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prepared by	Associate Professor Ann McNeill, John Wilkins and John Piltz
co-authors/ contributors/ collaborators	Dr Nyima Tashi, Mdme Se Zhu, Mr Jin Tao, Dr Tsamyu, Mr Tim Heath, Associate Prof Colin Brown, Dr Scott Waldron, Dr Jay Cummins, Ms Carol Rose, Prof David Coventry, Dr Nick Paltridge
approved by	Dr Peter Horne, Research Program Manager for Livestock Production Systems, ACIAR
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Contents

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2 Executive summary

Increasing the output of dairy products in the Tibet Autonomous Region (TAR) of the Peoples Republic of China is a high development priority identified by local and Central government. Previous ACIAR project research in TAR highlighted the unexploited potential for fodder production without necessarily compromising staple cereal grain yields. An increased supply of fodder could contribute to addressing the issues associated with poor dairy livestock health and low productivity identified by other ACIAR research in TAR. However, ultimately the adoption of any identified technological changes will be dependent on the flow of useful information to farmers. The type of information required and the credibility of that information will be reliant on sound scientific research in an appropriate socio-economic context. Subsequent flow of information requires appropriate mechanisms that can be optimised by an in-depth understanding of the attitudes and circumstances of the target audience (farmers). Various approaches to improve the overall productivity of the cropping/dairy system in TAR were examined within this integrated project directed at increasing household income and industry productivity, and at developing community based initiatives for improved dairy, crop and fodder production for farmers in the central valleys of TAR.

The project goal was achieved with the interdisciplinary team from TAR and Australia working closely together on all aspects of the project and exchanging information from the various research components. Agronomic options for forage production without reducing cereal grain yields were researched and demonstrated in the central valley zone of TAR. Feed intake and milk production were monitored to relate nutrient requirements to availability, and determine the risk of restriction. This allowed the demonstration and promotion of principles and strategies for feed supplementation and access to water to improve animal health, nutrition and milk production. That the project has been successful in promoting the use of fodder crops is evident in the changing pattern of crop distribution in the landscape seen during the review in 2011, and as recorded in surveys or interviews with farmers and others in the agricultural sector. The whole farm model (CAEG Tibet) has been a critical project output in regard to the integration process by providing a means of assessing the socio-economic implications of these new technology options for households and economies in TAR. Anecdotal evidence gathered towards the end of the project suggested that where new technology has been demonstrated to improve livelihoods it was adopted, although continuing government financial support appeared to be a strong influential factor.

Research also provided information for Australian livestock producers on management of cereal and cereal/vetch forage crops for hay and silage production. The use of these crops for supplementary feeding will have directs benefits in an Australian farming environment where supplementary feeding is essential, grain supplements are becoming prohibitively expensive, and where spring drought may be increasing in frequency.

Project outputs include recommendations and interventions flowing from the research, capacity building in the technical skills of research and extension staff, and the formation of effective information transfer pathways that promote change on-farm. It is anticipated that community benefits will flow from improvement in family and village incomes, and technical and social changes to community based production systems. Impacts were observed within the term of the project for immediate participants and impacts on other communities are likely to occur within 5-10 years of completion of the project; the latter through extension programs involving demonstrations, focus farms, training courses and information packages. There should be positive environmental impacts from improvements to resource use efficiency.

It is recommended that a future project be considered to consolidate capacity building in TAR in order to increase the pathways for adoption of recommended technology changes by householders. Further research will facilitate the understanding of the impact of these,

and other potential changes suggested by the project outputs, on the natural resources that underpin agricultural production and livelihoods in TAR. In addition to crop, forage and dairy production any future project should be expanded to include yak, sheep and goat production systems. Research into biological and management issues in crop, forage and animal production is an ongoing challenge for Tibetan scientists and extension staff.

3 Background

Human-Crop-Livestock Systems in TAR

In the central area of Tibet Autonomous Region (TAR) there are about 330,000 ha of valley floors and lower hill slopes where intensive crop and livestock agriculture is practiced. This zone, known as the crop-dominated zone (Tashi *et al.* 2002), spans the Shigatse, Lhasa, Shannan and Linzhi Prefectures, and runs from west to east across southern Tibet in valleys associated with the Yalongzangpo River and its two main tributaries, the Nyachu and Lhasa Rivers. Approximately 2.2 million of Tibet's 2.7 million permanent residents live on farms in the region. Practically all are of Tibetan ethnicity. Average farm size is approximately 1-2 ha and the average number of people per household is seven. Across the cropping zone, farms vary in altitude between 3,500 - 3,900m asl. All have cold-dry winters, highly summer dominant rainfall (400-440 mm) and a long growing season, with accumulated temperature above 2000 Growing Degree Days, even in the higher reaches of the zone. Most of this crop-dominated zone is irrigable. The predominant farming system within the cropping zone is heavily focussed on cereal production, with around 75% of the cropped area sown to spring barley and winter wheat. While yields are comparable to those achieved in many of the worlds' cereal growing areas, they are appreciably lower than would be expected given the abundant heat, light and water (Paltridge *et al.* 2009). Most grain is held on farm for family food use. Only after domestic needs are met is any grain able to be sold or used for barter.

The raising of livestock is also important, with valley-based farmers keeping 1-5 cattle that are fed generally poor diets based heavily on cereal straw, with limited grain and other supplements or access to grazing. These animals are an integral part of the farming system as they produce dairy products and meat, utilise the by-products of the cropping operation, and represent the major "asset bank" for farmers. However, production levels are very low (Paltridge *et al.* 2011a). Milk supply is well below demand (Tashi *et al.*2002) due to inadequate quantity and quality of forage in animal diets, and deficits are predicted over the next decade (Tashi 2005a, b). Few farmers produce a surplus of dairy products to sell and the growing demand for these products is not being satisfied by Tibetan farmers. Increasing genetic potential using AI has been promoted by government as the way forward but the strategy is flawed in the absence of vastly improved feeding systems and may exacerbate the problem. While dairy imports from elsewhere in China are growing, high transport costs make these more expensive than in other parts of China. Thus imports are not affordable to most Tibetans and the product is less acceptable to their tastes. Low levels of production, the small scale of farms and the fact that most grain and dairy products are consumed on the farm of origin result in low farm incomes – in most cases less than US$1 per day per adult. Food supplies are also inadequate on many farms - around one third of farmers do not produce enough grain to meet their year-round household food needs (Goldstein *et al.* 2003). Food security risk and low incomes are therefore major issues in rural Tibet.

It is understood from previous ACIAR projects (Coventry *et al.* 2008; Wilkins and Piltz 2008*)* that most Tibetan farmers have small-scale subsistence or semi-subsistence operations with little surplus grain or dairy produce to sell; farmers believe that a lack of income is the single most important barrier to improving lifestyle; and that farmers see that off-farm work or government assistance as the best solutions to their problems (Paltridge *et al.* 2009). Across the cropping zone, off-farm work provides more than half the cash income for most farmers (Goldstein *et al.* 2003). Farmers in some areas also showed awareness of the benefits of education and training in agriculture (Paltridge *et al.* 2009).

Opportunities for change in these systems

Notwithstanding the survey work done in previous ACIAR projects in TAR, data on farmer attitudes and motivations are limited, and based on only a small sample of households and on some focus group discussions. Increased socio-economic knowledge is required to understand facets such as: farmer motivations and ambitions (subsistence versus profit); focus and flexibility of production (grain, fodder and livestock); labour availability (ability to lift labour inputs, effort versus benefit); attitudes to different approaches to fodder production (relay-crops versus double crops, free-grazing versus tethering or fencing of fodder land, communal versus individual approaches); and attitudes to cattle ownership (for maximum production versus maximum number of cattle versus maximum returns or value of output). These data are essential to improve the understanding of what methods are currently used for extension of new research and technologies, and what methods and resources will be necessary for best outcomes in the future. An integral part of the process of promoting technological change is the development of economic models describing the application and profitability of varying combinations of grain, fodder and dairy production. The ultimate goal will be to demonstrate to farmers how different management choices affect farm income and family livelihood, and reveal how labour invested in different management options is rewarded.

The relative areas sown to the major crops in the crop-dominated prefectures of central Tibet are around 45% spring barley, 20% wheat (mostly of winter type), 5% winter barley, 10% oilseed, and 15% pulses, vegetables, tubers and forages (Tashi *et al.* 2002; TSY 2006). Typical farm yields for the main cereal crops are 4-6 t/ha for winter wheat and 2-3 t/ha for spring barley (Goldstein 2003; Fischer 2006). These cereal yields are at least 30% less than those attained on well-managed government research stations (Tashi *et al.* 2002; Kaiser and Zhan Dui 2005), indicating scope for significant increases. It is suspected that the factors depressing potential yields are associated with poor levelling of fields (leading to inefficient irrigation), inefficient seeding methods, poor weed control and less than optimal fertilising regimes. However, at the inception of this project there were few data available to assess the importance or impact of these factors. Given the high levels of food insecurity in Tibet, closing this yield gap was seen as a high priority for the present project. Boosting total farm grain production by increasing yield would also allow for some farmers to dedicate a part of their land to fodder production to improve livestock nutrition. Work in the previous ACIAR agronomy project identified three main strategies for fodder production in Tibet: lucerne (yielding 12-16 t/ha each year); broadcasting vetch in maturing winter cereal crops in early July (yielding 2-5 t/ha by the end of September) or zero-till seeding of vetch into winter barley stubble (Paltridge *et al*. 2006). Other agencies working in TAR had also identified similar strategies (Lane 2006). The on-farm testing of these options was the next stage required which would promote awareness of these new technologies.

Zero-till seeders are perceived to have great promise for TAR farming systems (Jin Tao 2005; Jin Tao *et al*. 2006) with potential for reducing labour input, lifting the intensity of cropping systems (e.g. allowing double crops to be sown), reducing disturbance to levelled irrigation fields and improving soil structure: optimising zero-till seeding technology is important technology for Tibetan farmers. Such new technology needs ongoing evaluation in comparison to conventional seeding for the influence of seeding method and seeding rate on performance of spring barley, and winter wheat and barley, as well as for new forage systems (Paltridge *et al*. 2006). Results will be extremely valuable in support of the TAR government initiative to promote zero-till seeding in Tibet.

The government promotes use of N and P fertilisers by providing subsidies, but there is no clear information on efficacy of use or any nutrient response functions. Also there was emerging evidence (from the previous ACIAR agronomy project) that deficiencies of other nutrients, particularly K, might be factors limiting crop yields. On-farm nutrient response trials were therefore proposed to provide new data and clear direction for the effective and economic use of fertilisers.

Summary

Increasing the output of dairy products in the Tibet Autonomous Region (TAR) of the Peoples Republic of China is identified by local and Central government as a high development priority to meet current and predicted future deficits. The policy of increasing genetic potential promoted by government contains management risks which can exacerbate the overriding problem of nutrient deficiencies. Grain production in TAR, whilst currently sufficient to satisfy demand for human consumption, will also need to be increased to support growing populations as well as supplementation of livestock diets, particularly dairy cattle, and to provide land on which to grow more forage crops in order to improve the nutrition, reproduction and milk production of the cattle. The particular geographical nature of Tibet provides local agricultural production with a competitive advantage due to the high transport costs of products from elsewhere. However, most farmers fail to make best use of the natural resources available for crop and livestock production; indeed although frost free and moist conditions can continue until late autumn, fields are often uncropped after late summer. Various approaches to improve the overall productivity of the cropping/dairy system in TAR were therefore proposed for this integrated project directed at increasing household income and industry productivity, and at developing community based initiatives for improved dairy, crop and fodder production for farmers in the central valleys of TAR.

4 Objectives

The overarching objective of the project was to understand and utilise key socio-economic, agronomic and livestock production factors affecting the adoption of improved technology: the attitudes of farmers, practical constraints and opportunities for implementation of recommendations as well as strategies and structures for extension. The project had five specific but inter-related objectives aimed at the development of strategies to overcome current constraints to crop and dairy production:

1. To evaluate on-farm cereal, fodder and dairy cattle nutrition options in two contrasting farming systems, and monitor implementation of improvements
2. To develop, test and demonstrate cereal/legume forage crop management options that increase quantity and quality of food and feed outputs in the central valleys of TAR
3. Identify, test and demonstrate methods for conserving mixed cereal/legume and crop residues for winter feeding
4. Identify, test and demonstrate feeding strategies that make best use of mixed and legume only forages for milk production and animal growth
5. Enhance research and extension capacity in crop-livestock systems in Tibetan agencies

Activities associated with these objectives and achievements against milestones are given in Section 6 of this report.

5 Methodology

5.1 Introduction

There were a range of methodologies used for this project including the following: field trials and experiments at research institutions/stations and applied research on-farm, best practice technology demonstrations in households or villages, structured and informal interviews and surveys, household and economic modelling, plus capacity building activities such as postgraduate training, study visits, workshops and meetings.

Since an integrated approach to forage-livestock production was the central theme of this project there was much interchange of information and ideas within and between the TAR partners and the Australian team and often personnel assisted with and contributed to more than one component of the work. For example Tim Heath had input across livestock production, forage and cereal agronomy, household interviews and economic modelling, Pemba Drolma conducted interviews, assisted with surveys and undertook field agronomy trials, Colin Brown conducted interviews, assimilated survey data and interacted with livestock and agronomy personnel to enable the integrated household model to be developed and applied.

Surveys of agronomic practices, households and extension staff were undertaken at various locations in Tibet (details below) that had been selected in collaboration with the local counterparts and that were considered representative of the broader regions. Agronomic research trials were largely undertaken, with input by many project participants, on the two Tibet Agricultural Research Institute (TARI) field stations; one located in Lhasa (29.40'N, 91.08E; 3649m asl) and the other at Shigatse (29.15N, 88.53E; 3836m asl), being representative of the typical agro-climatic environment for the central valley agricultural region. On-farm agronomic research trials in Tibet were also undertaken to characterise productivity for other agro-environments (different soil types, temperature regimes and rainfall). Animal production, feed quality and diet experiments were undertaken using the animal house research facilities at TLRI and those at Wagga Wagga in Australia. Best-bet options, identified from both agronomic and livestock research, were incorporated as on-farm demonstrations in association with field studies in key areas. Project results were therefore considered applicable across three main prefectures (Shannan, Shigatse and Lhasa) of the central valley regions. No access was granted to work in Linzhi, although this was originally suggested in the project proposal.

5.2 Research Station and On-farm Field Trials

5.2.1 Cereal & Fodder Crop Agronomy trials (Tibet)

In each year from 2008-11 agronomic research trials were established at the research stations in Lhasa and Shigatse, maintained and sampled by TARI staff and overseen by Jin Tao. These trials evaluated a number of options for fodder agronomy such as sowing method, rate and timing, as well as time of cutting and method of conservation. These research trials included testing the performance of different varieties of triticale as winter sown fodder crops, and the productivity of different varieties of oats and maize as spring sown fodder crops. In 2008 Nick Paltridge undertook an on-farm fertiliser response trial (eight 3m x 3m plots and adjacent farmer field as control) near Lhasa measuring biomass and grain yield in cereals after foliar application of K as sulphate of potash. Further work, investigating growth and yield response of barley to K applied as potassium chloride at sowing was carried out by Tim Heath in 2 field trials in 2010, one at Shigatse and one at Lhasa, with a follow-up in 2011 at Lhasa. Crop nutrition experiments, designed and overseen by Guoyi Liu, examining response to different rates of application of N, P and K fertilisers were also carried out in 2009 &10 at TARI and at several on-farm locations across the central valley region.

5.2.2 Livestock Research

The research program comprised conventional feed evaluation, nutrition and animal production experimentation at research institutions in Tibet and Australia, forage production and conservation work to identify and demonstrate best-practice, and a large component of on-farm applied research in Tibet. The on-farm work monitored milk production on family household units through annual production cycles, while concurrently documenting associated nutrients fed in the diet to allow examination of input/production associations. The participatory approach for the field research was aimed at fostering ownership and facilitating two-way flow of information between farmers and scientists, thus benefiting both parties and enhancing eventual adoption of project results and improved technologies. Thus the field research component had outcomes for demonstrational purposes as well as in data collection for analysis of available nutrition and its association with milk production.

Animal House Experiments in Tibet at TLRI

Experiments, designed and overseen by Tsamyu, were conducted in the animal house at TLRI to examine the effect on milk production of varying either concentrate:forage ratio, or levels of protein in the diet when fed to local genotype and crossbred dairy cows. Experiment 1 used six improved (I - F1, local x Holstein) cows (mean liveweight 258kg ±16.3) and 10 local breed (L) cows (mean liveweight 180kg ± 20.7), randomly assigned to two dietary treatments differing in concentrate:forage ratio - C30:F70 or C40:F60. A total of 4 treatment groups - 30:70L; 30:70I ; 40:60L; 40:60I. Experiment 2 used 9 improved (I - F1, local x Holstein) cows (mean liveweight 234kg ± 26.1) and 9 local breed (L) cows (mean liveweight 193kg ± 31.3), were allocated in a completely randomized design among the 2 breed groups (3 diets x 2 breeds, each with 3 animals per replication). The 3 diet treatments differed in crude protein level - 16%, 18% or 20% protein fed to either improved (I) or local (L) cows, thus there were 6 treatment groups - 16% L; 16% I; 18% L; 18% I; 20% L; 20% I). Diet quantities within treatments were formulated for individual cows to meet requirements according to NRC feeding standards for dairy cattle (NRC 2001). Following birth, calves were given 2-4kg milk up to 20days and 4-5kg milk for 20-50days. After 50 days the milk was gradually reduced and they were transferred to *ad libitum* high quality hay (oats and Chinese wild rye) and calf concentrate. Calves were weighed monthly and weaned at 60 days.

Experimental cows outside TLRI animal house

Tsamyu showing Annie McNeill hay provided by TARI for animal house experiment at TLRI

Household sites: Field research in Tibet

This component was carried out with 15 family household farms in Changzhu village, Naidong County, Shannan Prefecture, with data collection over 3 milking seasons during 2009 to 2011. These households had mixed cropping and livestock production, each having small numbers of dairy cows. The dairy and cropping practices were typical of this and other regions of similar production around Lhasa and further afield. The cow genotypes were "local" or crosses with Holstein or Simmental breeds, the latter two crossbred genotypes commonly referred to as "improved" by Tibetan staff and farmers. These have been bred locally as part of the widely practiced AI program subsidised by the central Chinese government. The "local" cow genotype covers a wide range of animals that have been bred over centuries in Tibet, with research suggesting they are one of the strains of *Bos taurus* independently domesticated from local wild cattle (Tu *et al.* 1997; Cai *et al.* 2006). In our experience the females are typically of only 200 – 300 kg mature liveweight, and thus much smaller than most European dairy or beef breeds. Data were collected documenting feed offered to the cows and recording associated milk production. Reproduction data included dates of insemination and calving as well as detailed records of calves at birth.

John Wilkins taking notes at a farmer interview

A further site, Bairong community dairy (Naidong county), was initially proposed for inclusion in the study, intended as a demonstration site. Changes in management prevented implementation of the original plan within the project timeframe, although TLRI staff were able to provide advice on feeding and breeding strategies for ongoing operations, which we believe will have flow-on benefits to the wider community.

The field data were collected at each household site using standardised sheets recording daily milk production and feed offered, detailing the components of the diet. The data on the field sheets were essentially entered by the farmers, but with intermittent supervision of TLRI field staff. Data were transferred from field sheets from each site to a central data file that enabled analysis of various aspects of milk production and detailed dissection of the associated nutrient quantity and quality of the diets. Thus a complete nutrient profile could be constructed for each cow at the same time as her milk production. The format of the data sheets for milk production, feed offered and for reproduction, as well as an example of the data in the central file that was used for analyses are attached in Appendix 11.1.

Feed offered - nutrient status

The purpose of this component was to describe the nutrient status of the diets offered to the cows in the current study, extending the information previously gathered (Wilkins and Piltz 2008). This was used to demonstrate the principles involved in balancing the nutrient requirements of animal production to those available in the diets on offer. Detailed data were collected as described above so that we could determine the nutrient intake in relation to the types of feed offered in the total diet.

Colin Brown and Scott Waldron talking with a farmer about feed on offer

Milk production

Milk production data from the household sites were analysed for effects of breed, season and stage of lactation. Stage of lactation is known to be the most consistent factor affecting milk production regardless of other factors, and this has been given specific attention. Nutrient intake obviously also has a major effect and this was examined for correlation with milk yield, when other factors were taken into account.

Lactation curves

Wood (1969) proposed the first lactation curve model, which has been the most well used but with many modifications or alternatives developed since. Quinn *et al*. (2005) evaluated 14 published models for “goodness of fit” of a very large data set and concluded that a modification of the one proposed by Ali and Schaeffer (1987) was the best of those examined. They (Quinn *et al.* 2005) proposed that the modified model (called “Ali-B”) provided a single well-fitting and robust expression with four parameters that could be fitted to any data set using a polynomial non-linear regression model. We therefore examined our data for fit to both the Wood and Ali-B models, with the aim of determining suitable equations for the prediction of milk production for the Tibetan cows. The form of the models and equations generated are shown in the results section.

Reproduction

The reproduction data were analysed for effects of year and genotype on parameters of fertility (calving percentages, repeat calving, post-partum re-mating, intercalving intervals) and calf production.

Tools

Additional tools have been generated or provided for the Tibetan staff to assist calculations of nutrient requirements for livestock, nutrient supply from diet components etc., and for ongoing future activities.

Statistical analyses for this component generally used Genstat REML procedures for analysis of variance, regression or correlation as appropriate. Data sets used to analyse various parameters of production often varied and thus there may be differences in predicted means generated – in some cases an extra year of data for particular parameters was able to be included.

Forage conservation and Feed quality (Australia)

Field experiments, overseen by John Piltz and maintained and sampled by staff from Wagga Wagga, were sown at sites across southern NSW over 4 years to evaluate cereal and cereal vetch crops for hay and silage. Severe drought conditions in 2008 forced the abandonment of the experiment and an additional experiment was sown in 2011. The experiment sites were at the Wagga Wagga Agricultural Institute, Wagga Wagga in 2008 and Mr Andrew Cotter's property at Henty in 2009, Temora Agricultural Research and Advisory Station, Temora in 2010, and at Mr Brian Buchanan's property 'Tolmie', Coolamon in 2011. Seven cereal varieties were selected to provide a cross section of types grown in southern NSW and either grown as a monoculture or in a mixture with popany vetch (*Vicia benghalensis*). The cereal varieties were Tobruk triticale, Strezlecki (grain only) & Wedgetail (dual purpose) wheat, Gairdner (malting) & Urambie (dual purpose) barley, and Echidna (grain) and Mannus (dual purpose) oats. The crops were sown at 70 kg/ha cereal or 15 kg/ha cereal plus 60 kg/ha vetch with MAP fertiliser 105kg/ha and at 15 cm row spacing.

The intention was to harvest forage from the plots at the boot, anthesis (flowering), milk and soft/mid dough stage of cereal grain development (later referred to as harvests 1, 2, 3 and 4) but due to seasonal conditions the actual number of harvests varied with year and treatment. Samples from each plot were cut by hand approximately 5cm above ground; none of the plots were taken to maturity for cereal grain harvests. A subsample was dried at 80ºC for 24 hours to determine dry matter (DM) content; this was used to calculate DM yield. Botanical composition was determined for the vetch and cereal mixed crops.

Metabolisable Energy (ME) content (MJ/kg DM) and crude protein (CP) content were determined by NIR. Yield, ME and crude protein (CP) content were statistically analysed using linear mixed models (REML directive) in Genstat. To estimate the potential value of animal production growth rates and intake for 300kg British breed steers and 30kg crossbred wethers were predicted using Grazfeed (ver. 5) based on estimated feed quality (ME and CP) data and assuming *ad libitum* intake of the forage as the sole diet. Expected value of livestock production ($) from these crops was calculated assuming only 70% of the forage was conserved and further loss/wastage reduced production by 20%.

A barley (*Hordeum vulgare* var. Urambie) and an oat (*Avena sativa* var. Cooba) crop were grown at Wagga Wagga Agricultural Institute and harvested for silage in spring 2009. Adverse seasonal conditions meant the oat crop was only harvested at 2 stages. The silages were fed to weaner steers in the Wagga Wagga Agricultural Institute's animal house during 2010 to determine apparent *in vivo* digestibility.

Additional experiments were conducted in conjunction with this project as part of John Allwright Fellowships by two researchers from TAR (Wang Li and Xiangba Zhuoga).

Cereal crops grown at 2 locations Craboon (central western NSW) and Wagga Wagga (southern NSW) and including varieties of barley, oats, triticale and wheat were harvested at the boot, anthesis and milk stages respectively. The effects of maturity stage and variety on feed quality parameters, including predicted digestibility, were measured by near infrared reflectance spectrophotometry (NIR). Digestibility was predicted using 2 calibrations based on the Pepsin/cellulose (P/C) technique (AFIA 2009) or the Tilley and Terry (1963) rumen fluid (T&T) method. Differences in digestibility were noticed for due to calibration. Samples were then re-analysed using 'wet chemistry' methods to determine *in vitro* digestibility using either the P/C or the T&T methods and results statistically analysed using the REML directive in Genstat.

Two experiments were conducted concurrently to investigate the effects of supplementation with lucerne silage on the utilization of barley straw (*Hordeum vulgare*), a typical low quality feed. A barley straw plus cottonseed meal (CSM) diet was also fed as a typical industry practise protein supplement. Diet digestibility, feed intake and growth rate was determined using Hereford yearling steers (284 – 342 kg liveweight).

