs	4	17	9	59
Carry out socioeconomic research into extension delivery	5	15	9	59
Develop a standard integrated treatment for control of common stock diseases	3	17	10	56
Investigate re-sowing techniques and technologies	7	5	18	56
Obtain and test the appropriateness of a seed drill (for direct sowing)	7	6	16	56
Survey spatial distribution of rodent populations	4	13	13	55
Select and screen rodenticides and other control agents	6	8	15	55
Evaluate impact of rodent grazing and links to rehabilitation of rangeland	5	10	14	54
Analyse the benefits of an improved market structure	5	11	12	54
Improve the monitoring system of the dynamics of rodent populations	4	12	13	53
Investigate indigenous communication systems	4	10	16	52
Test attractants to improve bait uptake	2	12	15	47
Undertake studies on indigenous knowledge in livestock management and disease control	2	10	18	46
Develop cost-effective methods of bait distribution	3	8	18	46
Extension Activities				
Strengthen extension packages on parasite and disease control	15	13	2	88
Establish rangeland rehabilitation demonstration areas	16	9	4	86
Strengthen extension packages on fodder production	13	13	4	82
Develop a market information dissemination system	13	11	6	80
Establish rodent control demonstration areas	12	13	5	79
Incorporate new extension methods	9	17	4	74
Develop livestock and forage management techniques	8	17	5	71
In-service training for current extension staff	8	17	5	71
Involve herders in all aspects of trials	10	10	9	69
Support extension planning	9	10	11	67

	Number of participants scoring this activity's importance as . . .			Weighted score
	High (factor=4)	Medium (factor=2)	Low (factor=1)	(n*factor)
Carry out a pilot project in commercial production of woven goods	3	13	14	52
Develop new methods for field activities	3	12	14	50
Other Support Activities				
Train researchers in participatory techniques	16	10	4	88
Support the use of GIS/RS as part of a Decision Support System for research and planning	14	13	3	85
Provide technical in-country attachment	12	11	7	77
Train government staff in rangeland and livestock production systems	9	16	5	73
Develop training material based on existing knowledge/findings	9	14	7	71
Promote commercial oats and fodder seed production	10	10	10	70
Provide overseas and in-country training	9	12	9	69
Strengthen the system of veterinary drug supply	9	12	9	69
Develop linkages with overseas' research organisations	8	13	9	67
Establish a system for improved use of meteorological data	6	15	8	62
Develop technical manuals and discussion papers on rodent control	5	14	11	59

- The high priority given to investigating economic aspects (alternative livelihoods, marketing potential)
- The high priority given to the technical side of extension (improving packages for disease and parasite control, fodder production, establishing demonstrations for rangeland rehabilitation and rodent control) over the methodological side
- The relative importance attached to training and networking as support activities
- The low interest in research into indigenous knowledge and indigenous communication
- The low priority given to research on rodent control (is this an indicator of distrust in the technology, or a conviction that nothing more can be done ?)
- The low priority given to the methodological and participatory aspects of extension and to extension planning
- The apparent lack of insight into the importance of support activities, or the lack of understanding of the place and purpose of such activities because the listing in this category is rather incoherent

6.2 Future Project Implementation

The seminar participants agreed that, within any future project, management systems should be developed that emphasise the following.

- A firm research basis with links to a wide range of provincial institutions and direction towards research paper production, presentation, and publication nationally and internationally within the objectives of the project.
- A strong capacity building base, including training using a wide range of techniques
  - professional updating through attendance at in-country and overseas' personal development training activities;
  - career development through in-country and overseas' M.Sc. programmes;

- direct management and administrative experience through shadowing experienced staff in relevant organisations; and
- direct hands-on skill training and improvement through shadowing experienced staff in relevant organisations

- Strengthening of counterpart skills in the use of planning, monitoring, and evaluation techniques
- The involvement of a parallel organisation in poverty alleviation at the earliest opportunity
- Development of acceptable alternative structures through which the extension component can be delivered

6.3 Future Livestock Project Components

The weighted prioritised activity list produced by the seminar group in the area of research provided a useful basis on which to develop a set of immediate objectives.
In the area of research the emphasis within the first ten proposals concentrates on four areas.

- Grassland rehabilitation
- Livestock production and disease control
- Strengthening information and planning systems
- Alternative livelihoods

In the area of extension, the emphasis within the first five proposals concentrates on three areas.

- Strengthening of extension packages
- Establishment of practical demonstration areas
- Development of a market information system.

In the area of support activities, the emphasis within the first five proposals concentrates on two areas.

- Staff training activities
- The use of GIS

Annex 1
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