Livestock Development and Rangeland Conservation Tools for Central Asia

Narrative Summary

Central Asia (CA) represents a large region in the center of the Eurasian continent that encompasses the territories of Turkmenistan, Uzbekistan, Kazakhstan, Tajikistan, and Kyrgyzstan. Rangelands occupy nearly 80% of the territory and provide the main source of forage for livestock. Sustainability of extensive production and human nutritional welfare were negatively impacted by socio-economic changes immediately following independence. Division of state and collective herds into smaller private units caused erosion of animal stocks that started in the early 1990s and is in contrast with the long-term increase of livestock population in the region. The decline in livestock numbers can be attributed to the deterioration of the terms of trade for producers. Lack of winter forages, collapse of marketing networks, and poor maintenance of livestock water wells have resulted in hand-harvesting of range plants for feed and fuel and concentration of livestock around populated areas and active wells. In spite of declining livestock numbers, rangeland degradation is accelerating near surface water and populated areas. Rangelands of CA may constitute a significant part of the “missing sink” that attenuates the increase in atmospheric carbon dioxide. Additionally, restoration of degraded lands may constitute a source of carbon credits for the region. Thus, this project addresses the immediate need to improve welfare of small landowners, to prevent further deterioration of rangelands, and to document their role as carbon sinks.

This research is divided into two modules (GIS/Basic Resources and Range Forage and Carbon Flux), and is supported by two components – Animal Production and Socio-Economics. We take an integrated multidisciplinary approach to improve the welfare of herders that involves not only on-farm solution of technical aspects, but also the assessment of alternatives and policy instruments to support them. Alternatives are evaluated from the point of view of sustainability, impacts on the global carbon budget, and economic profits. Models incorporating ecological and policy scenarios are used to explore the regional impacts of various technical alternatives.

The original plan for the 2001-2002 year included:

1. Complete and distribute A-Where GIS analysis programs for Uzbekistan and Turkmenistan.
2. Augment the GIS for Uzbekistan.
3. Continue the Bowen ratio-energy balance (BREB) measurements for the entire growing season using representative rangeland ecosystems in Kazakhstan, Turkmenistan, and Uzbekistan.
4. Continue the roving measurements of energy, water vapor, and CO_2 fluxes with eddy covariance (EC) technique using replicated wheat fields and abandoned croplands near Shortandy, Kazakhstan.

5. Obtain replicated measurements of instantaneous fluxes of water vapor and CO_2 with the chamber technique using four rangeland ecosystems near Shortandy, Kazakhstan.
6. Collect non-growing season (winter) CO_2 flux measurements.
7. Use remotely-sensed data to predict rates of carbon sequestration in Central Asian rangelands using regression and regression tree techniques.
8. Compare the BREB and EC techniques to measure energy, water vapor, and CO_2 fluxes over a pristine grassland steppe near Shortandy, Kazakhstan.
9. Complete three animal experiments including establishment of in vivo digestibility of *Alhagi pseudoalhagi* and diet selection in the Artemisia community.
10. Conduct range inventory on six sites in Uzbekistan and digitize a map of plant communities for Uzbekistan.
11. Collect plant samples for in vitro forage quality analyses.
12. Estimate how sheep and goat producers formed their price expectations and how such expectations have changed over time.
13. Estimate the determinants of slaughter of sheep and goats based on a given farm's stock at the beginning of year, births (which depends on flock composition as well as total numbers), and the animals lost or added as a result of transfers to/from another farm.

A summary of accomplishments for the 2001-02 year follows by research activity. Most of the planned activities were accomplished as reported below with slight departures from the original plans.

Research

GIS and Basic Resources Module

Problem Statements and Approaches. The GIS and Basic Resources module is designed to serve as the basis for regional application and modeling of research results. The main activities of this component are the creation of a GIS for KZ, TK, and UZ. Information is used for direct dissemination and as a basis for the other modules and components. During the fifth year of the project we proposed to augment the regional GIS, create and distribute a spatial tool for Uzbekistan and Turkmenistan, and begin regional estimates of C balance in rangelands (integration with CO_2 component).

Augmentation and refinement of the databases will emphasize meteorological and remote sensing data. Integration with other components was done to build, synthesize, and calibrate spatial models, to validate these models against ground truth data, and to use these models to test alternative scenarios and predict the outcome of management actions. Existing models will be extrapolated to Central Asian vegetation types and then integrated in the GIS over the spatial extent of the region to produce landscape-level estimates of total carbon flux.