In Experiment 1 twelve steers were used to compare the digestibility of barley straw (BS) and BS with various levels of lucerne silage (L2, L4, L6) or CSM, and lucerne silage (LS) diets. Digestibility was determined at a restricted level of feeding (16.5g DM/kg liveweight), using a partial changeover design; 3 estimates per steer and 6 estimates per diet. In Experiment 2 thirty six steers were fed barley straw *ad libitum* for 49 days with daily supplements of either 1.9, 3.9 or 5.7 kg DM lucerne silage (L2, L4 and L6) or 0.8 kg DM CSM to determine liveweight gain and intake. The ratio of barley straw:supplement fed in the mixed diets in Experiment 1 was calculated to give similar proportions to the expected ratio of barley straw:supplement consumed in Experiment 2. Results were statistically analysed using the REML directive in Genstat.

5.3 Demonstrations, Field Days & Farm Visits

Demonstration sites with an emphasis on extension of best bet technology to farmers were established at two locations during 2008, at Changzhu village, Naidong County, and at Dazi village, Mozhugongka County. Two new technologies demonstrated in these areas: were zero-till seeding of vetch as a double crop over an area of 50 ha in Changzhu village; and zero-till sown cereal crops established for winter wheat at Dazi. These demonstrations continued through the project and additional demonstration sites were established in 2010 at several locations including Duopozhang, to show the fodder producing ability of winter sown Triticale. There were also demonstrations of new technology for harvesting and conserving forage; a hay baler (large squares) was acquired to demonstrate baling oats at Shigatse. Vetch hay-making was demonstrated in 2009 with double crop vetch at Changzhu.

As described in previous section the site at Changzhu village was also used for demonstrating best practice livestock production in 15 farming households and TLRI staff lived nearby in Tsedang to oversee ongoing monitoring. At this location, feed and milk data were monitored on a daily basis during the main stages of lactation during 2009, 2010 and 2011. Results from analysis of the data, characterising diets and milk production, were used to demonstrate to households and field staff the principles involved in matching production requirements with nutrient availability

Farmer field day on sowing forages with Jin Tao & Nick Paltridge

Regular farmer field days were held at demonstration sites in each year of the project – organised chiefly by Jin Tao and with collaboration of many external organisations and government agencies. On-farm visits were a routine part of the program when Australian project personnel or ACIAR staff visited TAR, and provided an opportunity to further extend information in the community, and more widely to government and overseas visitors.

5.4 Surveys & Interviews

Surveys of agricultural practices on 45 farms conducted as structured interviews by Australian and local project team members in the latter stages of the previous ACIAR agronomy project CIM/2002/093 were analysed in the first year of this present project, allowing typical agricultural practices to be reported, and constraints to production and opportunities to improve productivity to be identified and discussed (Paltridge *et al.* 2009). Also analysed were the agronomic survey data collected previously by Nick Paltridge to assess the nutritional status of wheat and barley crops in 16 fields across Tibet's cropping zone, including soil pit characterisations and soil and plant tissue analyses.

The adaptive research/extension component of the Tibet project aimed to look at the adoption characteristics of Tibetan farmers and the attitudes of extension and research staff to extension and adoption of technologies. This was undertaken in 3 steps - survey of farmers adoption characteristics undertaken in 2009; questionnaire in 2011 with farmers on critical factors affecting adoption in relation to ours and government projects, including research and extension resources; and scoping the present TAR government extension and training services through discussions with staff and general observation over the entire project (2008-2011). As part of the ACIAR 'Mineral response in Tibetan Livestock' project, a further adoption characteristics survey of farmers at Duopozhang was undertaken in 2011.

Carol Rose and Lamu interview a farmer

Interview surveys that focussed on extension networks and household economics were designed in 2008 by project staff from NSW DPI (Carol Rose) and PIRSA (Jay Cummins). In conjunction with local staff these surveys were pre-tested in two households during May 2009 and implemented in 14 villages during August and September 2009 - a year later than planned due to travel constraints. Each interview took about 1 hour and 15 minutes, and they were conducted across the cropping areas of Tibet, from Tsedang in the east to Lhasa in the central cropping area and to Shigatse in the west. Some interviews were also conducted in far western Tibet, in the remote Ngari prefecture where both agricultural and pastoral practices are carried out. A total of 39 farmers were interviewed. Qualitative and quantitative information was collected by asking farmers questions about attitudes, motivation and farming practice. Questions were not targeted at specific technologies; rather general questions were asked that could allow research issues to be investigated by associative analysis. Information was often sought through questions with non-numeric responses, such as attitudes to farming practices. In these cases, a 5 point (Strongly Agree to Strongly Disagree) Likert scale was used to rate their perceptions or feelings. This provided information on “level of agreement” for farmer’s perception of the positive or negative effects on adoption of various technologies. The methodology allows approximate quantitative data to be obtained from qualitative data. The qualitative information mainly focused on the adoption characteristics in relation to farming practice and new agricultural technologies. The quantitative information described the characteristics of the people, households and farm practices. The information from these surveys was reported in the Masters Research thesis by Pubu Drolma at The University of Adelaide.

The Adoption Characteristics survey was designed, simplified into plain English, translated into Mandarin and extensively workshopped for content and for accuracy in translation with a large panel of local staff, from both Tibet Livestock Research Institute (TLRI) and Tibet Agricultural Research Institute (TARI). The modified survey was translated into Tibetan by an English/Mandarin/Tibetan speaker to enable the interviewers to ask the questions in the local language. Staff were trained, the survey piloted and then run in several farming areas in Tibet. Farmers were interviewed in 3 localities in 2009 (34 farmers) and further interviews conducted in Duopozhang (fourth locality 13 farmers) in 2011. Two sections on specific technologies were the only changes to the 2011 survey. The surveys were verbal due to the low level of literacy in Tibet, with each taking approximately 45 – 90 mins to complete.

Villages were selected in 2009 by TAR extension / research staff to represent project and non project locations. Due to the necessity of using government staff to set up interviews, the non project locations were still likely to have been influenced by non project related extension activity. In 2011, Duopozhang was selected due to its planned association with the ACIAR Mineral response project. Village leaders were asked to arrange interviews with different householders of both gender and from a wide range of households with a wide range of incomes.

5.5 Household and Economic Modelling

To perform the economic analysis of different crop and livestock enterprise mixes and various crop and livestock interventions and practices, a household modelling approach was adopted. The household modelling approach was adopted because of the need to account for the many interactions that exist within crop-dairy systems. For instance, improved livestock productivity will impact not only on liveweights or milk yields but also feed required, manure, own consumption, labour and finances. Furthermore the complexities and diversity of these farming systems and household systems entails that an approach is needed that can facilitate rapid but detailed analysis of different and in some cases unforeseen scenarios is needed and this is best achieved through a modelling approach. In addition the approach is governed by the fact that the primary inputs and outputs into these systems (including own consumption, own feed and inventory changes) are non-monetary and so the analysis needs to an approach to facilitate the valuation and incorporation of these non-monetary values into the analysis.

To accommodate the flexibility and complexity of the household systems in the model requires a large amount of specific information in order to be able to construct the interactions in the model and synthesize the key parameters. A multi-faceted approach was used to gather this information with the focus on case studies of farms rather than a large statistical survey in order to better understand the information and to gather information and knowledge extending beyond the existing systems. Thus it was decided to synthesize representative farms for different regions and types of farms. The primary source of this detailed information came from farm case studies in three agricultural regions in which the project was working namely Bailang county in Shigatse prefecture; Naidong County in Shannan Prefecture; and Mozhugongka County in Lhasa Prefecture. This provided a spectrum of crop, livestock and household systems to be investigated but also ensured the relevance of the model to the agronomic and animal production research being conducted in the project. Detailed interviews were conducted with households on land use, finances, own consumption, cropping systems, livestock systems, feed systems, prices, off-farm activities, labour and household structures. Twenty household interviews were conducted in 2009. Most households were re-visited in 2010 to fill information gaps, to check on the model's robustness, to gain a better appreciation of the dynamics of these systems, and to understand adaptation of these farm households, especially as 2010 was a very dry year with impacts not only on crop yields but also on price and availability of feed resources.

The case study households were selected in consultation with local officials. The households came from at least two villages in each of the counties while they were also selected to account for diversity in size (household numbers, crop areas and livestock numbers) and incomes. Village level data on the distribution of households by size and income classes in Bailang and Naidong counties was obtained to place the case study farms in context and to aid interpretation of model results Secondary information collated from regional statistical yearbooks were also used to place the specific household information in a broader context but were of limited use because of underlying biases in the data and masking associated with the level of aggregation.

The interviews were constructed as semi-structured interviews that facilitated the collection of core information across households but that also allowed extension of questions into areas where the particular household had good information. The interviews generally involved half a day while several members of the household were interviewed to obtain information on particular items. Local staff from TAAAS that had multilingual capacity (including Pemba Drolma) were critical in the survey and interview components of the project, and the fact that one Australian team member (Scott Waldron UQ) was fluent in Mandarin also assisted greatly. Many other project staff, local and Australian, also participated in these interviews at various times.

Scott Waldron interviewing a farmer

Apart from assistance with the selection of households, local officials were also interviewed to gain an understanding of historical developments and local strategies and policy directions. Enterprise managers (including grain and dairy processors and feed companies) along with local traders were interviewed to gather information on local markets, prices, product requirements and service costs over a period of years.

The model also requires a range of technical parameters from crop yields and responses, livestock productivity, milk yields, livestock feed requirements and feed nutritional contents. Information was obtained where possible from project scientists and the trials and experiments reported elsewhere in this final report. Information was also drawn from previous research and surveys such as that in Paltridge *et al.* (2009) as well as general information on feed nutritional contents and energy and protein requirements such as NRC (2001). The TARI and TLRI scientists and extension officers in the project, with their extensive local knowledge, provided a useful reference point for commenting on the information from the case studies and in establishing farm level parameters. To facilitate its use, the model simulates a range of parameters such as crop yields, liveweights, milk yields and feed rations but still allows the user to overwrite these endogenously determined values to account for individual variation.

Another important facet or element in the design of the modelling approach was to allow for new information and parameters to be incorporated into the model as that information became available from the trials conducted in the project. This was especially important given the lack of pre-project information on agronomic responses and livestock productivity that the project was seeking to address and hence the need to facilitate the updating of this information. The model also needed the flexibility and capability of performing multiple analyses to account for rapidly changing environmental and market conditions.

The interviews and information collected in 2009 and 2010 were used to develop the model. Detailed presentations of the model to the TAAAS members of the project team were then used for feedback on refinements needed to the model to make it a more effective research and extension tool. An advanced version of the model and manual was then translated into Chinese in 2011 in conjunction with TARI (Wei Na), and training in use of the model was conducted with TARI, TLRI and Naidong government officials, and ownership of the model transferred. The model was used to test cropping scenarios for the 2011 project final review, and for crop-livestock scenarios in Duopozhang. Further testing and extension was planned for 2012 but was not possible due to travel restrictions.

Workshop for the CAEG Tibet model at TARI

5.6 Activities to enhance research and extension capacity in TAR

Dr Tsamyu and Mr Jin Tao were key project personnel in TAAAS involved in design and conduct of all the experiments and demonstration work referred to previously, and by collaborating with Australian partners were able to build their skills in this area, as well as transfer some of their knowledge to other TAAAS staff involved in the project. When Australian project staff visited TAR there was always an emphasis placed on facilitating contact with as many other project staff as possible to enable knowledge and skills transfer. Three project staff members from TAAAS (Xiangba Zhuoga, Pubu Drolma and Wang Li) were recipients of John Allwright Fellowships and successfully completed Masters by research degrees in Australia.

Research capacity building was enhanced by inputs from visiting Australian Youth Ambassadors (AYAD). Tim Heath spent 4 months as an AYAD on the project in Lhasa in 2009, and with a solid background in farming and extension agronomy, was able to help other TARI and TLRI staff to improve methods of agronomy and language skills, as well as assisting with project agronomy experiments and farm surveys. Tim subsequently (in early 2010) replaced Nick Paltridge as research officer on the project and continued his capacity building efforts until leaving the project in Dec 2012.

Bonnie Flohr spent 6 months as an AYAD on the project in Lhasa in 2012 and with local assistance undertook a highly successful research experiment at TARI to assess the suitability of local Tibetan cereal cultivar varieties for dual-purpose use (forage and grain). During this time Bonnie also held informal sessions aimed at improving English language skills of local staff. She also provided hands-on training to new project staff, and refresher training to existing staff, on basic aspects of agronomic research that she had learnt during her Honours year at University of Adelaide.

The start of 2011 involved a key project workshop in Adelaide for the project combined with the associated ACIAR project LPS/2005/129 'Mineral Response in Tibetan Livestock' The week long workshop brought together 10 local staff from Tibet and all Australian project personnel from both projects. It was a great opportunity for networking, capacity building and to discuss opportunities for the future.

John Allwright Fellowship scholars Ms Wang Li and Ms Xiangba Zhuoga inspect plots with John Piltz for sowing cereal forage trials at Wagga Wagga

6 Achievements against activities and outputs/milestones

Objective 1: To evaluate on-farm cereal, fodder and dairy cattle nutrition options in two contrasting farming systems, and monitor implementation of improvements

No.	Activity	Outputs/ Milestones	Completion date	Comments
1.1	Survey household and community access to crop-livestock system inputs and resources in the Shigatse, Lhasa, Shannon and Linzhi districts	Assessment of crop, forage and dairy production options in selected farm communities and identification of new research needs via surveys and focus groups Establish local arrangements for engagement with individual farmers/members of the target communities (including local appointments) Develop and implement a communication strategy to meet internal and external needs and monitor project effectiveness Meetings of the Coordination Committee held annually to monitor performance/satisfaction, reviews project plans and proposed operations and to provide feedback and directions to operations	Year 1, m10 Year 1, m10 Year 1, m10 Annually for the duration of the project.	Achievements against these milestones are reported in detail in previous annual reports. In summary: 1. Experiments and on-farm demos of best practice livestock and agronomy options have been completed during years 1-4 2. Project effectiveness monitored via feedback from annual meeting in Lhasa of whole project staff, from seeking the input of key individuals outside of project (e.g. minerals project staff and Poverty Alleviation Office) and comments from the major review of the project in 2011 3. Project impacts assessed by interviews with farmers regarding uptake of options tested, use of project methods by other local projects (e.g. feed sheets), and by the improved capability of local research and extension staff to implement activities that promote change on-farm Australian staff met as a whole group twice in 2012 to ensure continuity of progress and active discussions and development of publications and reports.

1.2	Survey attitudes to technological change in two different target prefectures	Benchmark survey of farmer and community resources, production, wellbeing and attitudes, constraints and opportunities Follow-up survey after 2 years of intervention to monitor, collate, interpret and report on crop-livestock systems in the 2 demonstration sites A documented understanding of farmer and community opportunities and constraints to the adoption of new technologies	Year 1 m 9 Year 3 Year 4	Achievements against these milestones are reported in detail in annual reports. In summary: 1. Benchmark survey was completed in 2009 - late due to travel restrictions 2. Data from benchmark survey has been analysed and documented in a Masters thesis and a short conference paper 3. A second survey was completed in 2011 - Short summary report on this survey information is completed and attached as appendix 11.2 to this final report.
1.3	Evaluate impact of on-farm cereal, fodder and dairy cattle nutrition options on household livelihoods	Develop representative whole farm household models for systems under investigation Collate information from surveys, interviews, project research and other sources for use in household models Analyse impact of crop, feed and livestock options on household costs and returns (including opportunity costs and imputed returns), labour and land use, and other livelihood indicators Assess household impacts against household objectives and constraints to adoption identified in Objective 1.2	Year 1 Year 2 m4 Year 3 m12 Year 3 m12	1. Detailed household and other sector interviews completed in 2009 and 2011 2. Information used for initial construction and further development of the model. 3. Model refined after input from Tibetan and Australian project researchers - handbook and conference paper written 4. Appropriate agronomic and livestock scenarios for socio-economic impact analysis& investigation by the model identified and conference paper written and submitted. 5. Transfer and extension of model to local TAAAS staff has been completed and the manual for the model has been translated into mandarin. 6. Model has now been used for various scenario analyses and used to generate 3 conference papers, a publication in *Agricultural Systems*, and others in process. .

1.4	Establish on-farm demonstration of options that include best-practice cereal, forage and cow management in two target districts	On-farm demonstrations established at each of a distributed and a peri-urban community Best-practice cropping and livestock management demonstrations at the two farming community sites Performance of the unchanged and 'improved' systems of production monitored On-farm visits, meetings and field days that reinforce project operations and system components	Year 1 m8 Year 1 m8 and onwards Year 1 m8 and onwards Year 1 m8 and onwards	Achievements against these milestones are reported in detail in previous annual reports. In summary: 1. Sites for best practice crop and livestock demonstrations were established 2. Monitoring schedules were developed for crop, fodder and livestock production at the farm household demonstration sites 3. Regular on-farm visits, meetings and field days held in each year of project.
1.5	Australian researchers (Rose, Cummins) and Pubu Drolma from TARI to compile (a) short technical report and (b) conference /journal paper summarising information gathered during project on constraints to farmer adoption of practice change and any detectable attitude changes	Report written and distributed across project staff and other relevant agencies/persons Conference/journal paper written and submitted	?	Australasia Pacific Extension Network (APEN) Conference presentation by Carol Rose completed in Nov 2011. Potential follow up for APEN conference in 2013
1.6	Australian and TAR team led by Waldron to update info in Goldstein paper with survey info from the ACIAR project & test key trends using CAEG.	Publication ready to submit to Asian Studies - An overview paper reporting on Rural Development, Agricultural Transition and Household Incomes in Tibet	Dec 2012	Conference paper prepared and to be presented in April 2013

Objective 2: To develop, test and demonstrate cereal/legume forage crop management options that increase quantity and quality of food and feed outputs in the central valleys of TAR

No.	Activity	Outputs/ Milestones	Completion date	Comments
2.1	Survey current agronomic practices in target prefectures that are at different altitudes and thus have different seasonal conditions (Shigatse, Lhasa, Shannon)	Farm surveys of agronomy, including seed quality and placement, plant populations, fertiliser management and weed management Identification of specific local issues affecting crop production and constraints to optimal yield	Year 1, m9 Year 1, m9	Achievements against these milestones are reported in detail in previous annual reports. In brief: This activity has resulted in published outputs as referred to in the publications section of this report and extra activities in the appendix 11.2.
2.2	Test new vetch/lucerne/oat and cereal relay and double crop agronomy options on-station and on-farm that make best use of available resources (Shigatse, Lhasa)	On-station research to address issues raised from activity 1.1 (or 1.2) Farmer-relevant crop management strategies with the potential to increase wheat and barley yield by 20% Field trials summarised in reports and research publications	Yrs 1-3 Yrs 1-3 Yrs 2-4	Achievements against these milestones are reported in detail in previous annual reports. In summary: 1. New agronomy options for increasing fodder production and yield of cereals tested in all years of project 2. Results disseminated to farmers at field days and other visits 3. Agronomy information presented at workshops in Tibet and conferences in Australia 4. Selected information published by TARI staff in FAO Handbook on Forage Production in collaboration with an EU project.

2.3	Australian and Tibetan researchers to work together on interpretation of data from crop and forage trials & demos undertaken in TAR , formulation of key messages, application of data to the CAEG model for economic analysis, and international publication of work	Focussed meetings in Australia to progress publications Email/Skype contact between Australian researchers at UQ, UA, & NSW DPI with TARI researchers Jin Tao, Guoyi Li, Wei Na and Pemba Drolma Manuscripts submitted to journals	February & Nov 2012 Ongoing during extension Dec 2012	February 2012 - successful planning meeting held in Adelaide for all Australian project partners and with phone hook up to partners in TARI November 2012- meeting in Sydney with Australian staff to work on project final report as well as publications. October 2012 - Paper presented at Australian Agronomy Conference on forage options for Tibet. Model description published in conference paper

Objective 3: To identify, test and demonstrate methods for conserving mixed cereal/legume and crop residues for winter feeding

No.	Activity	Outputs/ milestones	Completion date	Comments
3.1	Identify best methods for conserving lucerne/vetch and other feeds in an integrated cereal/forage system	On station research in Tibet and Australia into lucerne, vetch, cereal and other crop management to optimise yield and quality Practical, reliable and appropriate methods to conserve high quality forages suited to different Tibetan farming systems developed Field trials summarised in reports and research publications	Years 1-3 Years 1-3	Achievements against these milestones are reported in detail in previous annual reports. In summary: 1. Field studies in Australia 2009 and 2010 were conducted to investigate effects of time of harvest (stage of maturity) on feed quality in cereal and cereal/vetch mix forage crops. 2. In Tibet hay making was completed using a baler and compared to traditional methods in 2010. 3. Several workshops with farmers in 2011 on the management of oats and triticale as fodder crops 4. Information summarised for annual reports in TAAAS, for ACIAR and for conferences/workshops in Australia

3.2	Australian and Tibetan researchers to work together on (a) data interpretation of experiment/trials undertaken in Australia, formulation of key messages for TAR and international publication of work (b) interpretation of data from household feeding trials & other experiments in TAR, formulation of key messages, application of data to the CAEG model for economic analysis, and international publication of work	Focussed meetings in Australia to progress publications Email/Skype contact between Australian researchers at UQ, UA, & NSW DPI with TLRI researchers Tsamyu, Xiangba, Wang Li and others Manuscripts submitted to journals	February, July & Nov 2012 Ongoing during extension Dec 2012	February 2012 - successful planning meeting held in Adelaide with publication plan and implementation strategy agreed Follow up meeting completed in November 2012. Regular contact is maintained with all project partners and staff. Tim Heath acts as a facilitator /co-ordinator for this under project leader direction. Restricted international travel in final year of project limited interaction between collaborators. Tim travelled to Tibet for one month but plans for other staff visits were not possible. Theses completed and papers from study submitted attached in appendix 11.3

Objective 4: Identify, test and demonstrate feeding strategies that make best use of mixed and legume only forages for milk production and animal growth

No.	Activity	Outputs/ milestones	Completion date	Comments
4.1	Conduct animal house trials to evaluate nutritive value of silages and other feeds	Determine the nutritive value of lucerne, vetch and other feeds for milk production, milk components and animal growth in pen studies in Tibet Investigate the interaction between dairy cow genotype and the quality of feed on milk production and feed use efficiency Evaluate silages produced from cereals cut at different stages of maturity in an animal house experiment in Australia Develop improved laboratory techniques for evaluation of feed quality in Australian laboratories	Yrs 2-3 Yrs 2-3 Yrs 2-3 Yrs 2-3	Achievements against these milestones are reported in detail in previous annual reports. In summary: 1. Animal house feeding studies undertaken in various years both in Tibet and in Australia 2. Animal house experiment in Tibet in 2010 evaluating possible interactions between cattle type (local and improved) and 3 feed rations varying in protein. 3. Experiments on varying silages and rations undertaken in Australia. 4. Australian Standards for estimating digestibility (pepsin and/or cellulase) evaluated against rumen fluid (Tilley and Terry method) - undertaken by JAF Masters student from TLRI.
4.2	Develop feed budget options for the profitable use of different feeds in Tibet	On-farm and on-station results used to refine an existing spreadsheet model (with modifications as appropriate) that facilitates the assessment of feeding options on milk production and profitability in differing herd production situations Use this tool as a communication vehicle targeting farmers, extension staff, researchers, teachers, administrators and planners	Yrs 2-3 Yrs 2-3	Achievements against these milestones are reported in detail in previous annual reports. In brief: 1. On-farm data has been collected and processed 2. Feed budgeting component incorporated into CAEG Tibet model - results from household production and local feed evaluation used as appropriate 3. Outputs are currently being used to communicate to farmers via researchers and extension staff in Tibet that providing the cattle with good feed quality and unlimited access to water will improve milk production. .

4.3	Encourage greater ownership of data collected from households by key junior TLRI research staff and improve ability to interpret and prepare material for extension	Workshop when Australian researchers in Tibet in late April/May and visit to households – discuss draft info for papers in prep	2012	AYAD Bonnie Flohr spent 6 months and project researcher Tim Heath spent 6 weeks in country. Scheduled travel for Wilkins, Piltz and McNeill in 2012 was not possible due to partner country entry restrictions. Similarly it was not possible for local staff to travel. These issues have limited delivery on this mile stone.

Objective 5: Enhance research and extension capacity in crop-livestock systems in Tibetan agencies

No.	Activity	Outputs/ milestones	Completion date	Comments
5.1	Conduct assessment of training needs in crop – livestock systems in TAR agencies	Identify and prioritise the capacity needs (including a skills audit) relevant to the crop-livestock research-extension sector in TAR	Yr 1	Achievements against this milestone have been slightly constrained by institutional boundaries between research and extension staff causing limited flow of information. Nevertheless progress has been made in identifying where there are capacity building opportunities and these have been acted upon where possible (see next activity).
5.2	Plan and deliver capacity building programs (that may involve training in Australia)	Build on the capacity of the Tibetan scientists through training programs in China and Australia in areas of agronomy, livestock production and feed evaluation Core of scientists with applied research and/or extension skills and English language skills	Yrs 1-4	Achievements against these milestones are reported in detail in previous annual reports. In summary: 1. Pubu Drolma, Wang Li and Xiangba Zhuoga completed Masters degrees in Australia as John Allwright Fellows 2. Weina, Song Gouying and Darwa continuously developed their English and skill in agronomic data collection. Two AYAD volunteers over the duration of the project. 3. Five Tibetan staff spent one month in Australia in November 2009 travelling around the Wagga and NE NSW districts with a particular focus on dairy operations and fodder production. 4. Carol Rose delivered a workshop to the Farmer Training Centre at TAAAS in May 2009 on agricultural extension in Australia, and strategies to improve extension systems in TAR. 5. 10 local staff to Adelaide for week long workshop in March 2011 gave the staff the opportunity to see Australian research standards and work with local counterparts to build research capacity of the local staff.