Progress. Country Almanacs (Almanac Characterization Tool or ACT) were completed for Turkmenistan and Uzbekistan and begun for Kazakhstan. The ACT is an integrated spatial information system designed for agriculture and natural resource management. The ACT's analytical and visualization tools enable the rapid characterization of areas within the target geographic regions. Development of the Kazakhstan component of the ACT is being carried out by project participants in that country.

The ACTs for Turkmenistan and Uzbekistan were completed by the TAMUS Blackland Research and Extension Center during summer 2002. The ACT software was complemented by the construction of a foundation database for Kazakhstan in the fall of 2002 by the Central Asian Regional Environmental Center (CAREC) and currently includes climate, meteorological, infrastructure, and demographic, topographic, and political data. A workshop for representatives from agricultural government, research, and non-governmental agencies was held in late October 2002 in Almaty, Kazakhstan together with CAREC. There were 18 Kazakhstan participants, 4 from Turkmenistan and 12 from Uzbekistan with representation from the ministries of energy/oil, natural resources, and economics. Participants received a copy of the software, licenses for the software and the ACT manual (Russian translation) upon completion of the workshop. The workshop also received attention in the local press and media. Evaluations from the participants were very positive. They felt it was easy to grasp the concepts and master the program during the training. The graphing and data tables were found to be very useful and all the participants said they would recommend the program to their colleagues. Since the workshop, CAREC has distributed the software to the ministries of ecology from the five Central Asian states.

The Uzbekistan GIS data set has continued to develop with extensive work on the creation of vegetation and soil maps. The vegetation map is nearing completion. Continued training of our Uzbek counterparts contributed to this effort. Training was targeted at instruction in IDRISI software and its potential use in GIS work, modeling in GIS, and methods of using satellite images in GIS.

Range Forage and Carbon Flux Module

Problem Statements and Approaches. The main objectives of the Range Forage and Carbon Flux module are to: 1) quantify annual net primary production (ANPP) on representative Central Asian rangelands and 2) assess the role of Central Asian rangelands in the global carbon budget. Accurate estimates of ANPP from these rangelands will provide important information on carrying capacity to sustain livestock production in the region and are important for evaluating whether Central Asian rangelands are net sources or sinks for atmospheric CO_2. Our studies in Central Asia will provide data necessary to quantitatively assess the role of Central Asian rangelands in the global carbon budget.

The Central Asian Region is dominated by vast rangelands, and we hypothesize that these extensive rangelands may constitute a significant portion of the “missing sink” that attenuates the increase in global atmospheric CO_2. The capacity of rangelands to sequester atmospheric CO_2 could be increased with better rangeland management practices, thereby improving the welfare of small landowners and, if acceptable treaties and protocols can be developed, possibly providing opportunities for trading “carbon credits.” Daily and seasonal carbon balances of rangeland ecosystems are measured with a Bowen ratio-energy balance (BREB) technique that calculates net CO_2 exchange between a terrestrial surface (including soil and vegetation) and the atmosphere. The net CO_2 exchange between rangeland ecosystems and the atmosphere was monitored continuously during the growing season in the following study sites in Central Asia (described in AR 00-01).

• Shortandy site – This represents the 'typical steppe,' which consists of the vast area of the true steppe spreading from the lowlands of the northern Black Sea through the southern parts of the Russian Plains to the steppes of northern Kazakhstan. This site is located in the field experimental station of the Barayev Kazakh Research Institute of Grain Farming, near the town of Shortandy, about 60 km NNE of Astana, Kazakhstan (51°40' N, 71°00'E, 367 m a.s.l.).

• Karnap site – This represents the 'sagebrush-ephemeroidal' arid rangelands of the foothills of Central Asia. This site is located in the territory of the agricultural enterprise "Razzok Jahangirov," 150 km NWW from Samarkand, Uzbekistan (40°N, 65°30'E, 310 m a.s.l.).

• Karrykul site – This represents the 'shrub sandy desert,' which includes the majority of the rangelands of Turkmenistan (26 million ha). This site is located in the southern part of the Central Karakum Desert, 80 km to the north of Ashkhabad, Turkmenistan (38°36'N, 58°24'E, 90 m a.s.l.). The site is part of the Karrykul Research Station of the National Institute of Deserts, Flora and Fauna of the Ministry of Nature of Turkmenistan.

Fluxes of energy, water vapor, and CO_2 may differ within rangeland ecosystems and among types of land. To assess the spatial variability of fluxes across a landscape, two roving EC systems were used for continuous measurement of fluxes in four blocks (or replicates) that included two rangeland ecosystems: wheat crop and abandoned cropland. Additionally, water vapor and CO_2 fluxes were measured instantaneously with the chamber method (i.e., canopy or soil chamber interfaced with portable gas exchange system) using 1-m^2 plots that represented various rangeland ecosystems.