5.3	Extension of household model and transfer to local collaborators	Refined model parameters and interface Translation of model from English to Mandarin User Manual (in English and Mandarin) for the model TLRI/TARI staff trained in use of model Model extension seminars and workshops in Tibet	Year 4	English language model and manual refined The full model and manual translated from English into Mandarin Training sessions with TLRI and TARI and Naidong County staff in use of the CAEG Tibet model conducted Ownership of Chinese model handed over Model data and parameters updated and extended through inputs from project researchers, and dedicated fieldwork especially in Duopozhang. Dairy, forage and cropping scenarios (in Bailang and Duopozhang) run in response to requests from reviewers and project team. Results presented to TLRI, TARI and various government staff in Naidong and Duopozhang Model has been used to examine the effects of best bet management options identified by the project on productivity and returns to the household. This has been done for representative households within the target prefectures and compared to the initial baseline survey data. Further training opportunities limited due to restrictions on entry to TAR for Australians in 2012

7 Key results and discussion

7.1 Introduction

Overall approach for this project was to integrate farming systems research in TAR, including aspects of cereal and forage production, feed conservation, dairy livestock nutrition and production, with an understanding of household attitudes and economic structures - in order to better predict the socio-economic effects of any identified technological innovations for improving the livelihoods of farmers in TAR. We believe the project goal was achieved with the interdisciplinary team working closely together on all aspects of the project and exchanging information from the various research components. Agronomic options for forage production without reducing cereal grain yields, and strategies for feed supplementation to improve milk production were demonstrated to households and in farmer fields. It is evident that the CAEG (Tibet) model has been a critical project output in regard to the integration process by providing a means of combining socio-economic implications with financial outcomes in assessing options for new technology Surveys early in the project indicated farmers attitudes were amenable to change, and observations towards the end of the project suggested that where new technology has been demonstrated to improve livelihoods adoption rates were high, although government financial support appears to be a strong influential factor.

Key project results are presented and discussed under the following major headings: (i) cereal, forage and soils agronomy (ii) livestock nutrition, milk production and forage utilisation, (iii) household economic modelling, and (iv) farmer' attitudes to adoption of new technologies.

7.2 Cereal, forage and soils agronomy

7.2.1 Cereal nutrition

The work undertaken during this project underlined that farming practices in TAR are generally degrading the soil resource base by removing more nutrients from the system than are currently being input by current fertiliser applications. Nutritional constraints to production varied across different research sites and farmers' fields, and research showed that this could be attributed to insufficient nitrogen, phosphorus or potassium individually, or a combination of these elements. Many soils are very low in organic matter (<1%) and this will exacerbate potential for nutrient deficiencies. Optimising fertiliser applications will require further testing and research.

During the first year of the project (2008) analysis of results by Nick Paltridge from an earlier field survey indicated that approximately one third of Tibetan crops may be marginal or deficient for potassium and one third to one half marginal or deficient for Zn and Mg (Paltridge *et al.* 2011b; Appendix 11.2). Calculations of crop nutrient removal indicated that with average grain yield for winter wheat of 4.5 t/ha and spring barley of 4.3t/ha around 140-150 kg/ha of K, 15-20 kg/ha of Mg and 0.2 kg/ha of Zn would typically be removed from Tibetan fields in harvested grain and straw each year. The reported use by farmers at sowing of urea at rates around 270 kg/ha and DAP at 225 kg/ha, together with top-up urea of 75kg/ha was thought to be minimising any potential for N and P deficits (Paltridge *et al.* 2009).

Though much of the removed nutrient may well be returned to fields each year in manure, household waste and ash, there is an increasing trend for farmers to sell grain (and sometimes straw) for cash. Further increases in grain sales from Tibetan farms, as are likely to occur as Tibet develops, will only exacerbate the depletion.

Following on from the survey, a field-based response trial in spring barley at one location near Lhasa showed grain yield responses to foliar applied K fertiliser significant at the 10% level (Figure 7.2.1.1) suggesting that indeed K could potentially be limiting production in some farmers' fields, although of course it could also have been response to S as the K was applied as potassium sulphate.

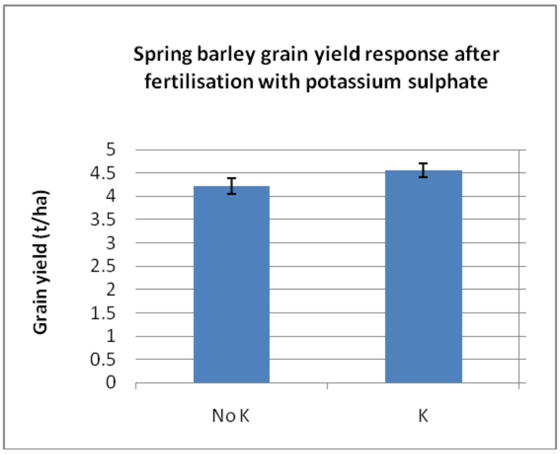


Figure 7.2.1.1: Spring barley grain yield response in 2009 to foliar application of potassium sulphate (6 kg/ha) at tillering (Zadoks growth stage 2.4, May 27) and again at booting (Zadoks growth stage 4.3, June 21).

However, whilst further field trials at Lhasa in 2010-11 and Shigatse in 2010 where K fertiliser was applied at different rates to spring barley demonstrated an increased K concentration in herbage (Figure 7.2.1.2), these effects did not translate to increased yields (data not shown).

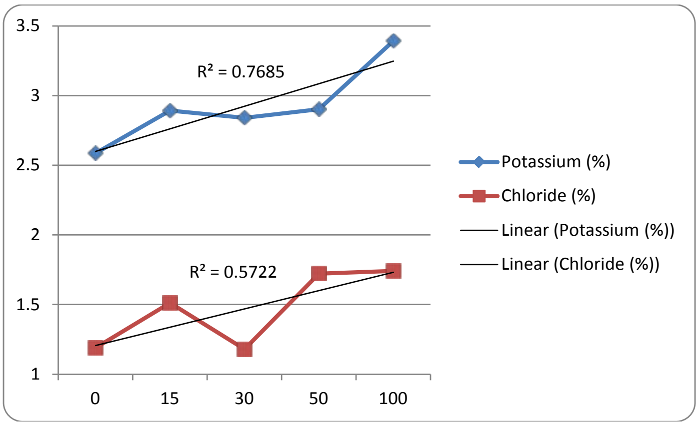


Figure 7.2.1.2: Potassium and Chloride percentages in the leaf at 39 DAS from Lhasa site. P values for each under general analysis of variance are 0.013 so these responses to potassium fertiliser are considered to be highly significant at a 5% confidence level.

Urea and DAP fertiliser applications in these K response trials were lower than typical on-farm rates reported from a survey in the previous ACIAR project (Paltridge *et al.* 2009). These trials received 41 kg N/ha (as 90 kg/ha urea) and 69 kg P/ha plus 27 kg N/ha (as 150 kg/ha 18:46DAP) at sowing, and 28 kg N/ha (as 60 kg/ha urea) topdressed at tillering. Nutrient balance calculations based on soil test values for mineral N at start of season (<20 kg N/ha) and measured off take in grain (72 kg N/ha) and straw (150 kg N/ha) indicate that N may have been limiting production. In fact plant tissue sampled 37 days after sowing at the Lhasa trial had marginal N concentrations (Table 7.2.1.1) ranging from 3.7 to 4.0% in tissue whereas at Shigatse N was sufficient but tissue P concentrations indicated deficiency being 0.40 - 0.43% (Table 7.2.1.1). Most agricultural soils in TAR are very low (<1%) in organic matter (Paltridge *et al.* 2011b) and this will exacerbate potential for nutrient deficiencies.

Table 7.2.1.1 Summary of tissue nutrient analysis from ICP analyses of shoot material taken (a) at Lhasa 39 days after sowing and (b) at Shigatse 40 days after sowing from plots receiving 0,15,30, 50 or 100 kg K/ha as potassium chloride prior to sowing in 2010.

(a) Lhasa

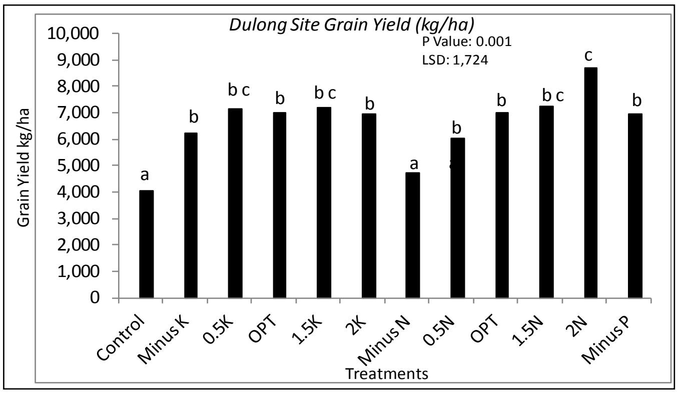
ICP Values CSBP 39 DAS	0	15	30	50	100	LSD	CV %	P	Deficient	Marginal	Adequate	Toxic
Boron (mg/kg)	22.3	22.2	21.3	21.5	16.8		64.4	0.708				>112
Calcium (%)	0.323	0.333	0.338	0.333	0.543		27.9	0.42		<0.18	0.21 - 0.4	
Chloride (%)	1.19	1.512	1.18	1.722	1.742	0.3984	22.3	0.013			<2	>3
Copper (mg/kg)	8.66	9.31	9.48	9.2	9.18		9.7	0.343	0.9	1.2	2.8	>14
Iron (mg/kg)	163.7	158.9	154.9	152.5	162.8		14.5	0.775				
Magnesium (%)	0.1567	0.16	0.1567	0.155	0.1467		13.3	0.154	<0.11	0.11 - 0.12	0.13 - 0.3	
Manganese (mg/kg)	40.22	40.28	41.65	38.97	39.35		12.6	0.774	<12.4		>17	
Phosphorus (%)	0.4383	0.4733	0.4617	0.47	0.5183	0.05636	15.8	0.092	<.44	0.45 - 0.49	0.5 - 0.68	>0.68
Potassium (%)	2.587	2.893	2.84	2.902	3.392	0.4205	14.6	0.013	<1.5	1.5 - 2.3	2.4 - 4	>6
Sodium	0.982	0.923	0.828	0.93	0.692		37.8	0.31			<0.5	>0.8
Sulfur	0.33	0.33	0.325	0.322	0.455		34.8	0.521		<0.15	0.15 - 0.4	
Total Nitrogen (%)	3.857	3.76	4.042	3.923	3.997		9.1	0.471	<3.9	4.0 - 4.6	4.7 - 5.1	>5.1
Zinc (mg/kg)	24.38	25.57	25.99	24.91	27.1		4.7	0.328	<14	14	15-70	

(b) Shigatse

ICP Values CSBP 40 DAS	0	15	30	50	100	CV %	P
Boron (mg/kg)	118.1	111.2	114	106.8	108.2	5.7	0.736
Calcium (%)	0.667	0.67	0.617	0.642	0.652	4.9	0.611
Chloride (%)	1.572	1.47	1.492	1.59	1.425	4.8	0.677
Copper (mg/kg)	9.26	9.252	9.225	9.61	9.31	2.5	0.5
Iron (mg/kg)	217.8	219.3	221.5	222.5	233.9	5.9	0.862
Magnesium (%)	0.2775	0.28	0.2625	0.275	0.275	2.7	0.676
Manganese (mg/kg)	72.5	73.3	70.2	71	72.9	8.1	0.886
Nitrate (mg/kg)	1045	1244	1401	978	1398	9.90	0.32
Phosphorus (%)	0.400	0.413	0.425	0.433	0.428	11.40	0.87
Potassium (%)	2.823	2.6	2.74	2.885	2.388	16.6	0.529
Sodium	0.897	1.14	1.022	0.917	1.187	32.6	0.42
Sulfur	0.515	0.5325	0.5025	0.53	0.5325	6.1	0.762
Total Nitrogen (%)	5.705	5.98	6.09	5.813	5.965	1.8	0.26
Zinc (mg/kg)	23.3	24.02	24.24	25.99	24.84	6.6	0.762

Other fertiliser research trials overseen by Gouyi Liu in 2009-2010 demonstrated that often more than one nutrient may be limiting production. These trials were designed to test responses of winter wheat to optimum fertiliser regimes derived using pre-sowing soil test information and target yields. Rates of K and N above and below the optimum were included in the trials (Table 7.2.1.2). Results in 2010 demonstrated that N, and P at optimised N, but not K, increased yields at Dulong (Figure 7.2.1.3a) whereas crops were N, P and K responsive at Gongga (Fig 7.2.1.3b). At Zhalang yields were much lower than anticipated, possibly due to low plant density - a relatively common occurrence due to less than optimal seedbed preparation and sowing management, resulting in poor establishment. Nevertheless the crops that did establish were both K and N responsive (Fig 7.2.1.3c). No fertiliser P was used at this site because the soil test Colwell P of 44mg/kg was considered sufficient.

(a)



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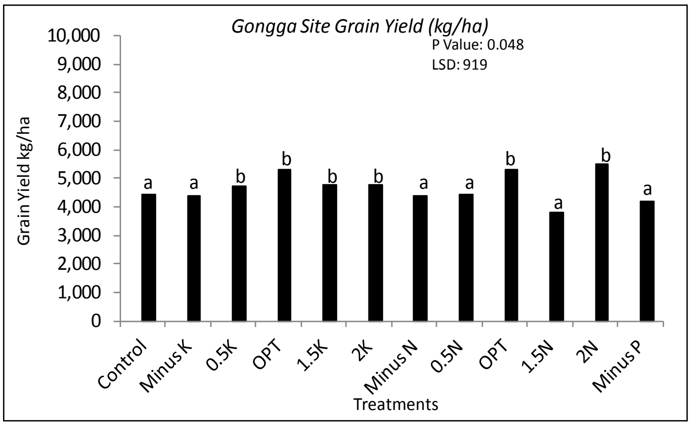

(c)

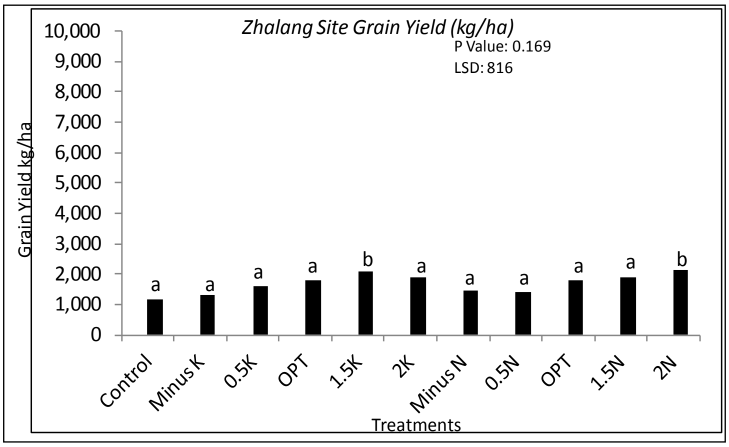

Figure 7.2.1.3: Winter wheat grain yield responses (2010) to fertiliser treatments at three locations across the Tibet autonomous region: a)Dulong b)Gongga and c) Zhalang

Table 7.2.1.2: Details of the fertiliser treatments used at sowing for winter wheat at three locations across the Tibet autonomous region: a)Dulong b)Gongga and c) Zhalang – OPT designated optimum nutrient rates.

Treatment	Dulong N P K kg/ha	Gongga N P K kg/ha	Zhalang N P K kg/ha
Control	0 0 0	0 0 0	0 0 0
-N	0 250 75	0 375 200	0 0 150
0.5 N	46 250 75	91 375 200	59 0 150
OPT	91 250 75	183 375 200	117 0 150
1.5 N	137 250 75	274 375 200	176 0 150
2N	183 250 75	365 375 200	235 0 150
-P	91 0 75	183 0 200	117 0 150
-K	91 250 0	183 375 0	117 0 0
0.5 K	91 250 37	183 375 100	117 0 75
OPT	91 250 75	183 375 200	117 0 150
1.5 K	91 250 112	183 375 300	117 0 225
2K	91 250 150	183 375 400	117 0 300

Trials with Zn fertiliser were not undertaken in this project and could provide valuable information on another potential nutrient limitation to yield as well as providing an indication of likely zinc deficiency in Tibetan diets. Furthermore, despite the fact that fields are irrigated and water should not be a constraint to cereal yield, symptoms of water stress were often observed in trials and farmers fields. Water–nutrient interactions have not been characterised for these systems and need to be considered, particularly as pressures on water resources increase from population growth, industrial use and global climate change.

7.2.2 Forage Production in Tibet

Agronomic research in the project evaluated options for the inclusion of fodder crops, especially legumes, in TAR farming systems where currently cereals comprise 75% of crops sown. The options included fodder crops of lucerne, triticale, oat, and maize grown as monocultures. On-farm demonstration of many of these management interventions has been an important part of the project. However, the least disruptive intervention to grain production was found to be relay intercropping by broadcasting vetch seed into maturing cereal crops, or planting sole crops of vetch after harvest, the latter preferably by direct sowing without cultivation for quick turnaround. In these two options, the challenge is to make the most productive and economically viable use of the time remaining after cereal harvest and before the cold winter. Zero-till sown double crops of vetch were popular with farmers at Changzhu, and produced around 3 t/ha of quality vetch hay that farmers stored on roof-tops and farm walls. By May 2009, zero-till sown wheat crops had established well at Dazi and were further demonstrated throughout the other years of the project.

Vetch/Pea mixture sown on-farm – either cut or grazed in situ

Dual purpose cereal crops (forage plus grain)

The agronomic research trial undertaken by Bonnie Flohr in the final year of the project was instrumental in demonstrating that cereals could be cut once for forage during the season without compromising grain yields. Overall, barley and triticale seem most suited to dual-purpose cropping for the Tibet environment with a single cut providing a high nutrition feed source and not reducing final grain yield.

Cutting the cereals in-season for forage significantly ($P<0.001$) reduced plant height with the greater height reduction occurring in double cut plots (Table 7.2.2.1). The greatest height reduction was observed in wheat and barley which may be an advantage since barley, in particular, is prone to lodging in TAR due to management, variety and seasonally high rainfall received as storms over the summer period.

Indeed, single cut barley had a grain yield increase of 0.9 t/ha compared to zero cut and this may be attributed to the fact that zero cut plots had all lodged one and half months prior to harvest , at the important stage of flowering and grain fill.

Table 7.2.2.1: Average canopy height (cm) at anthesis, in zero cut, single cut and double cut plots.

Species	Zero cut	Single cut	**% Reduction**	Double cut	**% Reduction**
Wheat	132	121	**8**	88	**33**
Barley	98	92	**6**	66	**33**
Oats	163	145	**11**	120	**27**
Triticale	179	164	**8**	135	**25**
Oats/vetch	162	145	**10**	126	**22**

$lsd_{(P<0.05)}$ (cereal)*** = 4.7 cm; $lsd_{(P<0.05)}$ (cutting treatment)*** = 3.6 cm

Bonnie Flohr (AYAD) worked on dual purpose cereals for forage and grain with Tibetan researchers & farmers

Aboveground biomass for all treatments ranged from 1.5 to 2.4 t/ha at the first cut on the 29th of May. Between cereal type there was a significant (P<0.001) difference in biomass removed, with barley producing the highest DM of 2.4 t/ha followed by triticale, wheat and oats respectively. The second defoliation occurred on the 14th of June. Here cutting treatment had a significant effect on biomass removed. Similar DM yields were obtained at this cut, ranging from 1.4 to 2 t/ha. However at this cut triticale and oats produced the highest dry matter, suggesting a greater recovery rate for triticale and oats. Biomass taken at harvest showed that with the exception of triticale, no single or double cut fully recovered to the biomass taken at harvest from zero cut plots, with DM reduction ranging between 0.5 to 2.5 t/ha between zero and single cut plots (Figure 7.2.2.1). Across all species, final biomass was lower for double cut plots compared to single and zero cut plots. The DM reduction for double cut plots ranged from 1.8 to 7.8 t/ha, showing cutting treatment to have a significant effect on final DM amount.

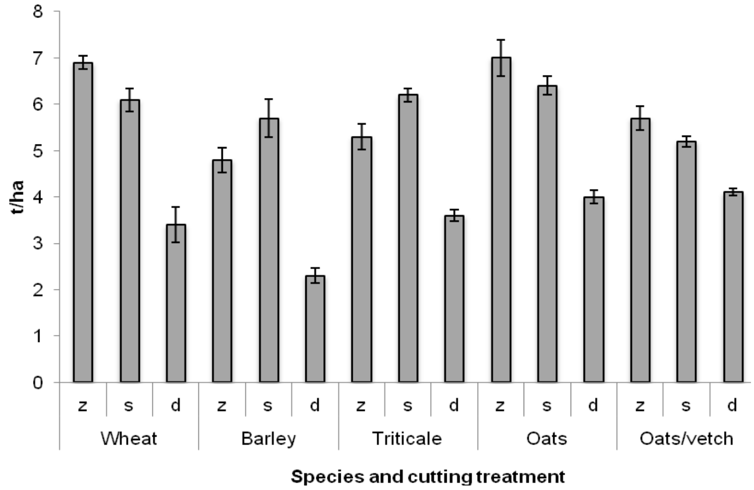

Figure 7.2.2.1: Yield t/ha for cereal species under different cutting treatments zero (z), single cut (s) and double cut (d). Error bars represent SEM

Oats was the highest yielding cereal of 5.8 t/ha, followed by wheat, triticale, oats/vetch and barley (Figure 7.2.2.1). Wheat suffered the greatest yield penalty from single cut, with yield reduced by 0.8 t/ha, followed by oats with a 0.6 t/ha grain yield reduction. However a single cut for both barley and triticale resulted in increased yield by 0.9t/ha. A single cut for oats and barley increased heads per m^2 by 38 and 12 respectively. Increased heads per m^2 for single cut barley contributed to a higher yield for single cut compared to zero cut. In all cases double cut reduced number of heads per m^2 and therefore final grain yield. The yield penalty of double cut was greatest for wheat and barley with a reduction of 3.4-3.5 t/ha. Oats grain yield was reduced by 3 t/ha, followed by triticale with a reduction of 1.7 t/ha. This reduction in grain yield caused a significant ($P<0.001$) effect of grazing treatment on yield. Barley single cut yielded 5.7 t/ha, compared to zero cut yielding 4.8 t/ha suggesting barley yield is not affected by a single defoliation. Similarly triticale single cut yielded 6.2 t/ha compared to zero cut at 5.3 t/ha.

Forage analysis measured at TLRI (Tibetan Livestock Research Institute) showed significant difference between quality (as measured from NDF and ADF) at the two different cutting times (Figure 7.2.2.2). Results, similar to forage analysis conducted on dual purpose crop trials in Australia, suggest vegetative cereals cut in Tibet are of high nutritive value.

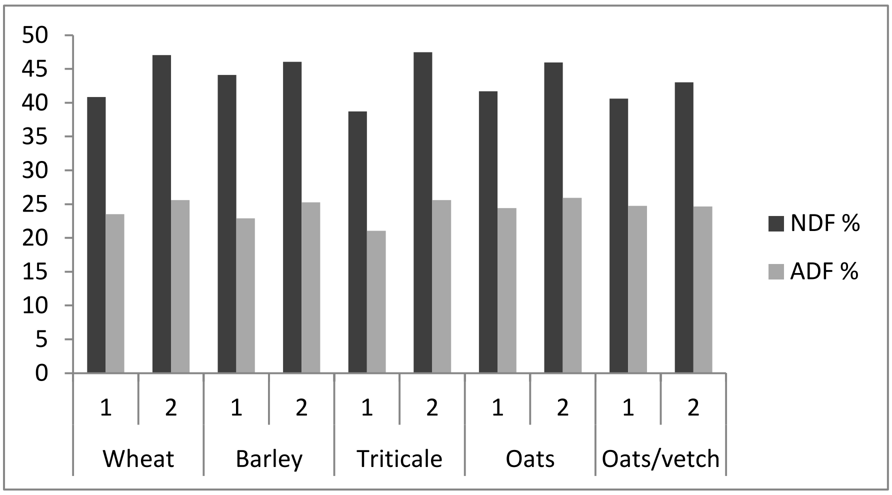

Figure 7.2.2.2: Proportion of neutral and acid detergent fibre (NDF and ADF) in forage from first and second cuts.

Soil characterisation

Previous studies have reported that arable soils around Lhasa comprise fluvial or lacustrine (alluvial) sandy or silty loams or clay loams of the Quaternary Period, rich in calcium carbonate and alkaline in reaction (Kaiser *et al.* 2008; Smith *et al.* 1999). Descriptions provided early in this project by Nick Paltridge of soil physical and chemical type in Lhasa are consistent with these earlier reports. Descriptions from additional soil pits in 2009 at Tsedang and Shigatse, and of further soil samples at other locations between the two suggested all these soils to be physically and chemically similar. Thus, the generalisation may be made that soils across the crop-dominated zone are typically sandy or silty loams or clay loams, rich in calcium and alkaline in reaction (Paltridge *et al.* 2009).

7.3 Livestock nutrition, milk production and forage utilisation

7.3.1 Animal House Experiments (TAR)

Experiment 1 (Varying concentrate:forage ratio)

- There were significant effects (*P*<0.01) of both diet composition and breed type on milk production. Higher milk production in the 40:60 diet compared to the 30:70 was evident within both breeds (Fig. 7.3.1.1)
- The improved cows produced more milk on both diets (Fig. 7.3.1.1).
- All treatment combinations produced more milk compared to the 30:70 L group (*P*<0.05), with 40:60 I having the highest milk production.
- There was no difference between 30:70 I and 40:60 L.
- Calf birth weights were similar between breed types, and calf survival was 100% over all treatments.
- Calves from Improved cows always grew faster with differences significant (*P*<0.001) from the third month onwards (Fig. 7.3.1.2).
- Calf growth rates here were much higher than those of 0.2-0.4 kg/d reported in our previous benchmark study (Wilkins and Piltz 2008*)*, demonstrating the growth potential when provided with adequate nutrition (milk and supplements).

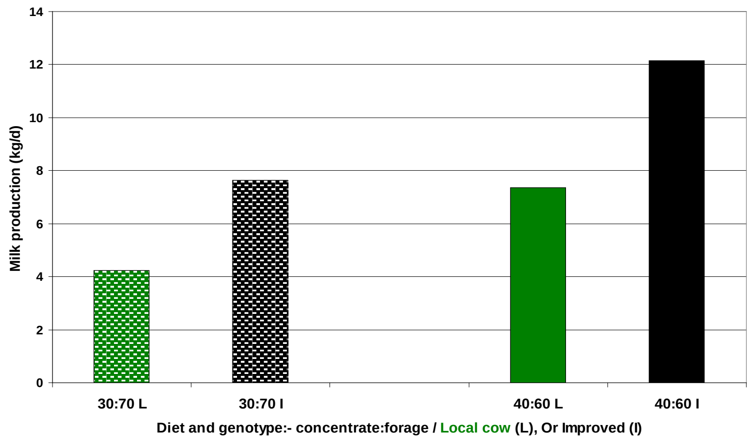

Figure 7.3.1.1 Effect of varying concentrate:forage ratio in the diet on milk production of local and improved cows.

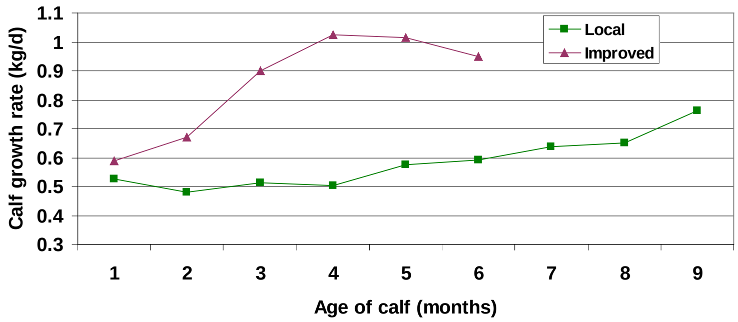

Figure 7.3.1.2 Calf growth rates according to dam genotype (local or improved).

Experiment 2 (Varying dietary protein)

- The improved cows produced more milk (*P*<0.05) at all levels of protein in the diet compared to local cows (Figure 7.3.1.3).
- Total milk production increased (*P*<0.05) with increasing dietary protein in the improved cows (Figure 7.3.1.3).
- There was a trend for higher fat and protein content in the milk of local cows compared to improved cows (fat 4.35-6.17% vs 4.11-5.37%; protein 4.32-4.78% vs 3.92-4.33%).

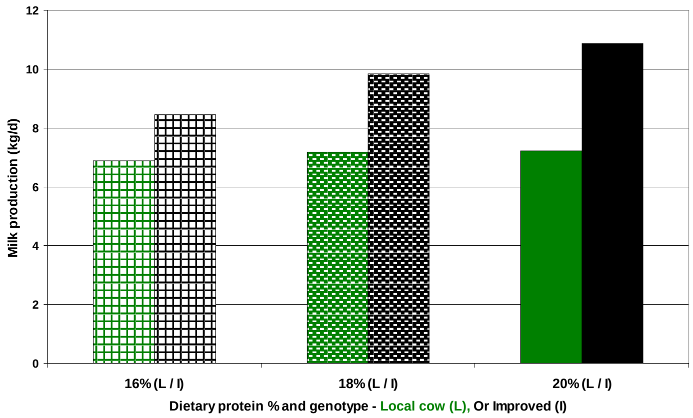

Figure 7.3.1.3 Effect of varying dietary protein on milk production of local and improved cows.

7.3.2 Household sites (TAR)

The 15 households used in this field study were typical of the cropping/livestock regions around Lhasa and Shannan Prefecture. The means (and ranges) for the sites were: size 11 mu (7-18) [1 hectare=15mu]; family size 5 (4-9); labour units 2.9 (2-4); numbers of cows 3 (1-6); mean cropping areas were 3.3 mu spring barley, 2.7 winter barley, 6.5 winter wheat, 2.0 canola, 2.7 vetch (some of the these double or relay crops). Other data on management practices were also collected.

There is a very large database holding the data on feed offered and milk production, but only a snapshot can be shown in results here. Further exposure of results and conclusions will depend on the future use of the data by local Tibetan staff.

Data analyses – feed offered - nutrient status

The major factors of any diet to consider are always intake and quality, which determine total nutrients available to the animal. A summary of the overall data reflecting those parameters is given in Table 7.3.2.1. Apart from the expected seasonal effects of different times of the year (*P*<0.001), there were significant effects of the cow genotype for all parameters (*P*<0.01), and the patterns were surprising. DM and thus ME intakes were higher when associated with local cows. This could suggest a greater capacity for intake despite their smaller size. However, the feed quality was lower and it may be related to compensation for that difference. The associations between these parameters are shown by the correlations in Table 7.3.2.2.

Table 7.3.2.1 Predicted daily means for DM, ME and protein intake by month and differences due to genotype of the cows at the household.

			2010					2011				Breed			
Daily means	Overall	*se*	May	Jun	Oct	Nov	Dec	May	Jun	Oct	*lsd*	Loc	Hx	Sx	*lsd*
DM intake (kg)	6.2	*0.18*	7.1	9.4	4.7	7.1	6.7	5.8	7.1	4.1	*0.46*	7.0	6.0	5.9	*0.54*
ME intake (MJ)	50.4	*1.33*	58.9	81.0	37.7	54.5	52.1	45.6	63.4	30.5	*3.55*	54.3	47.9	49.0	*4.10*
Prot intake (g)	654	*18*	731	1142	574	778	711	507	836	263	*60.7*	615.3	609	738	*58*
Diet ME/kg DM	8.3	*0.06*	8.7	8.7	8.9	7.7	7.9	8.2	9.1	8.8	*0.15*	7.9	8.3	8.7	*0.18*
Diet CP%	11.5	*0.23*	11.6	12.6	16.6	11.2	11.2	9.6	12.7	11.2	*0.62*	9.9	10.9	13.7	*0.70*

Table 7.3.2.2 Correlations of intake and diet quality parameters.

	DM intake	*ME intake*	*Prot intake*	*ME/kgDM*	*CP%*
DM intake	1				
ME intake	0.973354	1			
Prot intake	0.772244	0.856876	1		
ME/kgDM	-0.46926	-0.28433	-0.0079	1	
CP%	-0.32914	-0.18332	0.26541	0.772642	1

Both ME and protein intake were well correlated with DM intake but the negative correlations with ME/kg DM and CP% suggest a depressing effect on intake with lower diet quality. ME and protein intakes and proportions in the diet were well correlated as expected.

ME intake is usually the most important nutrient to consider in examining or formulating diets for dairy cows. Thus the pattern of ME intake is shown in Fig. 7.3.2.1

The details of the feed offered were analysed to determine the parameters of DM, ME and protein intake for the total diet and for the individual components. The range of possible dietary ingredients can be seen in Appendix 11.1 in the data recording sheets. These were grouped into suitable categories for analyses and summary presentation of actual results as shown below (Fig. 7.3.2.1). Differences between data shown in Table 7.3.2.1 and Fig. 7.3.2.1 are due to generation of predicted values from the statistical models.

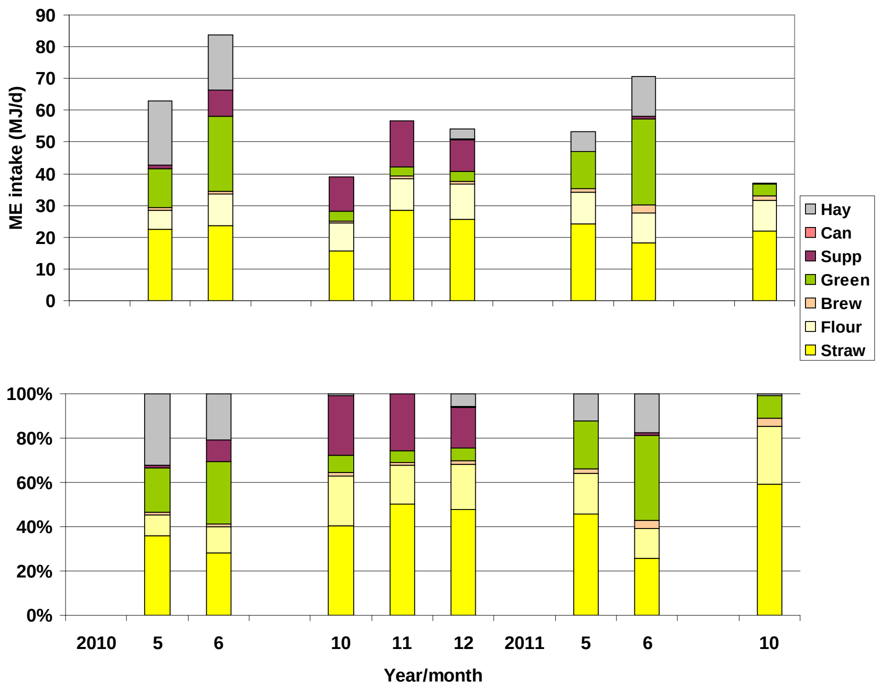

Figure 7.3.2.1 Mean daily metabolizable energy (ME) intake within each month (raw data). The bars show the breakdown of the contribution of various components to the total ME intake (top chart) and as a % of the diet (bottom chart).

The components of the diet shown in Fig. 7.3.2.1 are straw and flour (both wheat), brewer's grain, green (vegetable waste, weeds etc), supplement (high quality commercial product supplied to farmers – 30% protein, 9.3 MJ ME/kg DM), canola meal and hay (alfalfa and vetch). Average total daily ME intake ranged from 37 – 84 MJ/d. The high dependence on straw in the diet is evident, as highlighted in the results of the previous project (Wilkins and Piltz 2008). Straw, combined with the flour component, often supplied half or greater of the dietary energy, again emphasising the importance of cereal production to the household, apart from its primary use in feeding the family.

The total ME intake of the diet can be related to the calculated requirements for maintenance and production. A cow of 250 kg liveweight (typical of the local genotype) will require 40-60 MJ/d over her pregnancy and lactation to produce 5 kg of milk or 40-86 MJ for 10 kg of milk. A larger cow of 350 kg liveweight will require 50-68 MJ for 5 kg of milk, or 50-95 MJ for 10 kg. Based on the above, many cows from households in this project had ME intakes that were adequate or surplus to estimated requirements at currently low levels of milk production (Fig. 7.3.2.1). On the other hand there were also many cows that had lower milk production than their actual ME intake would support, suggesting restrictions other than inherent potential. Apart from physiological issues that may be involved, we have identified a large potential problem in restriction of water intake, which is known to depress milk production (see both below). Energy and nutrient requirements in general may also be modified by the unique Tibetan environment, which could affect utilization of nutrients in the diet.

Standard recommendations for dietary protein requirements of lactating cows are 10-12% for dry, 16-18% for early lactation, 14-16% for mid and 12-14% for late lactation. However, these values are for cows producing much more milk than Tibetan cows. The data suggests that around 25% of lactating Tibetan cows were given diets with less than 10% protein, and that only 25% get diets with > 14%. Thus around 50% of animals may be marginal or deficient in protein intake on standard estimates but in fact able to support the low levels of milk production observed here.

Water intake

Cows at the household sites are tethered adjacent to the home for most of the year and all feed and water is carried to them. Information from farmers indicated that most cows (85% of farms) were allowed only 15 litres per day or less when 45 litres or more is the recommended rate for the size and production of the cows (5-7 litres/kg DMI + 1litre/litre milk). The practice arises from the preference for solid dung for collection and storage, which is used for heating and fertilizer. There is also a strong belief that too much water will make cattle sick, evidenced by loose faeces. This issue needs resolution by experimentation to determine the extent of production loss, and investigation of appropriate alternative strategies.

Data analyses – milk production

Production trends

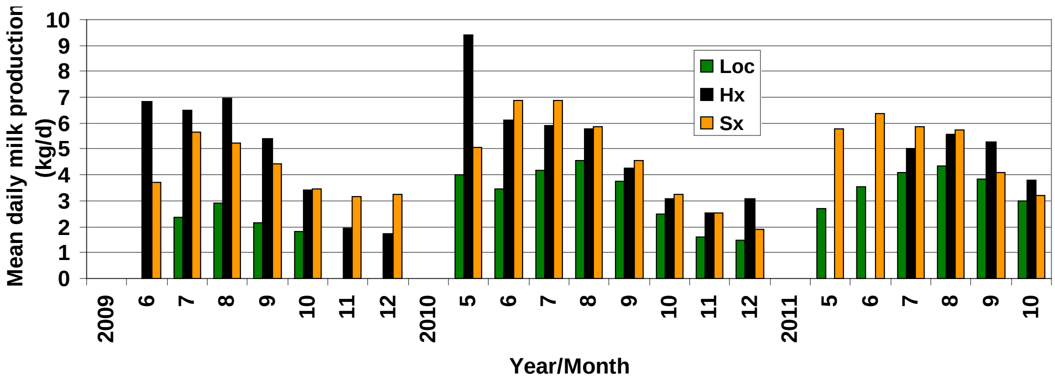

Figure 7.3.2.2 Mean daily milk production within each month for the 3 genotypes for 2009, 2010 and 2011 (raw data showing actual production).

The pattern of milk production shown in Fig. 7.3.2.2 reflects the time of calving which occurs mainly during May/June/July. There was a consistent advantage in production to the crossbred genotypes over the local in both average daily and peak production (Figs. 7.3.2.2 and 7.3.2.3).

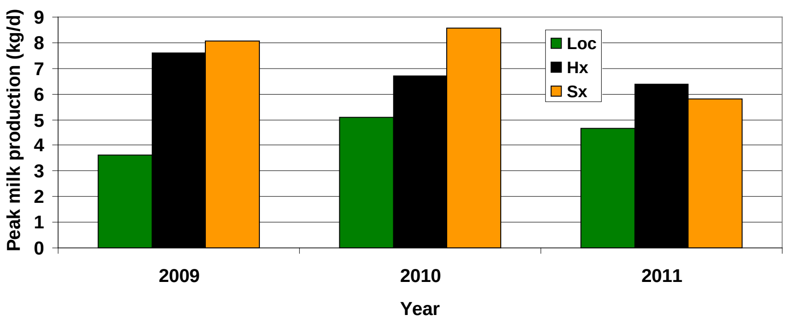

Figure 7.3.2.3 Mean peak milk production for the 3 genotypes over 3 years.

There was a significant effect of genotype in mean peak milk production (P<0.005, l.s.d. Yr*genotype ~ 2.7 kg/d), with differences between years non-significant (Fig. 7.3.2.3). Predicted means were 4.4, 6.9 and 7.6 kg/d for Loc, Hx and Sx.

REML analysis of the largest data set (8,000+ daily records) showed significant effects on mean daily milk production due to days in milk (stage of lactation), genotype, year and month within year (all $P<0.01$). Cow within farm was included as the random term in the model for this and other REML analyses.

The predicted means (kg/d) for genotype were:-

Local	Holstein cross	Simmental cross	lsd
2.92	4.81	4.41	~ 0.095

(Other data sets generated different predicted means for milk production but the pattern across breeds was consistent with both crossbred genotypes producing more milk than the local, and often little difference between them.)

Regression analyses were run to determine the factors having most effect on milk production. Terms were added sequentially to the model (Milk production = factor1 + factor2 +…………….) and their effect assessed by the difference in variation explained.

Calving month and days in milk are somewhat confounded but in combination should account for stage of lactation (37.5% variation explained – 31% for year*month alone, 18% for days alone). Addition of breed increased this to 42%. Addition of ME and protein intake individually or together affected variation by < 2% when other factors were accounted for. They explained < 5% when considered without other factors.

The total variance accounted for when all possible factors and interactions were included in the model was 64%. This is not particularly high but reflects the noise in the data that cannot be accounted for and unfortunately not unexpected for the circumstances of collection. This also

The very low correlation (essentially nil) between milk production and nutrient intake was surprising. However there may be confounding or constraining factors in play, and several possibilities are suggested: that the animals were already producing to their genetic capacity; production potential was constrained by pre-calving nutrition; they were constrained by other factors (see restricted water above). A possible further confounding factor is the timing of nutrients in relation to stage of lactation as cows may not respond if nutrient status is not altered soon enough into the lactation.

Lactation curves

The milk production data for each lactation period for each cow (72 lactations from 26 cows) were examined for fit to both the Wood and Ali-B models. Data were then combined over years to do an overall fit for each genotype to generate equations to provide predictions of milk production for various uses, including inputs to the CAEGTibet whole farm model.

The form of the equation for the Wood model is:

$$Y_n = an^b.e^{-cn}$$

And the equation for the Ali-B model is :-

$$Y_n = a + c\gamma^2 + d\omega + e\omega^2 \qquad [\ \gamma = 7n/305,\ \omega = \log_n(305/7n)\ ]$$

where:

Y_n is the yield in lactation week n; a,b,c (Wood) and a,c,d,e (Ali) are calculated coefficients.

While Quinn *et al.* (2005) concluded that the Ali-B model was the best fit to the data they examined, we found that the fit of our data to the Wood model was almost identical and in some cases had a more logical shape for the lactation, both at the start and tail end. They (Quinn *et al.* 2005) also commented that the coefficients of the Wood model were more biologically interpretable than Ali-B model. Thus we have opted for the greater simplicity of the Wood model, but with the recognition that examination of further data sets in the future may change this view. The application of the equations generated by the Wood model to the CAEGTibet model have shown the milk production predicted for various scenarios to follow logical lactation patterns in agreement with local data. It should also be noted that the precision of predictions is necessarily constrained by the accuracy of the coefficients of the equations. While we acknowledge these have been generated from low numbers of cows and with considerable noise and confounding effects, they have provided some "best bet" predictors from the local situation (genotypes and environment) which will be useful until refined by further research.

An example of the fit of milk production data for an individual cow to the Wood and Ali-B models is shown in Fig. 7.3.2.4 - in this case the fits are essentially identical. The fit of the non-linear regression was highly significant (*P*< 0.001 for both models), and the proportion of variation explained by fitting the expressions was > 95% for both models. The "goodness of fit" of the individual data for other cows however showed considerable variation as might be expected by the unavoidable noise in such field data.

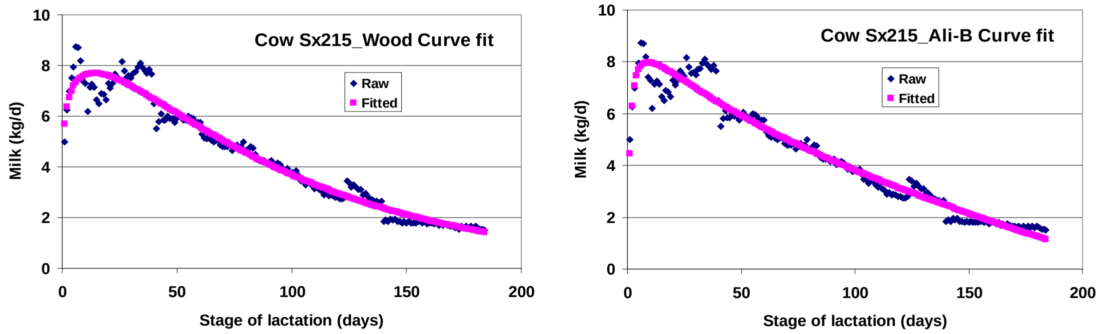

Figure 7.3.2.4 Lactation curve for Cow Sx215 showing the fit of the data to the Wood and to the Ali-B models.

Data were combined to generate prediction equations for the different genotypes as shown Fig.7.3.2.5 The nature of the curves for the 2 crossbred genotypes demonstrates their higher production potential over the local cows, which is also evident in the results of the animal house experiments (7.3.1).

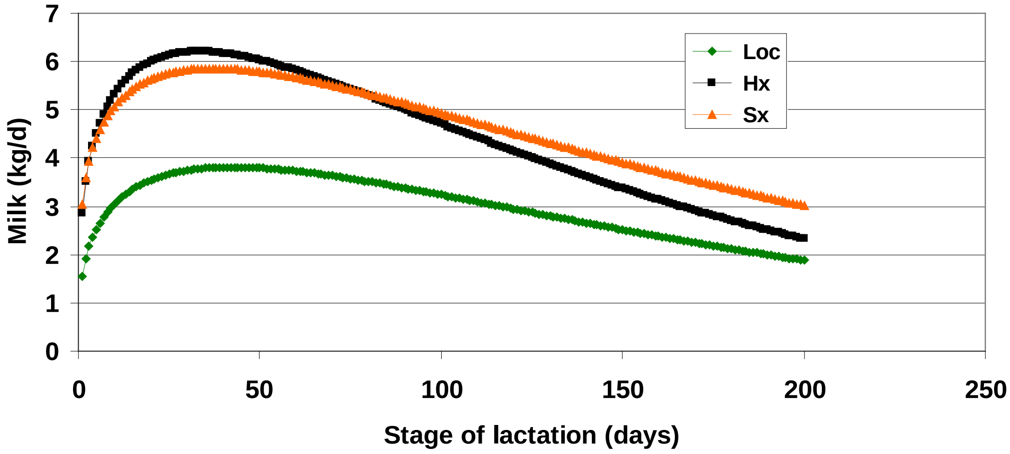

Figure 7.3.2.5 Predicted lactation curves (Wood model) for the 3 genotypes – local (Loc), Holstein X (Hx) and Simmental X (Sx).

These analyses allowed us to generate the coefficients for prediction equations from currently available data which can be used in the CAEGTibet model and for other demonstrational purposes. As mentioned above, the accuracy of the coefficients and thus predicted milk production needs refining by further well controlled production experiments. In particular, responses to improved nutrition that may be related to the content of the local genotype need to be fully explored, since such information will be vital to the longer term strategies of selecting appropriate genotype mixes for the environment. While the greater milk production potential of introduced genotypes seems an immediately attractive proposition, we believe that the possibility of adaptive advantages of the local genotype (see below) should not be ignored, but rather captured in crossbreeding strategies. Identifying the introduced genotype(s) best suited to the environment (climate and nutrition) is a major consideration in terms of size (maintenance requirements) and production (volume, fat and protein content of the milk).

Adaptation

There is evidence of impaired rumen function and effects on basal metabolism when Chinese Holstein and “yellow” crossbred cows from areas of low elevation were examined at increasing altitudes (Han *et al.* 2002b; Qiao *et al.* 2013), although varying effects were seen in a similar study (Qiao *et al.* 2012). In contrast it was reported by Han *et al.* (2002a) that the energy metabolism of the yak (*Bos grunniens*) was unaffected when examined at varying altitudes, suggesting benefits of adaptation due to evolution at high altitude. Thus it is possible that the ”local” Tibetan genotype(s) of cattle, also native to high altitudes, may have some beneficial physiological adaptation. If so, this could affect production, since effects on energy metabolism, for example, could alter maintenance requirements, and therefore affect efficiency of utilisation of nutrients, as suggested in results of Qiao *et al.* (2012). Berry *et al.* (2001) reported an increase of 0.72 times (and quoted others higher) in energy requirement for maintenance in dairy cows due to increased altitude. It is important to resolve this issue as it affects selection of suitable genotypes for high altitudes, estimates of nutrient requirements and predicted production. Adaptive advantages should be utilised if possible by judicious crossbreeding strategies.

Data analyses – reproduction

Calving % and proportions repeating in consecutive years have increased over the period of observation. Fig. 7.3.2.6 shows the overall trend which was consistent over genotypes. Overall fertility is approaching a reasonable level but still below rates expected in other environments. Repeat calving remains a problem, considered due to the general constraints of nutrition, but is also improving. Cows missing calving in any year are a considerable burden on the efficiency and profitability of the household due to the high cost of maintenance for little, if any, production – no calf and very minimal milk production if an extended lactation.

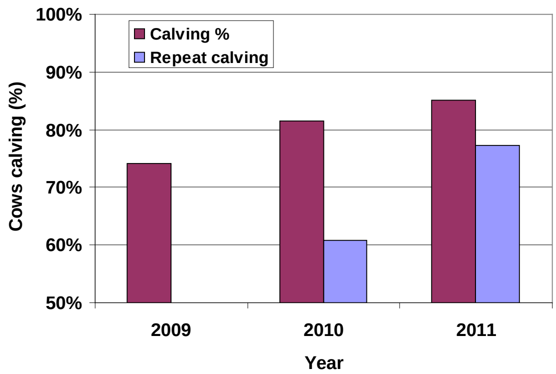

Figure 7.3.2.6 Proportions of cows calving and those calving in consecutive years.

Table 7.3.2.3 Intervals (days) to post-partum remating, and between calvings, for those cows calving in consecutive years.

	Post-partum remating		Inter-calving interval [1]	
Calving year	Mean	range	Mean	range
2009	116	56-217	355	303-405
2010	117	71-219	375	318-443
2011			393	354-453

[1] mean interval for 2008/09 (calving 2009) was biased downwards by particular selection of cows

Table 7.3.2.3 shows the trend in postpartum re-mating intervals, which are generally longer than the 85 days required to maintain a yearly calving interval, which is apparent in the data for the latter 2 years. Cows with intervals greater than 365 days will calve later in the following year but this also increases their chance of missing a year. This was shown by the cows that calved in 2011 but had failed to calve in 2010 having a mean intercalving interval of 718 days.