Progress. The BREB measurements were continued for the entire growing season at three rangeland sites: 1) abandoned cropland at Shortandy, Kazakhstan; 2) sagebrush-ephemeroid semidesert at Karnap, Uzbekistan; and 3) shrub sandy desert at Karrykul, Turkmenistan. Data at 20-minute intervals have been received at Utah State University where data processing and quality assurance will be performed.

Two state-of-the-art EC systems were used to obtain roving measurements of energy, water vapor, and CO_2 fluxes in two rangeland ecosystems near Shortandy: 1) wheat crop, and 2) abandoned cropland. These ecosystems were replicated in four blocks to assess the spatial variability of CO_2 fluxes in similar ecosystems and among different ecosystems. Additionally, the roving EC measurements were compared to the measurements obtained from a stationary BREB system that served as a reference point for the four abandoned croplands used in the 2002 growing season. Measurements at each block lasted for about 3-5 days, and were obtained from May-September 2002. The study sites were located within the research experiment station of the Barayev Kazakh Research Institute for Grain Farming near the town of Shortandy in northern Kazakhstan. Data processing and analyses are ongoing for the roving EC measurements obtained during the 2001 growing season. Preliminary results indicate that the pattern of CO_2 sequestration differed among vegetation types over the course of the season, indicating phenological variations between vegetation types:

• Abandoned land (AL) had higher photosynthetic capacity during the moist early season.

• Given similar environmental conditions, AL was able to fix more C than wheat fields in the early season.

- Later in the season, all vegetation types [AL, saline virgin land, and crested wheatgrass (*Agropyron* spp.) hayland] had similar CO_2 uptake.

The 1-m^3 canopy chamber and soil respiration chamber were used for instantaneous measurements of water vapor and CO_2 during the 2002 growing season. The chamber was interfaced with a portable gas exchange system and flux measurements were obtained from four rangeland ecosystems: saline virgin land, crested wheatgrass (*Agropyron* spp.) hayland, wheat crop, and abandoned cropland. These ecosystems were replicated into four blocks, where 1-m^2 plots were randomly identified at the beginning of the growing season and used for chamber measurements at various dates and times of the day from May to September 2002. Data from the chamber measurements are currently being processed and analyzed.

Non-growing season CO_2 flux measurements were obtained from late fall 2001 to late winter 2002 using EC technique at Shortandy, and BREB technique at Karnap and Karrykul to allow estimation of annual carbon balance at each study site. Preliminary results indicate the magnitudes of winter CO_2 efflux in Central Asian rangelands were similar with those observed in the rangelands in the USDA-ARS Rangeland CO_2 Flux Network. Non-growing season measurements are ongoing for the 2002-03 winter period.

Remotely-sensed data were used to predict rates of carbon sequestration in Central Asian rangelands using regression and regression tree techniques. The BREB measurements representing 1998-2000 growing seasons were analyzed with the light curve equations to quantify 10-day CO_2 fluxes associated with gross primary production (GPP) and total respiration (R). Remotely-sensed temporally smoothed NDVI (NDVIsm) and environmental variables were used to develop multiple regression models for the mapping of the Kazakh steppe 10-day rangeland CO_2 fluxes. Ten-day GPP was estimated ($R^2 = 0.72$) by day of year (DoY) and NDVIsm and 10-day R was estimated ($R^2 = 0.48$) with the estimated GPP (estGPP) and estimated 10-day photosynthetically active radiation (PAR). Regression tree analysis estimated 10-day PAR from latitude (lat), NDVIsm, DoY, and precipitation ($R^2 = 0.81$). Five-fold cross validation indicated these algorithms were reasonably robust. GPP, R, and resultant net ecosystem exchange (NEE) were mapped for the Kazakh steppe every 10 days and summed to produce regional growing season estimates of GPP, R, and NEE. Ten-day NEE estimates agreed well with BREB observations in 2000, showing a slight under estimation in the late summer. We estimate an average NEE equivalent to 1.27 tC ha^{-1} for the growing season (May to October 2000) in rangelands of the Kazakh steppe. Non-growing (winter) season CO_2 fluxes collected in the 2001-02 winter are being analyzed to close the annual carbon budget for the Kazakh steppe.