Mean calf birth weights have increased over the period recorded (P< 0.001) for all 3 genotypes (P=0.018), as shown in Fig. 7.3.2.7). Some of the improvement for the calves born in 2010 and 2011 (increase of 4 kg each year) can be attributed to the feeding of a specific high quality supplement during pregnancy, also coinciding with a large part of the winter. Apart from benefiting the growth of the fetus, this also allowed the cows to calve and commence lactation in better condition than under previous normal management. This also enhanced calf survival and early growth. Calf survival has improved markedly from the levels we reported in the previous project (Wilkins and Piltz 2008*)* – from an average of around 80% for this region during 2005 – 2007 (60% over 3 other regions for the same period) to almost 100% currently. Calf survival rates in the animal house experiments above (7.3.1) were also 100%. We believe this is attributable to the better peri-parturient nutrition of the cows as well as the recognition by the farmers of the importance of colostrum to the calf, which was often previously sacrificed for other uses.

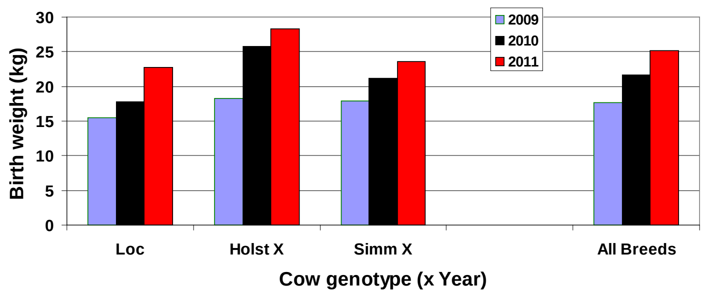

Figure 7.3.2.7 Mean calf birth weights for the 3 genotypes in consecutive years.

Tools and resources for future research and extension

The following material has been generated or provided for ongoing use for staff in Tibet.

Database (feed and production data), field recording sheets and transfer routines.

Requirements calculator ("CowReqCalc") – this is an ongoing update of an Excel based routine that can be used as a companion to the CEAGTibet model or as a stand-alone tool to calculate nutritional requirements for individual cows and total for the farm. An example of the output is shown in Appendix 11.1.

The following computer programs and extension publications have been introduced to staff as valuable resources for future animal production work :-

Ration Check

Grazfeed

Realistic Rations/ Target 10

7.3.3 Forage yield and quality (Australia)

Yield and quality of the crops varied markedly between seasons and to a large extent this could be attributed to available moisture. Hence each year's data is discussed independently.

2008. Experiment abandoned before the first harvest was completed due to severe drought conditions which caused the crops to die.

2009. Though seasonal conditions were improved on 2008 the region was still in drought conditions and annual rainfall at Culcairn was 377mm (long term average 586mm). Average yield, metabolisable energy (ME) and crude protein (CP) content were 6.6 t DM/ha, 10.5 MJ/kg DM and 12.0% respectively. Yield (Table 7.3.3.1) differed significantly between cereal varieties (P<0.001) and with harvest (P<0.001). Average yields, across all varieties were 5.5, 6.7, 7.0 and 7.4 t DM/ha at the boot, anthesis, milk and dough stage harvests respectively. And there was no difference in yield between cereal only and cereal/vetch crops however there was a significant (P=0.002) interaction between cereal variety and vetch so that when averaged across harvests vetch increased yield of Strzelecki crops but reduced yield of Tobruk and Wedgetail.

Table 7.3.3.1: Effect of cereal variety,vetch inclusion and harvest on total yield (t DM/ha) of cereal/vetch crops grown at Temora, NSW in 2010.

Cereal variety	Vetch	Harvest stage			
		Boot	Anthesis	Milk	Dough
Echidna	vetch +	7053	8687	8104	8540
	vetch -	7403	7504	8910	9893
Urambie	vetch +	5402	7293	5573	5866
	vetch -	4706	5035	5635	7639
Gairdner	vetch +	6452	6646	6510	6574
	vetch -	3663	6142	5493	7006
Mannus	vetch +	4231	5367	8248	6538
	vetch -	4282	5671	8372	7903
Strezlecki	vetch +	6004	6817	6557	7458 *
	vetch -	3957	4863	6231	6087
Tobruk	vetch +	5810	7532	6295	-
	vetch -	6428	8680	8717	8280
Wedgetail	vetch +	5175	7011	6004	-
	vetch -	6921	6823	7856	6985

* Only rep 1 plot harvested

The ME content of the crops (Table 7.3.3.2) harvested at Culcairn in 2009 was high (average 10.5 MJ/kg DM); at the boot stage all combinations except Strzelecki/vetch exceeded ME 10.5 with 4 crops exceeding ME 11. There were ME differences (*P*<0.001) between cereal varieties and ME declined (*P*<0.001) with maturity though it still remained high. There was no difference in ME between cereal and cereal/vetch crops. Average ME content was 10.5, 10.5, 10.8, 10.7, 10.5, 10.3 and 10.0 for plots containing Echidna, Mannus, Urambie, Gairdner, Wedgetail, Strzelecki, Tobruk respectively and 10.9, 10.4, 10.3 and 10.4 for harvests 1, 2, 3 and 4.

Table 7.3.3.2: Effect of cereal variety, vetch inclusion and harvest on metabolisable energy content (MJ/kg DM) of cereal/vetch crops grown at Culcairn, NSW in 2009 and Temora, NSW in 2010.

Cereal species	Cereal variety	Vetch	Harvest stage							
			Culcairn 2009				Temora 2010			
			Boot	Anthesis	Milk	Dough	Boot	Anthesis	Milk	Dough
Oats	Echidna	vetch +	10.5	10.4	10.3	10.2	10.0	9.6	9.6	8.8
		vetch -	11.0	10.7	10.6	10.3	9.3	9.0	8.9	8.0
	Mannus	vetch +	11.4	10.4	10.3	10.1	10.6	9.8	9.6	9.1
		vetch -	11.5	9.8	9.7	10.3	10.4	9.3	8.8	7.5
Barley	Urambie	vetch +	10.6	10.6	10.5	10.7	10.3	10.2	10.1	9.7
		vetch -	11.1	10.8	10.8	11.1	10.4	9.8	9.5	9.3
	Gairdner	vetch +	10.5	10.6	10.5	10.7	10.5	10.2	10.3	9.6
		vetch -	11.1	10.5	10.4	11.3	9.7	9.1	8.8	8.3
Wheat	Wedgetail	vetch +	10.7	10.8	10.0	-	9.9	9.8	9.1	-
		vetch -	10.9	10.8	10.4	10.1	9.4	8.5	8.7	8.3
	Strzelecki	vetch +	10.5	10.4	10.7	10.4 *	10.4	10.0	10.2	-
		vetch -	10.9	10.3	9.5	10.3	9.3	9.0	8.5	8.4
Triticale	Tobruk	vetch +	10.6	10.5	10.6	-	10.5	10.3	9.7	-
		vetch -	10.5	9.4	9.3	9.1	9.6	8.3	8.9	8.4

$lsd_{(0.05)}$ = 0.39 (2009); $lsd_{(0.05)}$ = 0.54 (2010). * Only 1 plot harvested

The effect of including vetch on CP content of cereal and cereal/vetch crops is shown in Figure 7.3.3.1. Average CP content of these crops was 12.0%, and CP content declined (*P*<0.001) with maturity, varied (*P*<0.001) with cereal variety and was higher (*P*<0.001) for cereal/vetch compared to cereal only crops. Average CP content was 14.3, 11.8, 10.9 and 9.9% for harvests 1, 2, 3 and 4 and 10.3, 11.4, 13.0, 12.4, 11.1, 12.9 and 13.0% for the Echidna, Mannus, Urambie, Gairdner, Wedgetail, Strzelecki and Tobruk treatments respectively. Including vetch increased average CP from 6.3 to 17.7%.

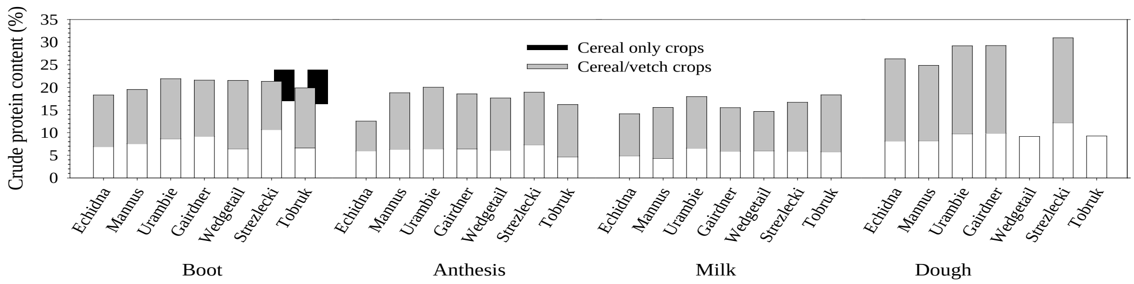

Figure 7.3.3.1: Effect of cereal maturity at harvest on the crude protein (%) content of cereal and cereal/vetch crops grown at Culcairn, NSW in 2009.

NB. Only 1 Strzelecki/vetch and no Wedgetail/vetch and Strzelecki/vetch plots were harvested at the dough stage.

2010. Growing conditions at Temora in 2010 were markedly different to 2009. Annual rainfall was 736mm which was above the long term average of 523mm and this was reflected in substantially higher yields, averaging 21.1 t DM/ha across all treatments. As was the case in 2009 yield varied with cereal variety (*P*<0.001) and with harvest (*P*<0.001), however in contrast to 2009 yields were lower (*P*<0.001) on plots containing vetch. There was also an interaction (*P*<0.001) between variety, harvest and vetch (Table 7.3.3.3). There was extensive lodging of crops containing vetch and this varied with cereal variety. The yield of forage below the 5cm cutting height was not accounted for and the difference between forage grown and yield appeared greater for crops that had lodged the most. The biggest effect of lodging was on the Gairdner/vetch plots where yield actually declined between the milk and dough stage harvests. Lodging in the wheat and triticale crops, which were later maturing and therefore due to be harvested later, following a severe storm forced the final harvests to be abandoned.

Table 7.3.3.3: Effect of cereal variety, vetch inclusion and harvest on total yield (t DM/ha) of cereal/vetch crops grown at Temora, NSW in 2010.

Cereal species	Cereal variety	Vetch treatment	Harvest			
			Boot	Anthesis	Milk	Dough
Oats	Echidna	cereal/vetch	17.2	23.0	28.9	29.6
		cereal only	17.6	28.0	25.9	27.3
	Mannus	cereal/vetch	15.0	25.8	17.8	23.2
		cereal only	20.6	19.7	21.6	28.3
Barley	Urambie	cereal/vetch	10.2	12.3	19.6	17.3
		cereal only	10.1	16.3	20.1	25.8
	Gairdner	cereal/vetch	14.9	14.1	25.1	14.5
		cereal only	19.4	16.3	18.1	31.5
Wheat	Wedgetail	cereal/vetch	14.5	16.6	14.0	-
		cereal only	13.6	21.1	24.9	28.7
	Strzelecki	cereal/vetch	16.1	16.2	14.7	-
		cereal only	15.1	15.4	22.0	28.0
Triticale	Tobruk	cereal/vetch	16.6	17.6	17.1	-
		cereal only	16.0	21.4	30.7	37.7

$lsd_{(0.05)}$ = 5.82

Average ME content (9.4) was lower than in 2009, varied (*P*<0.001) with cereal variety, declined (*P*<0.001) with harvest and was lower (*P*<0.001) for cereal only plots. In this experiment average ME was 9.2, 9.4, 9.9, 9.6, 9.1, 9.4 and 9.4 for plots containing Echidna, Mannus, Urambie, Gairdner, Wedgetail, Strzelecki and Tobruk respectively and 10.0, 9.5, 9.3 and 8.7 for harvests 1, 2, 3 and 4. As in 2009 there was an interaction between variety and vetch (*P*<0.001), variety and harvest

(*P*=0.005), vetch and harvest (*P*=0.002) and variety, vetch and harvest (*P*=0.024) (Table 7.3.3.2).

Average CP of the 2010 Temora crops was higher than at 14.8% and, as was the case in 2009, declined (*P*<0.001) with maturity, varied (*P*<0.001) with cereal variety and was higher (*P*<0.001) for cereal/vetch compared to cereal only crops. Averaged across all varieties CP was 18.1, 16.4, 13.9 and 10.1% for harvests 1, 2, 3 and 4, and 12.4, 13.8, 16.2, 18.4, 14.7, 12.5 and 13.8% for the Echidna, Mannus, Urambie, Gairdner, Wedgetail, Strzelecki and Tobruk treatments respectively. CP content content of all the crops is shown in Figure 7.3.3.2.

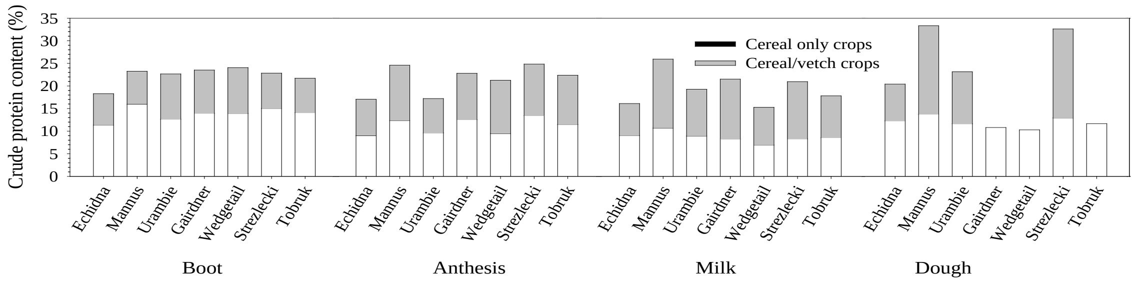

Figure 7.3.3.2: Effect of treatment on the crude protein (%) content of cereal and cereal/vetch crops grown at Temora, NSW in 2010.

2011 A late season 'break' meant that sowing was delayed until late June and it was then necessary to re-sow the crop twice because of mouse damage. As a result the final sowing occurred on August 2nd. Total annual rainfall was 640 mm (26% above the long term average) however 60% (384 mm) was received in the January, February, March period and only 34, 7.5 and 13.2 mm in August, September and October respectively and the crops did poorly or failed.

Yield varied with cereal variety (*P*=0.006), increased (*P*<0.001) with harvest though the increase was small, and was lower (*P*<0.001) for cereal/vetch (3.6 vs 5.0 t DM/ha) compared to cereal only crops but overall yields were low averaging only 4.4 t DM/ha across all treatments. The crops matured quickly though the rate of change from boot to soft/mid dough stage was erratic; some crops progressed very rapidly from boot through to milk/soft grain possibly within 1 week while others, though faster than normal, were much slower. As a result not all treatments were harvested at all stages. Moisture stress caused early death of the vetch plants and there was no final harvest for any of the cereal/vetch treatments or for the Tobruk treatment. Therefore it was not possible to estimate yield and quality parameter values for all treatments and treatments combinations. However based on the available data yield was 5.0, 4.4, 4.7, 4.8, 3.9, 4.4 and 3.9 t DM/ha for Echidna, Gairdner, Mannus, Strzelecki, Tobruk, Urambie and Wedgetail treatments respectively and 3.6, 4.8, 5.0 and 5.1 t DM/ha at harvests 1, 2, 3 and 4; CP content was 11.0, 11.7,11.1, 9.8, 11.9, 11.0 and 11.3 % and 13.4, 10.8, 10.5 and 7.6 %; ME was 10.6, 11.3, 10.3, 10.2, 10.8, 10.9 and 11.1 MJ/kg DM and 11.8, 10.7, 10.2 and 9.1 MJ/kg DM. Only 5 treatments reached yields of 6 t DM/ha or greater and none of these contained vetch: Echidna, Gairdner and Urambie at the flower stage; Mannus at the milk stage; Strzelecki at the soft/mid dough harvest stage. CP content varied (*P*=0.03) with variety, declined (*P*<0.001) with harvest and was higher (*P*<0.001) for cereal/vetch compared to cereal only (14.0 vs 9.5%) crops. ME also varied with variety (*P*=0.025) and declined with harvest (*P*<0.001) but there was no difference between cereal/vetch and cereal only crops.

Predicted livestock production

Based on the yield, ME and CP content data from 2009 and 2010 the expected liveweight gain (or loss) for cattle or sheep fed these forages *ad lib*,was estimated using Grazfeed (Figure 7.3.3.3). Data from 2011 was not used because of missing treatment information. The ME content of the cereal only and cereal/vetch crops in 2009 and the earlier harvests in 2010 was adequate to meet requirements for animal growth however without vetch the crude protein content of the cereal only crops was inadequate for young, growing livestock. Steers on later harvest cereal only crops, in both 2009 and 2010, were actually predicted to lose weight because of this. Even the lowest ME content cereal crop, Mannus at the dough stage in 2010 (ME 7.5), should have been adequate for maintenance but steers were predicted to lose 0.17kg/day due to the low CP content.

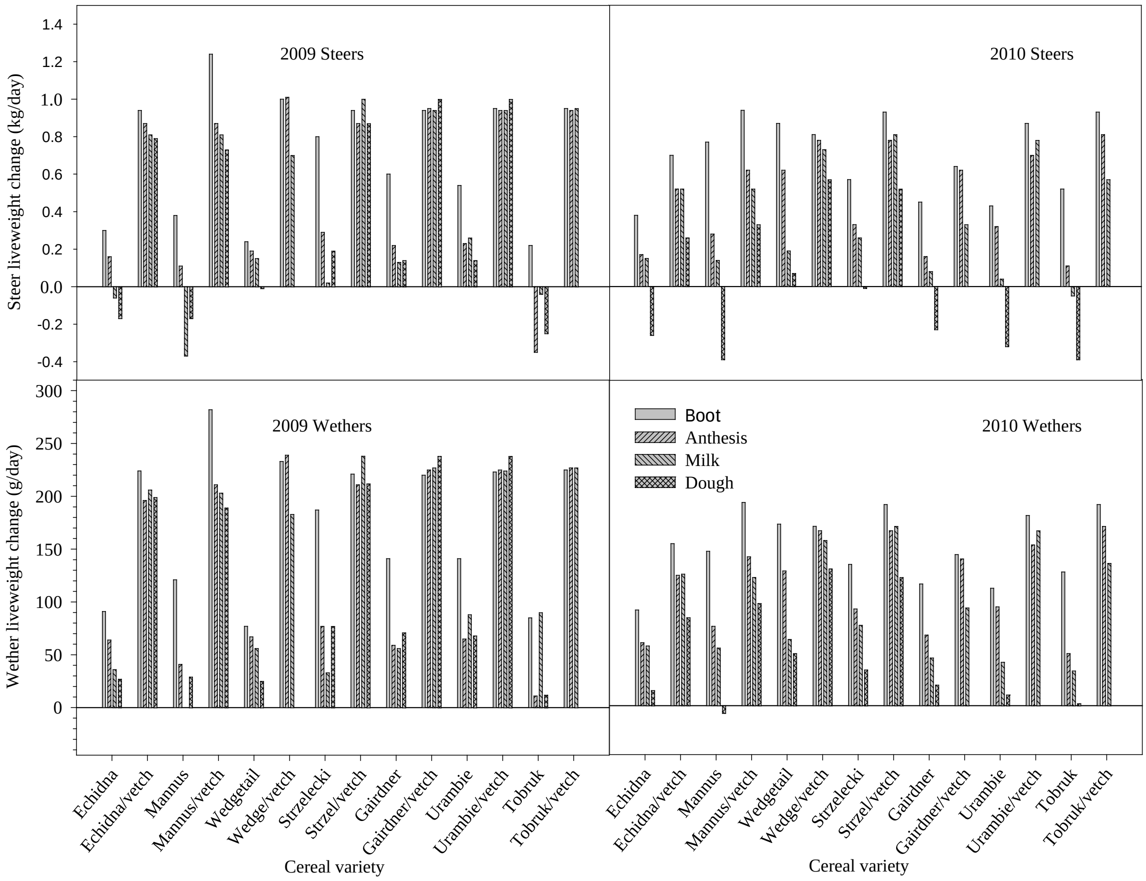

Figure 7.3.3.3: Effect of cereal variety, vetch and harvest on predicted daily liveweight change of 300kg 12 month old crossbred British breed steers and 30kg crossbred wethers when fed *ad libitum* cereal and cereal/vetch crops grown at Culcairn, NSW in 2009 and Temora, NSW in 2010.

NB. In 2009 only 1 plot of Strzelecki/vetch and none of the Wedgetail/vetch and Tobruk/vetch plots and in 2010 none of the Strzelecki/vetch, Wedgetail/vetch and Tobruk/vetch plots were harvested at the dough stage harvest.

Animal House experiment (Australia)

Due to the dry conditions in 2009 the yield of the barley and oat crops was low while the DM content of the uncut forage was high. The barley and oat crops were both wilted for a short period at the 1st harvest but the resultant forage was drier than ideal. There was no wilting of the forage for any of the subsequent harvests but the forage DM content of both the 2nd cut oats and 3rd cut barley were very high reflecting the seasonal conditions. The CP content of the crops was high at the first harvest and for the 2nd harvest of the oats but declined for the 2nd and 3rd barley harvests and all were within the range observed for cereal crops.

In early 2010 a significant amount of water penetrated the silage bunkers following a severe storm and the silages reabsorbed moisture which reduced the DM content of the silages markedly compared to the ensiled forage. When opened the silages had an odour associated with poorly fermented silage. Nevertheless the silage pH indicated the silages were well preserved suggesting that the deterioration was post the initial fermentation as would be expected given the time delay between ensiling and inundation. There was also the odour and presence of mould in some of the silages but this is more likely to have occurred during the initial phase likely due to the very high DM content. The CP content of silages is higher than the ensiled forage due to loss of DM, but not the N fraction, during fermentation. In this experiment there was a substantial increase in CP content suggesting greater loss of DM than normal possible due to the combined effects of the high DM content at ensiling and loss of DM due to leaching. Composition of the forage and silage is shown in Table 7.3.3.4.

Table 7.3.3.4: Composition of the barley and oaten forage and silage at ensiling

Harvest *	Forage DM content (%)		Forage CP content (%)		Silage DM content (%)		Silage pH		Silage crude protein content (%)	
	Oats	Barley	Oats	Barley	Oats	Barley	Oats	Barley	Oats	Barley
Boot	39.0	46.3	16.3	15.9	27.5	31.6	4.3	4.3	19.2	18.4
Milk	54.3	32.3	15.1	11.8	39.7	22.2	4.4	4.0	17.1	13.1
Dough	-	52.6	-	10.9	-	38.4	-	4.1	-	13.6

When determined in steers the apparent *in vivo* digestibility (Table 7.3.3.5) of the oaten and barley silages harvested at the boot stage was high but not inconsistent with other reported values for drought stressed cereal crops. Oaten silage digestibility declined between the 1st and 2nd harvest consistent with reported digestibility trends estimated by *in vitro* methods. Digestibility of the barley crop also declined between the 1st and 2nd harvests and thereafter remained unchanged.

Table 7.3.3.5: *In vivo* digestibility (%) and estimated metabolisable energy (MJ/kg DM) content of barley and oaten silages fed *ad libitum* to steers

	Cooba oats		Urambie barley			lsd $_{(P<0.05)}$
	Harvest 1 *	Harvest 2 *	Harvest 1*	Harvest 2*	Harvest 3*	
Dry matter digestibility	75.4	68.0	78.6	74.0	73.3	2.95
Organic matter digestibility	76.5	69.2	80.5	76.0	75.1	2.92
Organic matter digestibility (dry matter basis)	67.6	61.6	71.5	69.0	69.4	2.68
Estimated ME content	10.7	9.5	11.5	11.0	11.1	NA

* Harvests 1, 2 and 3 were at the boot, milk and soft/mid dough stage of crop development

An investigation on the effect of maturity stage and variety on the quality of cereal forages

Composition of the cereal crops grown at Craboon and Wagga Wagga are shown in Tables 7.3.3.6 and 7.3.3.7 respectively.

At Craboon both NDF and ADF content increased (P<0.05) from boot to anthesis for all varieties except Dictator barley and Bimbil oats where there was no change and Urambie barley where NDF and ADF content decreased (P<0.05). NDF and ADF content did not change from anthesis to milk stages for all varieties except Yambla barley (NDF) and Eurabbie oats (NDF and ADF), which declined (P<0.05). Wedgetail wheat had the highest and Eurabbie oats the lowest NDF content. Genie oats and Wedgetail wheat had (*P*<0.05) higher NDF concentration than Urambie barley and Eurabbie oats. Genie oats had the highest ADF content which was higher (*P*<0.05) than Eurabbie oats, Urambie barley, Bimbil oats and Amarok wheat. The ADF content of Wedgetail and Whistler wheat were higher (*P*<0.05) Eurabbie oats and Urambie barley.

CP declined (*P*<0.05) from boot to anthesis for all varieties and continued to decline to the milk stage for all varieties (*P*<0.05) except Urambie barley and Genie oats, which did not change. Amarok wheat CP content was higher (*P*<0.05) than other varieties. Bimbil oats had the lowest CP content which was lower (*P*<0.05) than Yambla barley and all the wheat varieties. There were no differences between Yambla barley, Eurabbie oats, Wedgetail and Whistler wheat.

Predicted P/C and T&T DOMD decreased significantly (*P*<0.05) between boot and anthesis stage for all varieties except for Urambie barley and Bimbil oats (P/C and T&T) and for Amarok wheat and Eurabbie oats (T&T). From anthesis to milk stage P/C and T&T DOMD continued to decrease (*P*<0.05) for some varieties but not Yambla barley, Eurabbie and Genie oats; P/C DOMD but not T&T declined for Wedgetail wheat. Among varieties, Eurabbie oats had highest predicted DOMD; DOMD was higher (*P*<0.05) than for all other varieties except for Bimbil oats (P/C only), Yambla barley (T&T only) and Urambie barley (P/C and T&T). P/C and T&T DMD were also determined but are not presented here.

At Wagga there were differences between maturity stages for NDF (*P*=0.018) and ADF (*P*=0.014). NDF and ADF were not different between boot and anthesis harvest stages but increased (*P*<0.05) between anthesis and milk harvests. Similarly there were differences (*P*=0.009) in CP content between maturity stages: CP content was the same for boot and anthesis harvest stages but declined from anthesis to milk.

As with the other parameters there were differences in P/C (*P*<0.001) and T&T (*P*=0.003) DOMD between maturity stages. P/C DOMD declined (*P*<0.05) for all varieties from boot to anthesis and from anthesis to milk harvest stages; P/C DOMD was 68.3, 66.9 and 64.8 % for boot, anthesis and milk stages respectively. Conversely predicted T&T DOMD did not differ between boot and anthesis or between anthesis and milk stages, but was lower (*P*<0.05) at the milk compared to the boot stage. Mean T&T DOMD across all varieties was 73.4, 71.7 and 70.4 % at the boot, anthesis and milk stages.

The Craboon and Wagga Wagga samples were re-analysed by ‘wet chemistry’ using the P/C and T&T methods to confirm the differences between estimates due to NIR calibration. For the Craboon samples significant differences (*P*<0.001) were found due to method, variety and stage and for the Wagga Wagga samples significant differences (*P*<0.001) were found due to method and stage for all estimates of digestibility. This confirmed the difference between the two methods observed using NIR calibrations. The difference between T&T and P/C for predicted DMD and DOMD for the Craboon samples were 7.2 and 7.4 % and for the Wagga Wagga samples were 5.2 and 5.4 %. The relationship between methods also appears to be different for oats compared to wheat and barley (Figures 7.3.3.4 and 7.3.3.5).

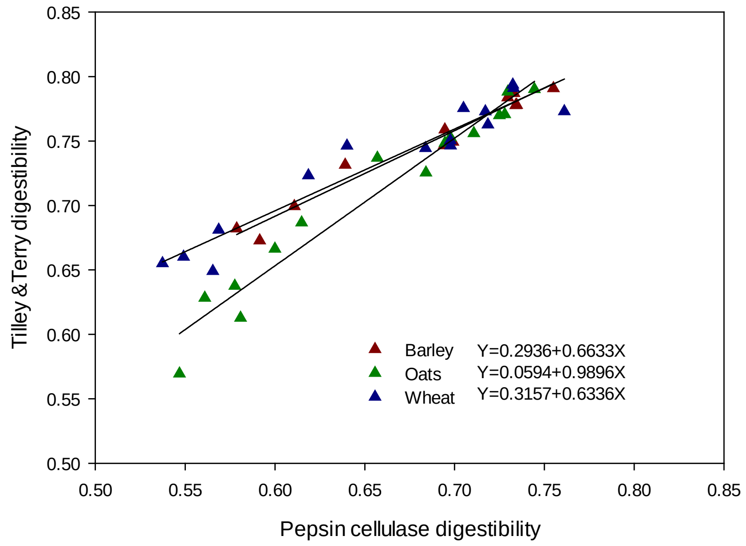

Figure 7.3.3.4. Effect of test method on estimated dry matter digestibility of cereal forages grown at Craboon and Wagga Wagga. Each data point represents a single variety at a harvest for each location.

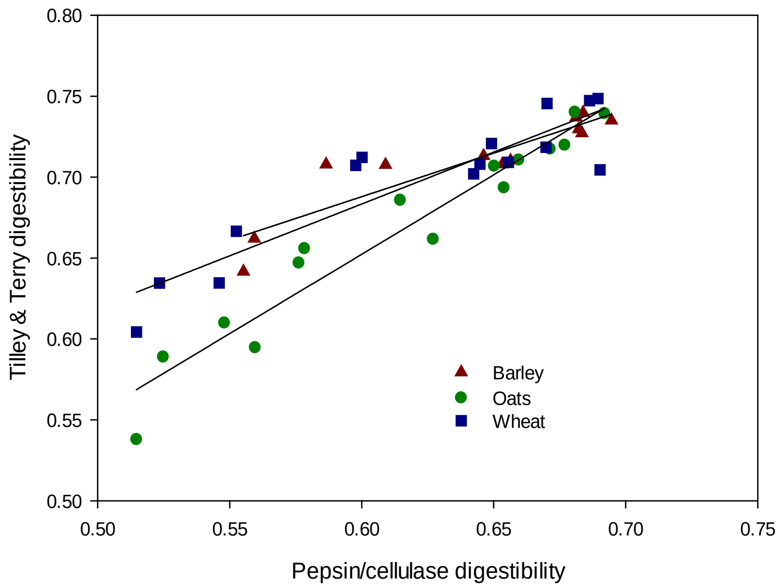

Figure 7.3.3.5. Effect of test method on estimated organic matter digestibility (dry matter basis) of cereal forages grown at Craboon and Wagga Wagga. Each data point represents a single variety at a harvest for each location.

Table 7.3.3.6: Composition of various cereal varieties harvested at three stages of maturity at Craboon, NSW

Species	Variety	Neutral detergent fibre (g/kg DM)			Acid detergent fibre (g/kg DM)			Crude protein content (g/kg DM)			Pepsin/cellulase DOMD (g/kg)			Tilley & Terry DOMD (g/kg)		
		Boot	Anthesis	Milk	Boot	Anthesis	Milk	Boot	Anthesis	Milk	Boot	Anthesis	Milk	Boot	Anthesis	Milk
Barley	Dictator[1]	536.2	549.6	-	313.0	315.7	-	119.0	91.2		601.5	541.5		624.8	578.3	
	Urambie	530.4	468.2	496.7	297.1	261.1	265.6	146.7	93.2	76.0	621.8	622.4	571.2	664.0	657.2	601.9
	Yambla	458.3	612.3	518.7	255.1	355.5	298.7	162.0	97.8	68.3	674.6	534.0	556.8	690.3	578.5	577.6
Oats	Bimbil	516.7	516.5	530.8	291.4	284.8	290.3	118.9	84.7	60.7	611.4	605.9	566.7	624.3	626.3	580.9
	Eurabbie	467.7	526.7	486.7	255.5	300.0	259.9	133.4	104.2	81.0	649.3	605.6	605.0	657.2	641.5	631.9
	Genie	494.8	609.6	580.1	289.8	352.0	332.4	123.3	82.6	71.8	628.4	547.6	534.1	635.3	569.1	540.1
Wheat	Amarok	469.0	538.4	583.0	251.0	298.7	323.0	238.4	146.0	73.7	668.8	596.1	499.4	646.8	639.6	528.3
	Wedgetail	501.4	624.3	591.9	278.4	354.0	333.1	167.3	119.1	87.4	626.6	533.1	519.3	634.2	581.7	533.8
	Whistler	481.6	593.7	590.6	267.6	333.7	326.7	174.6	108.1	80.0	644.8	541.7	507.9	654.9	577.4	520.2
Factor		Variety	Stage	Variety x stage	Variety	Stage	Variety x stage	Variety	Stage	Variety x stage	Variety	Stage	Variety x stage	Variety	Stage	Variety x stage
P value		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
lsd$_{(P<0.05)}$		47.90	47.98	47.98	33.56	33.60	33.60	19.16	19.20	19.20	26.38	26.42	26.40	32.00	32.00	32.00

[1] Dictator barley only harvested at boot and anthesis stage.

Table 7.3.3.7: Composition of various cereal varieties harvested at three stages of maturity at Wagga Wagga, NSW

Species	Variety	Neutral detergent fibre (g/kg DM)			Acid detergent fibre (g/kg DM)			Crude protein content (g/kg DM)			Pepsin/cellulase DOMD (g/kg)			Tilley & Terry DOMD (g/kg)		
		Boot	Anthesis	Milk	Boot	Anthesis	Milk	Boot	Anthesis	Milk	Boot	Anthesis	Milk	Boot	Anthesis	Milk
Barley	Urambie	434.1	422.2	450.8	238.9	226.8	253.1	163.7	163.6	140.8	676.8	672.2	643.7	735.2	727.8	708.1
	Gairdner	414.5	410.0	430.4	229.2	222.2	238.9	174.0	166.1	152.6	681.7	673.5	651.8	734.3	714.7	719.6
Oats	Echidna	411.7	397.4	423.6	225.7	218.9	230.4	172.0	179.2	152.0	686.4	672.4	661.1	724.6	724.7	698.4
	Mannus	415.1	410.3	435.4	223.5	226.7	239.5	172.1	172.3	147.4	690.3	670.0	647.3	741.3	720.0	717.7
Triticale	Tobruk	414.9	402.6	431.1	228.4	224.9	238.3	167.8	160.6	136.4	684.2	672.1	649.1	737.9	689.0	695.6
Wheat	Strzelecki	415.7	442.3	437.3	230.2	242.2	245.7	149.5	156.9	139.9	683.1	660.8	640.5	737.6	724.3	696.4
	Wedgetail	424.0	424.9	433.3	228.7	232.7	243.2	152.7	149.1	148.1	681.6	662.4	644.9	731.7	718.5	691.3
Factor		Variety	Stage	Variety x stage	Variety	Stage	Variety x stage	Variety	Stage	Variety x stage	Variety	Stage	Variety x stage	Variety	Stage	Variety x stage
P value		ns	0.018	ns	ns	0.014	ns	ns	0.09	ns	ns	<0.001	ns	ns	0.03	ns
lsd$_{(P<0.05)}$		-	38.22	-	-	26.82	-	-	37.62	-	-	27.36	-	-	47.80	-

The effect of lucerne silage supplements on the utilization of barley straw by steers

In Experiment 1 the proportion of straw in the CSM, L2, L4 and L6 diets were 83, 58, 33 and 23 % respectively, while actual total intakes were 10.8, 13.5, 12.9, 15.6, 15.3 and 15.2 g DM/kg LW for treatments BS, CSM, L2, L4, L6 and LS. Significant treatment differences were found for DMD (*P*=0.002), OMD (*P*=0.007) and DOMD (*P*=0.009). The LS diet had the highest digestibility and BS the lowest. Digestibility estimates for L2, L4, L6 and CSM were intermediate and similar to each other (Table 7.3.3.8).

Table 7.3.3.8. Apparent *in vivo* DMD, OMD and DOMD.

Digestibility	Diet					
estimate	BS	CSM	L2	L4	L6	LS
DMD	0.508	0.582	0.559	0.580	0.597	0.642
OMD	0.529	0.593	0.582	0.590	0.607	0.658
DOMD	0.487	0.549	0.537	0.542	0.557	0.604

In Experiment 2 the proportions of straw in the CSM, L2, L4 and L6 diets were 81, 59, 33 and 17 % respectively. L2, L4, L6 and CSM diets were estimated to contain 9.8, 14.4, 17.2 and 10.6 % CP with ME contents of 7.1, 8.0, 8.5 and 6.8 MJ /kg DM. There were significant treatment effects on total DM intake (*P*<0.001), straw intake (*P*<0.001) and liveweight gain (*P*=0.018). Total DM intakes were 4.66, 5.80, 6.91 and 4.28 kg/d (lsd = 0.485); straw intakes 2.73, 1.89, 1.15 and 3.47 kg/d (lsd = 0.493); liveweight gain 0.06, 0.23, 0.45 and 0.49 kg/d (lsd = 0.248) for L2, L4, L6 and CSM diets respectively. NDF intakes were similar between diets. A trend for higher gain with increasing silage supplement was apparent. Total intake increased (*P*<0.05), but straw intake declined (*P*<0.05) with increasing silage supplementation. Liveweight gain on CSM was higher (*P*<0.05) than L2 and L4 and considerably higher than predicted from feeding standards.

Results of these experiments have been submitted for publication (see list of forthcoming publications).

7.4 Household & Economic Modelling

The model provides input to the project analysis in a number of ways. First it provides a detailed outline and understanding of the household systems into which the interventions, changing enterprise mixes and practice changes are occurring. Second it enables the impacts on households of these interventions and practice changes to be investigated. Third it enables the impact on households of changes in market or production conditions to be explored.

Understanding household systems

In regard to the first use, Table 7.4.1 outlines key indicators derived from the model for households in the three field work regions: Mozhugongka, Naidong and Bailang. Note that these were not the only farm types in these regions that were investigated but do reveal much about many of the farms in these agricultural areas. Some of these insights have been reported elsewhere (see, for instance, Brown and Waldron 2012) but among other things indicate that over half of the value of agricultural outputs are for own consumption and also highlight the importance of livestock and feed systems to these households.

Impacts on households of changing enterprise mixes and practices

In regard to the second use, the model has been used to explore various scenarios initiated by the technical research or framed by agrarian and policy developments. One such case is the intensification and specialization of dairy productions and Table 7.4.2 and Figure 7.4.1 report selected results from that analysis. Table 7.4.1 highlights that increasing the number of dairy cows or shifting from local to improved cows can increase returns. There are other significant impacts from increasing the number of dairy cows on the household, however, and in particular in shifting it from being a subsistence dairy producer to a commercial dairy producer with greater engagement with dairy product, labour and feed markets. This raises the third use of the model in examining how the household impacts may vary under different market and production conditions. Figure 7.4.1 highlights how returns vary as the number of dairy cows increases under alternative market and production conditions. Figure 7.4.1 also highlights how the benefits of increasing cow numbers were much larger in the higher productivity case.

The results generate several insights. First, specialisation and intensification, at least in the case of the dairy industry, does offer scope for an improvement in household returns. They do elicit major changes in household systems relative to the modest increase in returns, however, and so decisions to implement these systems may not necessarily or even primarily be based on returns alone. Second, measures or efforts to scale up farm activities cannot be taken in isolation but should be a package of measures. That is, research in the project designed to boost livestock productivity is a crucial precursor to any efforts designed to build scale on dairy farms as the benefits from intensification are magnified. Furthermore well-functioning and integrated local and regional markets are needed if adverse local market responses to a greater industry size are to be averted. Third, increasing the scale of the dairy farms can shift these farms from semi-subsistence to commercially-oriented farms with a consequent much greater exposure to external markets especially feed, dairy product and labour markets. This also exposes them to different and potentially larger risks. Thus means of managing or coping with these new risks will be needed. Furthermore as local markets under the semi-subsistent conditions were also limited and rudimentary in the nature of the services they provided, they will also need to adapt.

Table 7.4.1: Key indicators of Mozhugongka, Naidong and Bailang farm households

	Mozhugongka	Naidong	Bailang
Profit/net returns			
Gross Farm Revenue (Rmb)	27,016	23,766	41,333
• Own consumption as % of total revenues	49	60	58
• Sales as % of total revenues	18	21	9
• Inventory (livestock & feed) change as % of total revenues	33	19	33
Gross Farm Expenses (Rmb)	10,783	7,388	14,790
Value livestock feed from own production (Rmb)	18,499	9,107	28,619
• Own feed as % of value of all feed fed to livestock	80	96	85
Return to management for farm activities [RMFA] (Rmb)	7,669	10,791	14,074
• Opportunity cost of household labour (Rmb)	14,746	8,869	16,811
• Opportunity cost of labour for farm activities (Rmb)	8,296	5,269	11,861
• RMFA with labour valued at casual labour rates (Rmb)	2,346	6,801	7,483
• RMFA per full time equivalent labour available (Rmb)	2,766	6,028	3,942
Return to management, labour & capital [including taxes, off-farm income & subsidies] (Rmb)	28,630	23,392	36,819
Off-farm income as % of returns to management and labour for farm activities	55	25	23
Cash flow			
Minimum monthly cash flow balance (Rmb)	-267	-1,034	-6,005
Off-farm income – Rmb (% of cash receipts)	8,850 (46)	4,050(30)	5850 (36)
Net dairy product sales as % of cash receipts (%)	14	13	15
Feed purchases as % of cash costs (%)	24	2	23
Labour			
Off-farm labour (person days)	270	135	180
Casual labour required (person days)	62	40	32
Adult surplus labour - November to March (person days)	138	125	169
Crop labour as % total labour in April (%)	14	22	37
Livestock labour as % of total labour in June (%)	28	28	31
Livestock labour as % of total labour in December (%)	67	46	70
Cropping/land use			
Crop areas (mu) [a]	11SB, 3C, 2V, 100P	10SB, 1C,4L	4WW,8SB, 8MBC, 5O,45P
Cereal production in kg (sales as % of production)	3,249 (0)	3,004(34)	5,456 (0)
Oilseed production in kg (sales as % of production)	360 (54)	100(0)	360 (37)
Feed			
Straw required in kg (% bought in)	6,353 (36)	3,951(0)	6,838 (0)
Cereal required in kg (% bought in)	3,605 (29)	2,221(0)	5,111 (14)
Oilseed meal and brewer's waste required in kg (% bought in)	161 (50)	395(22)	609 (23)
Lucerne, vetch & oats required in kg (% bought in)	249 (0)	1,404(3)	2,487 (11)
Cut grass & pasture in kg fresh weight (% bought in)	25,562 (0)	1,489(0)	32,279 (10)
Livestock & livestock products			
Livestock year start numbers[b]	3LC,1D,5Y, 1P,15L	3IC,3L	4IC,1D,20S 6G,2P,8L
Milk production (litres)	3,616	2,698	3,597
Net butter sales as % of production	20	-8	-8
Change in value of livestock inventory (Rmb) *of which:*	7,127	4,512	12,805
• bovine inventories (Rmb)	5,702	4,515	8,899
Increase in calves (number)	6.1	2.2	2.9
Manure			
Manure production (kg) *of which:*	6,082	3,782	10,175
• used for heating (kg)	2,325	2,325	2,325
• used for organic fertilser (kg)	2,200	1,457	4,200

[a] Areas are in mu where 1mu equals one-fifteenth of a hectare. "WW" refers to winter wheat; "SB" to spring barley; "MBC" to mixed barley and canola; "C" to canola; "O" to oats"; "V" to vetch; "P" to pastures.

[b] "IC" refers to improved cows; LC" to local cows; "D" to draught bull; "Y" to yattle ; "P" to pigs (sows); "L" to egg layers; "S" to sheep; "G" to goats.

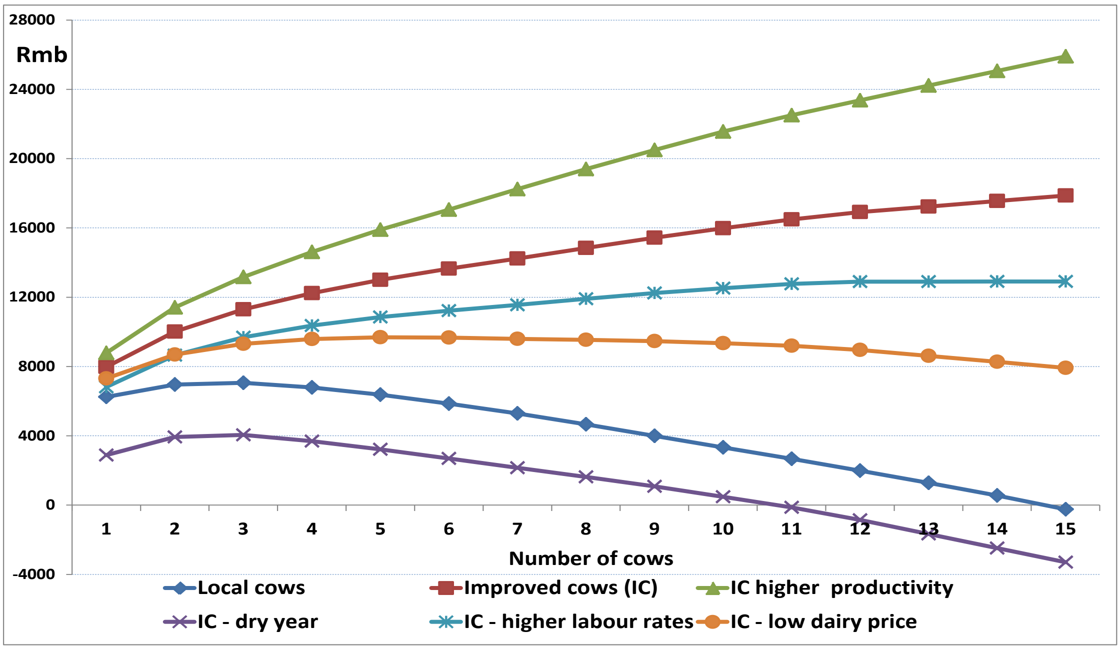

Figure 7.4.1: Returns to management from farm activities by cow number for alternate feed, casual labour and dairy product price scenarios

Table 7.4.2: Key household indicators for different types and size of dairy production

	Local cows	Improved cows				
	3	1	3	6	10	15
Net butter sales as % production	-105	-223	-8	46	68	78
Own feed as % value all feed	98	100	96	70	41	26
Casual labour (person days)	19	4	39	128	253	448
Surplus adult labour November-March (person days)	131	147	126	94	61	46
Manure available as % of intended manure application	26	0	65	100	100	100
Own consumption as % value of outputs	63	56	58	41	26	18
Off-farm income as % of returns to management and labour from farm activities	33	32	24	21	18	17
Returns to management for farm activities	7,051	7,976	11,301	13,648	15,976	17,864
Net farm income	12,451	12,799	16,905	19,818	22,518	24,578
Returns to management, labour and capital including off-farm income, subsidies and taxes	19,477	19,763	23,936	26,950	29,785	32,013

7.5 Farmer Attitudes to Adoption of Technological Change

The survey process sought both qualitative and quantitative information to identify: farmer attitudes to adoption; personal goals; risk and outlook on farming; perceived constraints to adoption; motivational influences; specific barriers and constraints to adoption; level of adoption of a range of farming practices; information sources (frequency of access and usefulness). General observation helps inform the interpretation of data, as does anecdotal information supplied by the farmers and interviewers during the process. It should be noted though that observation is coloured by our own western perceptions and experiences, yet is removed from the blinkers that limit interpretation by locals. It is therefore used with caution.

The survey showed that the farmers wanted greater income from the farm for the primary aim of a better life and illustrated that they believed that it was possible through increased production from livestock and cropping. They showed awareness that “better feeding” may be more important than changing the breed of the cows. Fodder cropping was highlighted as a way to achieve this. The majority of farmers were happy, but wanted their children to be educated and be able to work off farm despite seeing a positive future for farming. Low literacy in both Tibetan and Chinese was indicated, but there is increased education with younger farmers. Major information source on farming is from family, local farmers and the village committee but there was a desire for more information, and a request for more projects and extension. The detailed findings of this work will be published in the future.

An interesting side effect of this work was to see a transformation in attitude in TAAAS management to this work. Originally this work on understanding farmers’ motivations was tolerated but not well supported. This underwent a transformation with the presentation of some of the results, when the use could be seen.

The critical success factors work highlighted the key to adoption. The technique needs to be demonstrated to work, have an affordable upfront cost matched to a low level of risk. This was highlighted by farmers being impressed by maize yields but not willing to adopt due to high planting costs. Growing oats on the other hand, despite original opposition due to the weed problems with wild oats, is now considered a good option in areas around the original project site. This work also highlighted differences in what the farmers attitudes are between many research and extension staff and the farmers themselves. Farmers’ ability and willingness to learn, work and succeed is underestimated by many.

Review of the extension services highlighted a very disjointed approach with highly guarded areas. There is a turnover of staff in what is considered a lower status position. It was appreciated by some management that the use of critical thinking and initiative needed to be improved and they believed this to be a major benefit of the ACIAR and other outside funded projects. As the structures and culture of the Chinese bureaucracy is unlikely to be changed, work with individuals could have a flow on effect to others. A sample of extension and research staff surveyed indicated their keenness for information and further training.

This work highlighted a desire of farmers to improve their farm income, and an interest in new technologies that work within the limitations of cash flow. These combined factors and the ‘seeing is believing’ attitude together highlight the role of project demonstration in achieving adoption. Extension and research staff that show interest in further training would like to extend their knowledge beyond their current areas of expertise as well as into methods of technology transfer.

Issues for further research were also identified in this process, using a combination of farmer concerns and the combined expertise within the project. Examples include rhizobia on forage legumes, sowing rate investigations and charting the pests and diseases of various crops. Transfer of knowledge to farmers would benefit from extension of results of such research, as well on issues such as irrigation management, benefits of forage crop rotations to following cereal crops, management of forage crops, including sowing, cutting, management of pests and diseases, and animal mineral requirements.

The results of the survey component have shown the progress to date and confirm the need for future investment in research and extension to expand capacity and to ensure the successful transfer of new technologies.

7.6 General Discussion

The results of this multi-disciplinary project have advanced our knowledge of the many interacting factors affecting production and the implementation of new technologies into Tibetan agriculture, at both household and industry levels. The project extends the aims and findings of its forerunners by the integration of the variety of areas of investigation (agronomy, livestock, physical and human resources, social and economic influences, etc). Combining the interacting factors is well demonstrated by the development and implementation of the CAEG Tibet model as a major outcome, along with specific new technical and sociological information.

The agronomic research has produced valuable new information in areas of crop and fodder production and associated management techniques. New strategies for fodder crops have been demonstrated, while the forage produced need not compromise cereal yields. This maintains the security of grain required for household use and provides additional nutrients to supplement livestock diets, or to trade as surplus farm output. Strategies to improve feed quality by optimal management of cereal and companion legume crops have been devised as well as demonstrating the potential for silage supplementation to improve the utilization of low quality forages such as cereal straw. These areas of forage production and usage will benefit both Tibetan and Australian farming systems. The monitoring of milk production and associated feed intake has provided further definition of potential nutrient deficits that limit dairy product output, confirming previous findings of high reliance on straw based diets of low quality unless adequately supplemented. This has provided industry relevant data to demonstrate the principles of matching nutrient requirements to availability and indicated how shortfalls made be alleviated. The key to improving diet quality will be in the implementation of forage production systems devised by other research within the project. The dairy production component has also shown the importance of having the correct assessment of factors affecting production. Thus the previously held belief that low milk production would be turned around by increasing genetic potential has been shown to be of secondary importance to providing adequate nutrition, at the current stage of the dairy industry.