In 2001, we compared the BREB and EC techniques to measure energy, water vapor, and CO_2 fluxes over a pristine grassland steppe near Shortandy, Kazakhstan. We found good agreement between the two techniques with measurements of energy and water vapor fluxes. The EC flux data are undergoing further analyses to resolve or explain the differences observed with the CO_2 fluxes measured between the two techniques. In 2002, we continued the BREB versus EC technique comparisons using an abandoned cropland. Additionally, we included the chamber method as a third technique to compare CO_2 flux measurements. Data processing and analyses are ongoing for these three-method comparisons.

Animal Production Component

Problem Statements and Approaches. The Animal Production Module pursues two major objectives: (1) determine the production potential of the semi-arid and arid regions of Uzbekistan and Turkmenistan for sheep production, thereby facilitating the design of appropriate development programs for the livestock sector; (2) create modern planning capabilities in the host countries by establishing laboratories, provide training to host country scientists, and develop computer-based maps of production and development potential. Activities comprise research on diet composition of sheep, determination of nutritional quality of range and its dynamics throughout the forage year, parameterization of a mathematical model of sheep production for the determination of potential production levels as determined by the ecological characteristics of the natural pastures, and development of computerized maps to facilitate decision making in livestock development and range conservation.

Our project will produce data essential for an improved match between animal genotype and environmental resources in Central Asia. This is the basis for long-term sustainable production. The methods that will be developed in our project are highly relevant for extensive sheep production systems in the United States. The host countries will benefit by acquiring appropriate planning and analysis tools that will help them address the grave environmental problems of livestock production on Central Asian rangelands.

Progress.

Animal Experiments. Determination of diet selection of small ruminants on natural rangelands in Uzbekistan continued throughout the year. Six animal experiments were completed including establishment of in vivo digestibility of *Alhagi pseudoalhagi* (Camelthorn, the most important winter feed resource in Uzbekistan) and diet selection in the Artemisia community. We further completed an in vivo digestibility experiment with *Cousinia sp*., another important reserve forage harvested for winter feeding. These are the first reported in vivo digestibility experiments on these key reserve forages. In addition to diet selection experiments using the alkane marker method, we conducted two experiments to develop a new method for calculating a correction factor for the determination of alkane recovery in sheep and goats.

Range Condition Monitoring. Monitoring activities continued throughout the 2001-02 year and two years of range monitoring data have now been collected. A range inventory was conducted on six sites at least once per season in Uzbekistan; and a map of plant communities for Uzbekistan was digitized.

More than 400 plant samples were collected for determination of in vitro forage quality from Uzbekistan. Lab analyses on forage samples from Kazakhstan were completed as well. Animal and plant samples for alkane analysis are being processed currently in a collaborating laboratory in Israel because they could not be imported into the United States. Data analysis for one site is completed and the results were published.

GIS Modeling. A GIS layer for vegetation communities for Uzbekistan was completed. Work on layers for soil and pasture types/range sites is currently in progress.

Animal Production Models. Work on the re-programming of the SR-CRSP sheep, goat, and beef production systems models began in November of 2000. Work is performed in collaboration with Lahey Computers Systems, Inc. (LCS). Initial forage data and management data sets were compiled to parameterize and calibrate a bio-economic simulation model for sheep production systems.

Evaluation and rectification of all code problems for the Sheep and Goat Models was set as the first priority because of the need to simulate small ruminant production systems. Regretfully, several types of errors were detected in the existing software implementations of the TAMU models, including errors readily detected by a programmer who is porting the code, typically faulty logic, compiler diagnosed errors, run-time detected errors. This corroborates the initial hypothesis that significant errors in the code persisted, even after many years of use of the models, and they must be addressed first before embarking on simulation studies intended to support development policy. Work on the computer code of the TAMU models is an extremely complex task because of the almost complete lack of documentation available for the software. Further, there were in each program several authors involved in the programming, each with a different style and consistency.

The tasks as defined by the attached work plan lead to two versions of each flock/herd level program:

- Static: fixed flock/herd size, animal record database structure implemented as a doubly linked list;
- Dynamic: variable flock/herd size, animal record database structure implemented by pointers.

Both the sheep/goat and cattle models were completed, and a limited set of test cases was constructed for each. Results appeared coherent. However, the conversion of *Static Sheep* to *Dynamic Sheep* uncovered additional code problems in *Static Sheep,* which had been addressed in late fall of 2002. Work on the construction of suitable test cases is progressing. We expect that the team of the socio-economic component will contribute at least one data set from Kazakhstan. The dataset from Uzbekistan is finished and will be run in October.

The project required significantly more time than originally anticipated. While some errors were known to the PI, many additional program code errors were only discovered after the application of professional code analysis tools.