Results from the adoption survey have provided new insights to factors affecting awareness and uptake of new technologies. There are many interacting issues ranging from attitudes to change, social beliefs and pressures, practicalities of available labour and cash flow, personal goals, attitude to risk and outlook on farming, perceived constraints, as well as many others. Convincing demonstration of benefits was a very important factor affecting uptake as was the provision of incentive by financial support due to general low financial status.

The CAEG Tibet model provided a detailed outline and understanding of the household systems and enables the impacts of new technologies, altering enterprise mixes and practice changes to be investigated. It also enables the impact on households of changes in market or production conditions to be explored. Its ability to evaluate alternative scenarios will be extremely useful in exploring potential future directions apart from its use in identifying the most profitable and best bet strategies for the current situation.

Many components of the project identified the need for further basic biological and physical information (that could be obtained by future research) to improve the characterisation of production systems. An example is better prediction of responses in both agronomic and animal production that can be used directly in modelling exercises and to promote improved technology or practice change (e.g. – yield of forage systems or response of various cattle genotypes to improved nutrition).

Feedback from local and field staff and external agencies has reinforced the positive influence of this, and previous, ACIAR projects on uptake of new technologies. In particular, Mr Wang Jian from the Office of the Leading Group of Poverty Alleviation and the Office of Integrated Agricultural Development, who controls the initiation and funding of large community demonstration projects, has enlisted the help of TAAAS staff to include findings and recommendations of ACIAR work in the promotion of new technologies (the use of fodder crops at a village scale is just one example). This demonstrates a large impact on agricultural production in the project study areas and beyond.

8 Impacts

Project impacts are apparent in areas of research and extension, effects on farmer attitudes, farming community initiatives, influence on external agencies and research direction as well as general improvements in agricultural production and household lifestyle, as discussed in the relevant sections below. A major impact on the flow of information and stimulation of technology uptake has been the involvement of research and field staff with the production ‘coalface’ (i.e. household producers) that has resulted from the design of all the research components of the project. This has promoted ownership as well as forcing the understanding of principles involved and the practical application of various technologies that were previously viewed on a theoretical basis, if at all, and often poorly understood.

8.1 Scientific impacts – now and in 5 years

The obvious immediate scientific impacts are in the generation of new information from field and research institute studies. This builds on the knowledge of agronomic and animal production systems accumulated from previous ACIAR projects in specific areas and significantly in the integration of interacting factors. An example of the latter is the design of forage production systems to provide the means of improving the quality of livestock diets that have been identified as constraining production. Forage production has been demonstrated to give good yields of high quality fodder that is economically viable at the household level. Some areas of specific new knowledge include fertiliser response data, milk production data in relation to stage of lactation, nutrient intake and genotype and other information that can be used in predicting whole farm production.

Projections of impacts into the future fall into a few areas. Firstly the identification of ongoing research required to improve production will direct the best allocation of staff and funding resources by the research institute and stimulate the future support of local and central funding. Impacts will continue as the results of the project are translated into extension programs and establishment of demonstration sites, with activities continually evolving over both the short and medium term.

An underpinning scientific impact is the improvement in research and extension capacity of the scientists and collaborating field staff (as described below). Further ongoing scientific impacts to the wider international community result from the publication of journal and conference papers and extension material, during the project (as detailed later) and into the future.

8.2 Capacity impacts – now and in 5 years

There were clear impacts on research capacity during the life of the project particularly in relation to improved research ethos and extension of research findings on to farms. The Australian project staff through regular field visits to TAR worked closely with local staff to ensure that infrastructure and buildings funded in previous ACIAR projects were utilised in the best way possible to address important research questions and provide technological solutions. Hands-on instruction was provided in best practices for using agronomic and scientific equipment, such as seeders, balers, fertiliser drills and soil temperature loggers. Rigorous approaches to designing and sampling experiments were explained as well as methods for collecting, manipulating and interpreting large sets of data.

During the course of the project three TAAAS staff members successfully undertook John Allwright Fellowships (JAFs) for Masters Study in Australia: Ms Wang Li and Ms Xiangba Zhuoga completed Master of Philosophy degrees in the School of Animal and Veterinary Sciences at Charles Sturt University, Wagga Wagga, and Ms Pubu Drolma completed her Masters in the School of Plant Health and Biosecurity at The University of Adelaide.

These staff members returned to Tibet and have proved valuable contributors to ongoing project work, ensuring the training they have received is put to good use and passing this knowledge on to others. Another project staff member from TAAAS (Jin Tao) was successful in obtaining a JAF for 2011 but did not take up this opportunity due to professional commitments.

The transfer of the CAEG-Tibet model and manual into the hands of the local staff, together with the workshops provided by the Australian partners, has provided a physical frame work within which staff can integrate their research into the complete household system. It is envisaged that in the longer term local staff will be able to use the model to continuously evaluate household requirements.

The project has built the capacity not only of the local staff and enhanced their ability to run successful projects under the auspices of ACIAR projects, but the collaboration has also enabled them through the TAAAS organisation to apply for national, regional and local government project funding.

8.3 Community impacts – now and in 5 years

During the last year of the project it was evident that there was increased household awareness of the importance of livestock nutrition requirements and also how these requirements affected production. This had been achieved through the conduct of the on-farm research coupled with extension of research outputs – together these had conveyed an understanding of the relative nutritive values of varying types of forage available, and how the rations can be best utilised throughout the season. The project team were told by Dr Nyima Tashi during a conversation at the final project team meeting in Sydney in 2012 that ‘villages have a greater understanding of livestock nutrition and have an increased enthusiasm to improve the diets of livestock’

In the latter years of the project, as awareness was created of the importance of a stable fodder supply, one group of households conceived the idea to sow large areas of communal land to forages as a way of feasibly being able to produce and fit forage crops in their current farming systems. It will be interesting to see how this community approach will impact on household and village socio-economic structures in the future, and indeed, the CAEG Tibet model (as discussed in next section) will be useful to researchers in TAR for predicting likely effects on individual households of adoption of this approach. Clearly if the area sown to forages is increased this may have additional impacts on the community via increased livestock production and hence associated increases in labour and person hours required.

8.3.1 Economic impacts

The project aimed to increase rural incomes in Tibet by improving grain and fodder production. Evidence of adoption has been seen in the regions during the latter years of the project and was commented on by the reviewers. A comprehensive understanding of the economics of households has been gained from project activities and thus it has been possible to construct a realistic household economic model (CAEG Tibet) that can be used to predict economic consequences from adoption of the best bet practices identified from the on-farm trials. For example vetch double crops have been sown over a pilot area of 500Mu at Changzhu, leading to increased fodder production in this one village. 1,500 Mu of fodder oats has been sown in the Mozhugongka area in 2011which is a result of direct influence from project work and is now being implemented by local county level staff. It has also become apparent that findings and recommendations from the project are being applied in other locally initiated and funded demonstration programs. The model proves that increased production and its viability is dependent on commodity prices as well as the ‘value’ of labour.

8.3.2 Social impacts

The project is expected to have important social impacts over the longer term by improving rural livelihoods through increased grain and fodder production. It is also hoped that the project's focus on farmer consultation and farmer participatory approaches will improve the relationship between government researchers and extension staff, and rural dwellers in Tibet. Some evidence of this was noted also during the review process. We believe the project provides a platform of information regarding the socio-economic and biophysical structures currently in existence in TAR that will be useful in considering how any transition from subsistence farming towards commercial production may be managed. This will involve change in labour structure for households with perhaps increased number of house hold members seeking part time work off-farm.

8.3.3 Environmental impacts

The increased grain supply engendered if technological changes suggested by this project are adopted (such as improved fertiliser practices and better sowing techniques) and subsequent food security in TAR could reduce any trend for farmers to expand agriculture into more marginal land. Increased fodder supply from existing agricultural areas could, with appropriate environmental policies, reduce pressure on rangelands to supply forage and fodder for animals, and reduce land degradation on rangelands. It is recognised that water is becoming a scarce commodity in TAR. Adoption of the technological changes suggested by this project will contribute to conservation of water (zero till) and increased efficiency of water utilisation (optimising growth of cereals via improved fertiliser practices) but also may place greater demands on water resources (e.g. extended cropping period for relay cropping). However, there is potential for general improvement in use of the water resource by identifying and promoting use of more efficient irrigation practices, which was not addressed in this current project.

8.4 Communication and dissemination activities

The approaches and strategies to be used in the project were developed at a workshop convened by ACIAR in Lhasa, TAR in May 2007.

Travel by the Australian staff was somewhat restricted in 2008 due to difficulties in obtaining permits to enter TAR but on 22nd November 2008, TLRI a one day meeting was held with approximately 30 people present including Heads of the Poverty Alleviation Office, the Department of Science and Technology, and the Agriculture Bureau network. Results were presented from the initial dairy and agronomy projects by local and Australian project staff, and an overview of new project objectives was presented. All overheads were presented in English and Chinese.

Nick Paltridge and Tim Heath (AYAD) spent several months in TAR during 2009 and other Australian team members entered TAR to undertake collaborative research activities for periods of up to 4 weeks. Carol Rose delivered a workshop to the Farmer Training Centre at TAAAS 22nd May 2009 on agricultural extension in Australia, and strategies to improve extension systems in TAR. Five Tibetan staff visited NSW (Australia) from 25th October to 14th November 2009 and toured surrounding Agricultural Research Stations in NSW, farms and attended meetings with extension staff.

A project leader change-over meeting was held in Lhasa TAR in April 2010 with David Coventry, Tim Heath and Ann McNeill. Tim Heath remained in country for 6 months in 2010 and all Australian team members visited later in the same year to undertake project activities including on-farm research and extensive interviews in households.

February 2011 involved a key project workshop in Adelaide for the project combined with the associated ACIAR project LPS/2005/129 'Mineral Response in Tibetan Livestock' The week long workshop brought together 10 local staff from Tibet and all Australian project personnel from both projects. It was a great opportunity for networking, capacity building and to discuss opportunities for the future.

The review in July 2011 was extremely useful for the team in getting together to communicate outputs from the project to date to the ACIAR program leader, the research scientists on the review panel as well as key government personnel involved in development in TAR .

A project workshop to formalise the planned activities during the project extension was held at the start of 2012 (February) in Adelaide with all Australian project partners attending as well as the retired project leader Professor David Coventry, and the prospective AYAD Bonnie Flohr. During the workshop there was also a skype phone hook up with several staff from TARI and key project personnel in TAAAS including Dr Nyima Tashi.

Travel was again restricted in 2012 with Tim Heath being the only Australian project team member being able to visit TAR from April–June in order to spend time with TAR project team members and assist the AYAD Bonnie Flohr to set up experiments and undertake some capacity building activities. However, despite the restrictions the ACIAR CEO (Nick Austen) and program manager (Peter Horne) were also able to visit during 2012.

A final 3 day meeting of the Australian team was held in Sydney in late 2012 to discuss progress on publications and other outputs, and to collate material for the final report. It was also possible to have a brief phone conversation with Jin Tao, Yang Yong and Nyima Tashi in TAR, and receive their feedback on perceived impacts of the project.

The project was also pro-active in presenting outputs at workshops, national and international conferences, and in scientific journals – see section 10.2 in the report.

9 Conclusions and recommendations

9.1 Conclusions

The project has clearly demonstrated on-farm that potential in the TAR environment exists, to produce forage to fill the seasonal gap for household feed requirements for cattle, without compromising current cereal grain yields. Also, that the potential exists to increase yields of all crops if fertiliser applications are optimised. Results from surveys suggest that farmers will take up these new options for forage production provided there is government support to do so. Indeed, increased areas of relay forages were observed in the latter years of the project at the household and the community level. Further, the project has shown that if these forages are conserved, as hay or silage, and fed in the correct ratio with the cereal straw that is more commonly used, they can provide better quality nutritious diets for animals which will improve milk production, reproduction and animal growth. Additionally, using the CAEG Tibet it has been shown that increased forage production, whilst maintaining cereal productivity, is an essential part of improving livestock/cropping profitability and household incomes.

Australian trials supported those in TAR in highlighting the capability of cereal/vetch forage crops to produce significant yields for hay and silage production with very high yield potential in favourable seasons. The relationships of forage yield and quality to species and stage of maturity at harvest produced clear guidelines to optimise production systems. The potential of these forages to support animal growth was quantified. The use of silage and protein supplements to improve the utilization of straw diets provided practical strategies to benefit livestock production in both Tibet and Australia.

Project achievements are all the more remarkable given the restrictions placed on access to TAR during two of the five years of the project. This reflects the input by TAAAS in ensuring the project was able to operate and the dedication and enthusiasm of all the project team members.

9.2 Recommendations

The impact of the increased demands of cereal-forage systems on natural resources such as soil nutrients and water, as well as the socio-economic implications of adoption of such changes, require further investigation. There is a need to gather appropriate climatic and agronomic data for the application of biophysical models to determine productivity limits. Relationships of nutrient intake to production suggested further restrictions that require investigation, including efficiency of utilization. A component of adaptation may also affect the performance of local and crossbred genotypes. There is still much research needed to determine the genetic variability and potential of the “local” cow genotype, including response to improved nutrition. We don’t know the possible effects of adaptation. There is a need to further investigate previous indications of effects of high altitude on energy metabolism, thus feed efficiency etc., and if adaptation of the local genotype can have a significant positive effect on production. Thus we need to determine the balance between lower genetic capacity and adaptive advantage. Cattle monitored so far have had nutritional restrictions for all or most of their lives from conception to adult stages. Thus there is a need to generate cattle with completely unrestricted nutrition from conception onwards to determine the genetic capacity of the local and improved genotypes in Tibet. This is a related but separate issue to that of adaptation as it is necessary to supply the animals for valid investigations.

The farm model has been an extremely valuable component of the project, in providing whole farm system perspectives to production and profitability, as well as mechanisms for calculating and managing livestock feed budgets as just one example of its many features. It may take some time before it is used routinely as an individual farm decision aid tool, but it's more immediate and important use is in scenario testing – leading to research, extension and demonstration strategies. More work is needed to refine parameters used in prediction functions – e.g. in improving milk response relationships we need to update lactation curve equation parameters. Since the project was unable to access TAR in final year there is still a need to train more TAAAS staff in use of the model to help farmers understand the economic options. The use of cereal/vetch crops for forage production should be tested more fully in TAR using rigorous research approaches to evaluating fertiliser requirements including micronutrients such as zinc. The use of high protein feeds (CSM and lucerne silage) to supplement cereal straw based diets fed to dairy cows in TAR needs to be investigated. There is a need to encourage more forage conservation research in TAR to give extension staff the local knowledge for demonstrations and to foster adoption. This should also demonstrate some of the cutting time and processing strategies to maximise hay quality in the relay crops, as well as recommendations for the cereals grown for fodder.

Conclusions from the livestock studies to date are restricted by the limited numbers of cattle surveyed or used in experiments and by some logistic problems of the field data. The methodology and resourcing of field research for the animal studies here was a major factor in restricting the value of results and conclusions due to problems with oversight of studies: there is need for competent and committed operators; close control of recording of farmer practise to ensure no loss of information; adequate support with funds and equipment etc. These issues were intended to be addressed directly with local staff in a final visit to the project site, but this was not possible due to lack of access to TAR. Many of the same resource and commitment issues applied to the agronomy component of the project. Although there were some highly committed and competent individuals involved in the TAR project team, more generally across the spectrum, further training in scientific approach is still required.

Future work should consider the following:

1. Measurement and/or prediction using bio-physical modelling of the effects of proposed new technologies on the soil and water resources in TAR
2. Using and improving/refining the CAEG-Tibet model to promote new technologies to farmers and to investigate socio-economic implications of adoption of current new and any emerging technologies on households
3. Research to optimise fertiliser requirements of the new cereal-forage systems and include micronutrients such as zinc.
4. Research to better define nutrition and production in livestock - use of high protein feeds (CSM and lucerne silage) to supplement cereal straw based diets; update lactation curve equation parameters; generate cattle with completely unrestricted nutrition from conception onwards to determine the genetic capacity of the local and improved genotypes
5. Research at the interface of fodder/crop agronomy with rangelands - extend livestock research to include yak, sheep and goats
6. Increasing efforts and using new strategies to foster & maintain a high standard of research ethos in TAR supported by adequate infrastructure

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Handbooks and manuals

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A Chinese translation of the “Successful Silage” manual, produced by NSW DPI with funding by Dairy Australia, was delivered to TARI and TLRI staff to provide up to date information on forage production technology,

Concept Notes

A submission was sent to the “Australia in the Asian Century” White paper by the team of Australian scientists engaged in this project, initiated and co-ordinated by Dr Scott Waldron, with contributions by all team members.

A concept note discussing the directions, possibilities and priorities of future work was initiated and co-ordinated by John Piltz and presented to ACIAR. Discussion among the team explored many areas outside those already investigated in ACIAR (and other) projects to date, as well as follow up required on previous and current issues. This covered a wide range of topics across a variety of livestock species, production systems, agronomic practices, supply chains, market scenarios, modelling and farm budgeting etc., along with associated requirements of development, demonstration and extension

Meetings & Workshops

On every occasion of on-site visits to TAR by Australian team members, routine meetings were held with research and administrative staff (involving TAAAS, TARI and TLRI officers) to discuss the objectives of the trip, results emerging and future plans.

On Saturday 22nd November 2008, a meeting was held at TLRI with approximately 30 people present including Heads of the Poverty Alleviation Office, the Department of Science and Technology, and the Agriculture Bureau network. Results were presented from the initial dairy and agronomy projects by local and Australian project staff, and an overview of new project objectives was presented. All overheads were presented in English and Chinese.

Workshops were held to design and modify the format of the household survey as mentioned above in Section 5.4. Other workshops have also been discussed above in Section 8.4.

AYAD associated activities

During the course of the project 2 recent graduates from Australia were located at Lhasa on study missions sponsored by the Australian Youth Ambassador for Development (AYAD) program. This program allows young scientists to conduct research projects in various locations around the world, and has provided the opportunity for very useful and mutually beneficial research to be done in association with ACIAR projects.

During 2009 Tim Heath had a 4 month AYAD mission in China (Lanzhou and Tibet), having 3 months at Lhasa working in association with this project. Subsequently, in February 2010, Tim took up the position of Research Fellow within the project, following the resignation of Dr Nick Paltridge.

Towards the end of the project, Ms Bonnie Flohr was located at Lhasa from May to October 2012, and conducted a study on the potential of dual purpose cereals for fodder and grain production. Results from Bonnie's research have been presented above in Section 7.2.2 (Forage Production in Tibet).

Media Articles

Many articles have been published in local press media describing the aims and progress of the project and reporting visits to Australia by our colleagues from Tibet.

Example venues include;

- The Land Newspaper
- The Adelaidean
- The Stock Journal
- The Daily Advertiser (Wagga Wagga)

11 Appendixes

11.1 Animal production and nutrition

The following show examples of the household data recording sheets, detailing information collected on milk production, feed and reproduction. These data were collated for incorporation into a database file for summarising and analyses.

Milk production data

产奶量（升） 9 Farm number
农户号
户主 达瓦 Farmer name
月份 6月 Month

	奶牛号：228 (Cow #)			奶牛号：229			奶牛号：			奶牛号：		
日期	第一次	第二次	第三次	第一次	第二次	第三次	第一次	第二次	第三次	第一次	第二次	第三次
Date	Morning	Mid	Afternoon									
1/6/10	2.3	1.7	2.2				3	2				
2/6/10	2.3	1.7	2.2				3	2				
3/6/10	2.3	1.7	2.2				3	2				
4/6/10	2.3	1.7	2.2				3	2				
5/6/10	2.4	2.6	2.3				2.9	2.1				
6/6/10	2.4	2.6	2.3				2.9	2.1				
7/6/10	2.4	2.6	2.3				2.9	2.1				
8/6/10	2.4	2.6	2.3				2.8	2.1				
9/6/10	2.3	1.5	2.3				2.8	2.1				
10/6/10	2.3	1.5	2.2	出生犊牛			2.8	2.1				
11/6/10	2.2	1.5	2.2	2	1.5	1.5	2.8	2.2				
12/6/10	2.2	1.5	2.2	2	1.5	1.5	2.7	2.2				
13/6/10	2.2	1.5	2.2	2	1.5	1.6	2.7	2.2				
14/6/10	2.2	1.5	2.2	2	1.5	1.6	2.7	2.2				
15/6/10	2.3	1.4	2.2	2	1.6	1.5	2.7	2.2				
16/6/10	2.3	1.4	2.3	2	1.6	2.6	2.8	2.2				
17/6/10	2.3	1.4	2.3	2	1.5	2.6	2.8	2.1				
18/6/10	2.3	1.4	2.3	2	1.5	2.5	2.8	2.1				
19/6/10	2.3	1.4	2.3	2	1.6	2.5	2.7	2.1				
20/6/10	2.3	1.4	2.3	2	1.6	2.5	2.7	2.2				
21/6/10	2.3	1.4	2.3	2	1.6	2.5	2.7	2.2				
22/6/10	2.3	1.5	2.4	2	1.5	2.6	2.8	2.2				
23/6/10	2.3	1.5	2.4	3	1.5	2.6	2.8	2.2				
24/6/10	2.3	1.5	2.4	3	1.5	2.6	2.8	2.2				
25/6/10	2.3	1.5	2.4	3	1.5	2.6	2.8	2.3				
26/6/10	2.3	1.5	2.4	3	1.5	2.6	2.8	2.3				
27/6/10	2.3	1.5	2.4	3	1.5	2.6	2.8	2.3				
28/6/10	2.3	1.5	2.4	3	1.5	2.6	2.8	2.3				
29/6/10	2.3	1.5	2.3	3	1.5	2.7	2.8	2.3				
30/6/10	2.3	1.5	2.5	3.1	1.5	2.8	2.8	2.3				

Feed offered – separate feed types

Farm num 9.0
Farmer na jiangoun

Feeding to Milkers and dry cows
(separate feeding amounts - jin)

Cow ID	236	1	1.1		6	6.3			8	8.4			4	4.2		
	Wheat straw				wheat bran				vetch				weeds			
Date	Total	AM	Mid	PM	Total	AM	Mid	PM	Total	AM	Mid	PM	Total	AM	Mid	PM
1/6/10	10.0			10	2.0	2.0			11.0	11			12.0		12	
2/6/10	10.1			10.1	2.0	2.0			11.0	11			12.1		12.1	
3/6/10	9.8			9.8	2.0	2.0			11.0	11			11.7		11.7	
4/6/10	10.0			10	2.0	2.0			11.0	11			11.8		11.8	
5/6/10	10.2			10.2	2.0	2.0			11.0	11			12.0		12	
6/6/10	10.2			10.2	2.0	2.0			11.0	11			11.7		11.7	
7/6/10	10.0			10	2.0	2.0			11.0	11			12.1		12.1	
8/6/10	9.8			9.8	2.0	2.0			11.0	11			11.7		11.7	
9/6/10	10.1			10.1	2.0	2.0			11.0	11			11.8		11.8	
10/6/10	10.0			10	2.0	2.0			11.0	11			11.9		11.9	
11/6/10	10.1			10.1	2.0	2.0			11.0	11			11.8		11.8	
12/6/10	9.9			9.9	2.0	2.0			11.0	11			12.0		12	
13/6/10	10.2			10.2	2.0	2.0			11.0	11			12.0		12	
14/6/10	10.2			10.2	2.0	2.0			11.0	11			11.2		11.2	
15/6/10	10.3			10.3	2.0	2.0			11.0	11			11.8		11.8	
16/6/10	10.1			10.1	2.0	2.0			11.0	11			11.7		11.7	
17/6/10	9.9			9.9	2.0	2.0			11.0	11			11.6		11.6	
18/6/10	9.7			9.7	2.0	2.0			11.0	11			11.5		11.5	
19/6/10	29.5		15.5	14	2.5	2.5			0.0				15.0	15		
20/6/10	30.2		15.5	14.7	2.0	2.0			0.0				15.0	15		
21/6/10	29.3		14.7	14.6	2.4	2.4			0.0							
22/6/10	29.4		14.8	14.6	2.0	2.0			0.0							
23/6/10	30.0		15.5	14.5	2.4	2.4			0.0							
24/6/10	29.3		14.7	14.6	2.5	2.5			0.0							
25/6/10	30.1		15.5	14.6	2.7	2.7			0.0							
26/6/10	17.5		17.5		3.0	3			0.0							
27/6/10	17.0		17		3.3	3.3			0.0							
28/6/10	17.4		17.4		3.2	3.2			0.0							
29/6/10	17.3		17.3		3.3	3.3			0.0							
30/6/10	17.5		17.5		3.5	3.5			0.0							

Feed types

		Major types			
		Straw	1	Wheat	1.1
Possible feed types	饲料种类			Barley	1.2
Wheat grain	小麦	Grain	2	Wheat	2.1
Wheat straw	小麦秸			Barley	2.2
Barley grain	大麦				
Barley straw	大麦秸	Brewers grain	3		3.1
Corn stover	玉米秸				
Green Fodder - alfalfa	青绿饲料-苜蓿	Green	4	Misc	4.1
Green Fodder - vetch	-箭筈豌豆			Weeds	4.2
Green Fodder - turnips	-甜菜			VegWaste	4.3
Green Fodder - weeds	-杂草			Turnips	4.4
Green Fodder - vege waste	-蔬菜叶子				
Green Fodder -	-	Supplement	5		5.1
Hay - alfalfa	干草——苜蓿				
Hay - oats	-燕麦	By-Products	6	Canola meal	6.1
Hay - vetch	-箭筈豌豆				
Hay - vetch + cereal	-箭筈豌豆+谷物			Wheatbran	6.3
Silage - corn	青贮——玉米			Barley bran	6.4
Silage - other	-其他				
Other crops -	其他作物-	Silage	7	Maize	7.1
By-products - brewer's grain	副产品-酒糟				
By-products - barley bran	-大麦麸				
By-products - wheat bran	-小麦麸	Hay	8	Wheat	8.1
By-products - canola meal	-菜籽饼			Barley	8.2
Salt	盐			Alfalfa	8.3
Other	其他			Vetch	8.4
				Vetch+cereal	8.5
Extra project supplements	项目给予的饲料			Corn stover	8.6
Dairy mix	奶牛添加剂				
		Extras 1	9	Grazing	9.1
		Extras 2	10	Salt	10.1

Reproduction data

	繁殖性能数据	（记录奶牛配种及犊牛出生日期）			
农户号：Farmername					
户主：Farm number 9		月份:			
	Cow # 234	奶牛号	奶牛号	奶牛号235	奶牛号
去年的产犊时间	last year calving date			1/06/2009	
今年产犊（或流产）时间	this year calving date			21/06/2010	Inter-calving
Birth data					
犊牛耳号	Calf Number			235-2010.6.21	
犊牛难产情况（无，助产〔轻（L）、中（M）、高(H)）	Birthing difficulty	easy or hard		L	
出生时犊牛是否成活（Y/N)	Calf alive at birth (yes/no)			y	
1周后犊牛成活情况（Y/N）	Calf alive in 7 days (yes/no)			y	
犊牛出生重	Calf weight (Jin)			44	
犊牛性别(公牛：M，母牛：F）	Sex of Calf			F	
颜色	Calf colour			B&W	
Weaning					
断奶时间	when calf stopped drinking from mother (days after birth)				
断奶体重	weight of calf at this date (jin)				
Mating data					
	Date			15/10/2010	Post partum
第一次配种时间 (今年)	Bull Breed (holstein, simmental)			H	
AI 或当地公牛	sperm from improved cattle			AI	
公牛品种	sperm from local cattle			改良牛	
第二次配种	Bull Breed (holstein, simmental)				
AI 或当地公牛	sperm from improved cattle				
公牛品种	sperm from local cattle				
第三次配种	Bull Breed (holstein, simmental)				
AI 或当地公牛	sperm from improved cattle				
公牛品种	sperm from local cattle				

Database for analyses

Year	Month	Date	Farm#	Cow ID	Breed	DaysMilk	Calve Date	am Milk (Jin)	ad Milk (Jin)	pm Milk (Jin)	Total Milk		
2009	6	24/6/09	5	222	Sx	46	10/5/09	7	3	8	18		
2009	6	25/6/09	5	222	Sx	47	10/5/09	7.3	4	8	19.3		
2009	6	26/6/09	5	222	Sx	48	10/5/09	7.5	4.5	8	20		

Date	Farm	Cow	TOTAL INTAKE				1 Straw					2 Grain	
			Tot Fed	Tot DM	Tot ME	Tot Prot	Type	Fed	DM	ME	Prot	Type	Fed
24/6/09	5	222	37.7	14.18	120	1543.3	1.1	13.2	5.94	38.61	225.72	.	.
25/6/09	5	222	37.8	14.28	121	1549.1	1.1	13.4	6.03	39.195	229.14	.	.
26/6/09	5	222	37.9	14.3	121	1557	1.1	13.3	5.985	38.9025	227.43	.	.

Calculations of

Dry matter intake

ME intake

Protein intake

For each feed type and for total diet

"CowReqCalc" – calculator for estimating energy requirements over 12 months for individual cows and total for the farm. The following is one sheet of the Excel routine. Other sheets have calculations for protein requirements and lookup tables to enable calculations based on the information for each cow involved.

INPUTS		**ENERGY - OUTPUTS - AVERAGE DAILY REQIREMENTS/MONTH**											
Farm ID	**xx**												
Total number of cows	yy												
		Cow 1	Cow 2	Cow 3	Cow 4	Cow 5	Cow 6	Cow 7	Cow 8	Cow 9	Cow 10		
Cow ID		1	2	3	4	5							
Mating month													
Calving month		6	7	6	6	6							
Av milk production		5	10	5	10	5							
Energy req/litre		5.5	5.5	5.5	5.5	5.5							
Cow LW		250	250	350	350	250							
Calf birthweight		17.5	17.5	25	25	17.5	#N/A	#N/A	#N/A	#N/A	#N/A		
		Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Stage of lactation	Calve	1	2	3	4	5	6	7	8	9	10	11	12
Cow 1- mth lact	6	20	21	22	23	24	1	2	3	4	5	6	7
Cow 2 - mth lact	7	19	20	21	22	23	24	1	2	3	4	5	6
Cow 3 - mth lact	6	20	21	22	23	24	1	2	3	4	5	6	7
Cow 4 - mth lact	6	20	21	22	23	24	1	2	3	4	5	6	7
Cow 5 - mth lact	6	20	21	22	23	24	1	2	3	4	5	6	7
Cow 6 - mth lact	0												
Cow 7 - mth lact	0												
Cow 8 - mth lact	0												
Cow 9 - mth lact	0												
Cow 10 - mth lact	0												
Stage of gestation	Calve												
Cow 1- mth gest	6	5	6	7	8	9				1	2	3	4
Cow 2 - mth gest	7	4	5	6	7	8	9				1	2	3
Cow 3 - mth gest	6	5	6	7	8	9				1	2	3	4
Cow 4 - mth gest	6	5	6	7	8	9				1	2	3	4
Cow 5 - mth gest	6	5	6	7	8	9				1	2	3	4
Cow 6 - mth gest	0												
Cow 7 - mth gest	0												
Cow 8 - mth gest	0												
Cow 9 - mth gest	0												
Cow 10 - mth gest	0												
Cow 1	250	5											
maint ME		31	31	31	31	31	31	31	31	31	31	31	31
lact ME		11	5.5	0	0	0	22	27.5	27.5	22	22	16.5	11
preg ME		2.5	4.5	8	15	17.8	0	0	0	0	0	0	1.5
TOTAL MJ		**44.5**	**41**	**39**	**46**	**48.8**	**53**	**58.5**	**58.5**	**53**	**53**	**47.5**	**43.5**
Cow 2	250	10											
maint ME		31	31	31	31	31	31	31	31	31	31	31	31
lact ME		22	22	11	0	0	0	44	55	55	44	44	33
preg ME		1.5	2.5	4.5	8	15	17.8	0	0	0	0	0	0
TOTAL MJ		**54.5**	**55.5**	**46.5**	**39**	**46**	**48.8**	**75**	**86**	**86**	**75**	**75**	**64**
Cow 3	350	5											
maint ME		40	40	40	40	40	40	40	40	40	40	40	40
lact ME		11	5.5	0	0	0	22	27.5	27.5	22	22	16.5	11
preg ME		3.5	6	11	21	25	0	0	0	0	0	0	2.5
TOTAL MJ		**54.5**	**51.5**	**51**	**61**	**65**	**62**	**67.5**	**67.5**	**62**	**62**	**56.5**	**53.5**
Cow 4	350	10											
maint ME		40	40	40	40	40	40	40	40	40	40	40	40
lact ME		22	11	0	0	0	44	55	55	44	44	33	22
preg ME		3.5	6	11	21	25	0	0	0	0	0	0	2.5
TOTAL MJ		**65.5**	**57**	**51**	**61**	**65**	**84**	**95**	**95**	**84**	**84**	**73**	**64.5**
Cow 5	250	5											
maint ME		31	31	31	31	31	31	31	31	31	31	31	31
lact ME		11	5.5	0	0	0	22	27.5	27.5	22	22	16.5	11
preg ME		2.5	6	11	21	25	0	0	0	0	0	0	2.5
TOTAL MJ		44.5	**42.5**	**42**	**52**	**56**	**53**	**58.5**	**58.5**	**53**	**53**	**47.5**	**44.5**
TOTAL for FARM		**263.5**	**247.5**	**229.5**	**259**	**280.8**	**300.8**	**354.5**	**365.5**	**338**	**327**	**299.5**	**270**

11.2 Plant tissue analysis from Paltridge Survey 2008

Table 3 Plant tissue analysis of 24 wheat and barley crops from across the crop dominated zone

Crop[a]	Stage	Town/village	N(%)	Fe	Mn	B	Cu	Mo	Zn	Ca	Mg(%)	Na	K(%)	P(%)	S(%)	Al
SB	Booting	Tsedang	3.7	67	44	37	14	1.5	22	0.46	0.12	3900	2.5	0.31	0.36	8.3
SB	Heading	Tsedang research station	4.7	85	70	34	12	1.2	34	0.50	0.28	7800	1.8	0.53	0.76	8.1
SB	Heading	Chang zhu	3.9	86	58	37	14	< 1	36	0.47	0.20	6800	2.8	0.43	0.64	13
SB	Heading	Jie de xiu	3.9	81	44	16	13	2.0	28	0.58	0.25	6400	1.8	0.38	0.68	9.0
SB	Heading	Jie sha	4.1	83	48	12	9.5	1.5	26	0.78	0.15	570	3.1	0.36	0.65	16
SW	Anthesis	Jie de xiu	3.5	99	30	20	8.2	3.1	19	0.57	0.23	400	2.2	0.29	052	19
WW	Anthesis	Jie ba	2.7	76	19	11	6.0	1.8	12	0.51	0.17	62	1.7	0.26	0.40	19
SB	Booting	Qushui	3.3	76	61	6.1	8.8	2.6	19	0.70	0.13	460	3.6	0.32	0.33	16
SB	Booting	Qushui	3.8	76	45	19	8.0	2.1	19	0.54	0.13	1420	3.1	0.32	0.30	11
SB	Booting	Ciba village	4.1	91	34	59	9.4	3.3	17	0.48	0.19	3800	3.2	0.46	0.33	7.7
SB	Tillering	Qushui	no data	142	24	83	6.5	3.8	14	0.43	0.20	13300	1.9	0.28	0.39	19
WW	Anthesis	Ciba	2.8	74	14	57	7.7	3.1	16	0.60	0.26	128	2.2	0.36	0.46	17
WW	Anthesis	Qushui	2.4	82	33	5.0	5.8	2.3	12	0.44	0.14	29	2.9	0.21	0.28	24
WW	Anthesis	Ciba village	3.6	95	27	77	10	2.9	16	0.67	0.20	530	2.0	0.31	0.33	19
WW	Anthesis	Niedang	2.8	91	23	30	6.2	2.4	14	0.53	0.19	52	2.2	0.30	0.27	28
SB	Elongation	Medrogongk	4.0	125	57	32	9.8	1.9	38	0.49	0.16	6600	3.1	0.49	0.39	25
SB	Booting	Medrogongka	3.2	81	29	7.4	7.2	4.0	46	0.39	0.13	430	3.0	0.50	0.23	4.3
SB	Heading	Gongga	3.7	70	84	62	14	2.0	26	0.66	0.13	3400	3.1	0.32	0.45	7.2
SB	Tillering	Panam	5.0	210	58	45	10	< 1	15	0.61	0.29	6700	4.0	0.37	0.50	45
SB	Late tillering	Jiangda	5.7	125	48	166	14	3.1	28	0.46	0.23	14500	3.1	0.41	0.51	20
SB	Elongation	Panam	5.6	174	54	35	9.9	1.5	18	0.64	0.26	5800	4.7	0.42	0.45	29
SW	Heading	Jiangda	4.8	109	40	7.7	9.2	< 1	21	0.46	0.22	95	3.5	0.37	0.38	18
WW	Heading	Panam	2.8	94	31	38	6.9	< 1	13	0.45	0.18	51	2.7	0.26	0.49	30
WW	Heading	Panam	3.4	95	32	49	7.9	< 1	14	0.59	0.20	260	2.5	0.28	0.36	19
Thresholds for deficiency[b] SB			2.6	25	12	2-5	1-2	0.1	14-20	0.2	0.10-0.15		2.0-2.6	0.27-0.30	0.15	
Thresholds for deficiency[b] SW			2.6	10-25	10-15	3-5	2	0.1	16-20	0.2	0.10-0.15		2.0-2.5	0.23-0.26	0.14-0.32	

Units are mg kg^{-1} except where indicated at percentages; dark shading indicates likely deficiency, light shading indicates three cases of possible toxicity

[a] *SB* spring barley, *WW* winter wheat, *SW* spring wheat

[b] Critical thresholds estimated from those given for plants at similar stages of development in Reuter et al. (1997)

11.3 Examples of field reports from interviews

The following reports are interviews of persons from (a) a household, (b) a commercial enterprise and (c) the stalls at Shigatse markets. Text has been minimally edited from the original field notes.

Household 13, Changzhu Town, Changzhu village

Interviewers: CGB, SAW, Drolma, Tim, Pingcuo, David C, Nick P, Drolma

Interviewees: Mr P### and his household

Date: 090721

Section 1

5 people in hh

- 2 children. One older in high school this year. Helps a bit on the tractor and making butter. No school fees for rural households. Previously free to year 6, but as of this year extended to 12 years. Fees only at university level.
- 1 older generation – 62y.o. This is Mr P###
- And a couple. Do on-farm and off-farm labour. 4 months off-farm. Rmb1,000 per month – do all types labour

Section 2

18 mu of land in 6 plots

- 15 mu winter wheat. Local measurement unit of “k” - 28jin. Get 18”k” per mu of winter wheat. Means 490 (504?) jin/mu. 20jin/mu seeding rate.
- 1 mu canola.161jin yield. 3 jin seeding rate.
- 2 mu vetch. Has grown for 10 years. 1 cut per year, said they cut at about 1 meter, but actually cut whenever required, and cattle can be grazed on vetch. More grazing on crop stubble. 40 jin/mu seeding rate – planted every year. Sometimes get seed from town at about 20jin/mu. Rest from own seed. 1 mu for livestock, 1 mu for seed. Plants a bit after new year, then main cuts in July. Has planted lucerne before on a small plot just to try but didn’t grow and not used for feed. Rmb2.5/jin from a company/station under the prefecture AAHB.
- No vegetables.
- All single crops – no mixed crops

Section 3

Livestock

- 8 cattle
  - 6 females, 3 males.
  - OR 3 milkers, 3 calves
  - 2 bulls for sale or slaughter
- 4 pigs, 1 sow, 3 piglets. Sow produces 6 per birth, twice per year, but 2 deaths at birthing.

Dairy cows

- AI’d at 5y.o. then milked.
- Had a record of calving.
  - 1 calf born 2009, April 4.
  - Another May 25.
  - Another June 5
- All weaned in February. The same across the whole town and village. Done then because this is when feed is low, so to stop cows slipping too much in condition.
- Thinks he can produce a calf a year. No deaths.
- AI. All Holstein. From Beijiing nainiu zhongxin. Frozen straws bought by the Huangniu Gailiang project of the prefecture Nongfaban. This involves beef, yak, dairy cattle improvement. No Zexi genetics, used to have Simmentals – not now. AI done at another village with a vet station. No cost.

- There are vet / vaccine costs. Done at Disease Monitoring / vet station. Some sort of additive to feed for digestion / milk digestion functions etc. (scabies??). Don't feed any cold water in this time.
- Is not considering expanded cows from 3 to 5 head for example. The three head fits into his labour and feed availability.

Section 4

Consumption

- Spend about Rmb30 per day – veges, meat, rice – for 5 people
- Get their barely through exchange with their wheat
- Straight exchange between spring barley and wheat. Used to make tsampa. Not for beer, because he makes his beer with winter wheat.
- Use wheat to make flour, and for momo / mantou and flat bread. Uses about 100k (2800jin) for beer (waste for cattle), 740 jin for momo per year. Also uses a bit of leftover wheat grain for cattle feed. Doesn't sell any out.

So doesn't sell much

- As a rule, tries to keep one piglet for consumption and 2 for sale
- As a rule, sells one bull and keeps one for self-consumption per year
- No milk, butter, cheese sales. If sold naizha then worth about Rmb20.
-

Manure

- Used for cooking. About half a bag per day. About 9-10jin.
- For heating in winter use manure and pieces of wood. Only used in the morning, and use depends a lot the weather.

Section 5

Manure

- 1 tractor load of manure per mu. [Said 2 tonne! – very important – this is just the capacity of the tractor written on the side of the tray. Not actual. They (including Pingcuo) haven't weighed it. Includes pig, cattle and human manure]. Can be wet, dry, or in-between.

Other fertiliser application

- Urea – 53jin/mu
- Dap – 33 jin/mu

Section 6

Milk / butter yields

- 9jin milk per cow per day. Best cow3 about 10jin, lowest yielding cow about 7jin.
- Milks 270-300 days per year. Twice per day – milk in the morning and midday, then calf sucks in afternoon
- Make butter every day!! Takes about 2 hours straight.
- 27 jin milk produces 1.4jin butter. 3 naizha (wet cheese) to make 1 jin dry cheese.
- Process for making dairy products.
    - Churn the milk
    - Skim of the butter from the top
    - Boil the rest
    - Scrape off the clotted top layer for cheese (wet) then can be dried
    - The rest of the liquid used for cattle or ingredient into making bread etc.

Section 7

Rations – from his written records – per cow per day, fed 3 times over day

- Straw – 10jin
- Grass – 4jin. This means winter barley with head/grain on, but that has not formed grain properly or has been damaged with weather or pests etc. This is from neighbours free.
- Husk – 4 jin
- Vetch – 19jin

- Brewers waste (from barley beer) – 5 jin
- Cabbage leaf – 2 jin
- Salt – 8 grams

Bulls fed the same – no big difference.

- Plans to sell them out at 2y.o.
- Rmb2,900 – about 400jin.

Section 8

Assets

- Spent Rmb3,000 on timber for cattle pens (mainly the enclosure)
- Rmb1,700 for a second had tractor with no tray on it in. Bought in 2005, mainly for cultivation.
- Has another old one (1995) with a tray on it for transport – Rmb15,000
- Yangchangji – Rmb700
- Bozhingji – seeder – Rmb800. Second hand

Loans

- Had a loan of Rmb6,000 for tractor a long time ago (1995), but paid back now. Also sold an old tractor to make up the cash difference.

Subsidies

- Rmb15 per mu – thinks it might be the ag land protection program (same as 090720p hh)
- No other subsidies

Canola press Mozhugongka

Interviewers: CGB, SAW, Qunpei Dawa (TARI)

Interviewees: Canola press owner

Date: 3 July, 2010 (am)

This was an unplanned visit to a canola press that was located in the main street of Mozhugongka beside a noodle/tea house where we had breakfast before the day's fieldwork. It was located in a small room/office/stall (about 3m by 7m) among the many other offices and retail outlets along the main street. It consisted of two small canola presses (see photos) of which one was being used at the time. The room also contained bags of canola seeds against the back wall.

The press was run by the owner and what appeared to be his daughter. Although it could be a one person operation, it certainly appeared to be more convenient as a two person operation. The seeds were put into a funnel/hopper at the front of the machine which then entered the press and drum. The oil came out the bottom of the drum and then went through a filter before being funnelled into a bucket or container. The canola cake came out at the end of the machine. After the first pass through the cake was still quite moist and loose but this then went back into the funnel for a second round of pressing and the process was repeated a number of times. The residue from the filter was also returned to the hopper/funnel. After a series of pressings the canola cake/meal became solidified into the form that we are used to seeing.

Apart from processing for households (when we were there, a household arrived in a mini-van with three bags (perhaps around 45kg each of canola seed for processing) the owner also bought canola seed in his own right for processing and selling the oil and cake.

The owner gave some details about prices and fees. He said that canola seed was being sold at the moment for Rmb5/kg. Canola cake/meal was selling for Rmb1.6/kg. The service processing fee for households was Rmb0.5/kg (this was up from Rmb0.44/kg in the previous year because of a rise in electricity prices). He said that households would take the canola meal in winter when they needed it to feed their livestock but typically not in summer, and so he would sell the meal separately to the feed companies. The canola oil wholesale price was Rmb13/kg.

He also gave us the conversion rates for canola seed to oil. In good seasons, 2.2kg seed would give 1kg of oil. However in very dry seasons such as in the current season then it took 2.8kg of seed to produce 1kg of oil. Thus apart from other market factors, weather conditions would also seem to influence the price paid for the canola seed due to its influence on this conversion rate.

Later that afternoon we visited a household (see 100703p) in a village about 10km out of Mozhugongka. The household did not do his canola processing at this place but instead the village has its own collective press. This would seem to make sense as the press may not involve a great capital cost and the main element maybe the labour (and so may be suited to a village collective). We will need to check this in other villages. Thus for this canola press, it may service primarily households in and around the town or households in villages without a collective press.

Qumei Township

Interviewers: CGB, SAW, Drolma

Interviewees: J###, Township secretary

Date: 14 July, 2010 pm

Qumei Township belongs to Shigatse City. It has

- 18 villages
- 6,060 population
    - 3,825 labour age people
- 1,023 households
- Rmb3,871 – av net per capita income
    - But there is a very big income differentials amongst households
    - Also hard to average out incomes when there is such large discrepancies
    - 68 poverty households, or about 300 people not living to dibao standards – township gives to these households food, money etc.
- 41,140 mu arable land, 29,619 is actually planted, the rest is being fixed / reclaimed etc
    - Barley
    - Canola
    - Buckwheat – 5,500 mu – quite a lot relative to other areas
- GDP Rmb 49,310,000
    - Ag – biggest component
        - Is an agricultural area, so cropping bigger than livestock
    - Industry
    - Services
- Production of 8,468,000 jin edible oil
- 31,631 livestock at year end
    - Big animals – 5,616 head
    - The rest are small animals
- Grain output – 5,468,366 jin
    - Barley – 4,700,000 jin
    - Canola – 767,110 jin
    - Cash crops – 554,000 jin – potatoes and radishes etc.

Projects

- Ecological / tree planting. 20,000 plus mu coverage. Rmb30 million investment. Money comes from above, but the village looks after the trees. Rmb7 million spent on wages under project, and Rmb8 million on irrigation. 90% survival rate. Trees are painted (with house paint) to stop cattle and sheep eating them. The township itself has 1,000 mu of land planted to trees.
- Plus the TAAAS oats project.

Subsidies

- liangshi zhibu – grain – Rmb30 / mu
- liangzhong butie – improved varieties – Rmb10 / mu
- fertiliser – 50% of costs
- Nongji – ag mechanisation – 30%
- Nongyao – pesticides – 50%
- Grain for green – Rmb300/mu, every year for life of project. Extended from 8 to 15 years. However, must reach 50% tree survival rate. Subsidies paid directly to households (not through township or village). Trees come from the state, the household plants them.
- AI, disease etc. for livestock is free
- No subsidies for fodder, and not likely in future
- Disaster relief – not really – this is counted in poverty funds above.

No fees etc. for households to graze on mountains

The government grain purchases are done at hh door. Rmb1.1 / jin usually. However it has been dry for 3 years, so production is down so don't require households to sell grain to government.

Shigatse markets

Interviewers: CGB, SAW

Interviewees: Various stallholders

Date: 15 July, 2010 (am)

We asked around a lot about livestock markets in or around Shigatse. There was one somewhere but was said to only operate in the busy selling season (autumn and winter), where livestock are sold over long distances (e.g. to Lhasa). Either way, we couldn't find it. Instead, we went to a market area where stallholders were selling meat. Both stallholders said that because of the high price of meat now, only restaurants and rich households could afford to buy meat.

Yak meat stallholder

One rural household from an area 22kms from Shigatse was selling yak meat from one yak in 2 "stalls", which were actually just timber areas raised off the ground. The household pays Rmb10 per day for each of the stall spaces. The household sells his own yaks, which they slaughter, butcher and transport themselves. The household markets 2 to 5 head per year in this way. It was also said to be common in the village. The yaks are usually 8-9 y.o, but can be up to 14y.o. The meat sold for between Rmb22/jin for rump and Rmb17/jin for ribs.

Sheep meat stall

A large professional stallholder had at least 25 whole sheep carcass at his stall, some of which were fresh and some dried. The carcass of a 6y.o (??) sheep sold weighing 28-32 jin sells for about Rmb550. A 4 y.o weighing 15-20 jin (carcass weight) might sell for Rmb/350 per carcass. He sells in whole carcass form, half carcass, of will butcher if customers prefer.

He buys sheep directly from households around Shigatse – Jiangzi, Sazha or Bailang – based on an estimate of carcass weight, and on a price similar to meat prices. He then has them slaughtered by friends for about Rmb10/head plus beer. Then piles the carcasses on the back of the truck (he has his own truck) to take to market. Thinks he can make a profit of Rmb20-30 (must be from offal and hides) if volumes are up (so overheads and transport low per unit), but breaks even if volumes are low.

In summer / now he might sell 20 head per day, which is low season because it is too hot for households to store meat. In high season – autumn and into December – he said that he could sell 150-160 head per day. Household sell off sheep after harvest time (August to October). Prices are low then because the sheep are big / fat from grassland feeding (no penning/ feeding). So a sheep that he buys for Rmb200 at this time might cost Rmb300 in spring.

He buys a goat every now and then but people don't really like the strong smell of goat meat.

Butter stall

In the street (not the market) there were quite a lot of butter and oil sellers but, despite some searching, we couldn't find any that sold local product. One of them displayed very big chunks (many kilos) of butter. There were 3 different kinds (Colin has a photo). The lowest quality one was dark yellow from inland China (Rmb8/jin), there was another off-white one from Lhasa (Rmb14/jin) and another light yellow one from Lhasa (Rmb18).