The Animal Production module was faced with several obstacles this year. Experiments on the dietary overlap between domestic and wild herbivores could not be conducted because an arrangement with a local institution was not successfully executed (collaborating institution defaulting on work commitments). A substitute site in the Kyzlqum desert, a very important livestock region, was identified and an agreement with a collective farm for support of live animal experimental work was made. Work on this site started in the fall of 2002. Plant samples could not be analyzed in Davis as planned because specimens were rejected by USDA-APHIS because of the presence of spores of an unknown fungus in the samples. An essential piece of equipment for the preparation of plant samples was delayed in customs for three months. Information about the difficulties was not obtained until August. This problem delayed plant analysis work by at least 6 months. However, plant samples from the first 1.5 years of field work are now in analysis in the laboratory at UC Davis. Animal samples could not be imported into the US after the onset of the Foot and Mouth epidemic in Europe. An agreement with a lab in Israel had to be made, delaying this part of the project by at least 6-8 months. Because of the difficulties importing animal samples into the US, two diet selection experiments planned for Bukhara and Karnap were cancelled.

Training. The AP module carried out significant efforts to train Central Asian partners this year. The Central Asian PI was trained in laboratory methods critical to the digestibility experiments. In addition, several Uzbek students were trained on range ecology field methods, data entry and preliminary analysis methods, plant and animal sample preparation for laboratory assays, and detailed forage biomass measurements in the lab.

Socio-Economic Component

Problem Statements and Approaches. The Socio-Economic component is analyzing the causes and dynamics of structural changes in the Kazakhstan livestock industry. We are constructing a bio-economic simulation model of the livestock sector in Kazakhstan to explain the dramatic decline in livestock numbers and livestock production during the 1990s. The model will be used to predict the future performance of the industry under current and alternative policies. The model, and lessons learned from it, will be extrapolated to other countries in the region having a similar livestock sector.

We reviewed reports and papers regarding agriculture in Kazakhstan and other transition economies, conducted interviews with local producers, and local and international scientists, and analyzed available statistics. We conducted statistical analyses to test economic hypotheses, but the validity of the results were limited due to the limited number of data observations and the poor quantity of economic data available.

Nonetheless, we have been successful in identifying the principal factors that have caused the sharp decline in livestock production during the first decade of economic transition. The liberalization of input and output prices and the decline in the aggregate demand for livestock products produced by Kazakhstan, resulted in a sharp decline in the terms of trade for agricultural producers in Kazakhstan. Output prices fell because international demand declined (mainly by former socialist block economies) and domestic demand also fell as national income declined. Output prices had also been subsidized during the Soviet period and these subsidies were reduced. Similarly, input prices rose sharply because these had also been subsidized and the subsidies ended. In response, livestock producers reduced production and changed their production technology (inputs) to conform to the new relative price structure faced. A huge number of livestock were liquidated. Soviet-type feed-intensive production became costly, and producers switched to a low-cost, extensive production technology that depends mostly on natural pastures and uses purchased inputs as little as possible.

During the transition process, we believe that producers overshot in liquidating livestock assets, i.e., more livestock were liquidated than was optimal in the longer run. This overshooting occurred because 1) many livestock assets were distributed from the preexisting large farms/collectives to individual producers holding small plots as a result of privatization of the large farm units in a disorganized manner, and 2) producers incorrectly set their price expectations too low.

The transition period manifested simultaneous changes in a large number of factors. Such changes created confusion and uncertainty and created a complex situation in which the simultaneous changes reinforced and offset each other, making it difficult to clearly identify cause and effect. However, the basic changes are clear. The terms of trade declined sharply. Large-scale farms (former state and collective farms) dramatically reduced livestock production, slaughtering some animals and transferring other animals to households who produced animals mainly on a subsistence basis. These smallholders now hold most livestock in Kazakhstan. Large-scale commercial producers are no longer responsible for an important share of production.

Transition is an ongoing process. Domestic consumption demand for livestock products will recover as the overall economy develops and incomes rise. Whether increased demand will be met by domestic production or imports is yet unclear. Unless Kazakhstan gains competitiveness, imports, which have increased dramatically in recent years, may become dominant. At the same time, producers and other participants in the industry are also in transition: they are learning and adapting their decisions to the new and rapidly changing environment in which they operate.

Following the findings of the first phase of the research, we now focus on the behavior of livestock producers, given that they have largely shifted from an input-intensive production technology to an alternative extensive technology. In this research phase we will seek to understand why productivity on smallholder enterprises is still so low; to identify the constraints faced by smallholders; and to determine what will happen if such constraints are removed.

To explore these questions, we are developing a bio-economic computer simulation model designed for extensive sheep production in Kazakhstan. The model contains three components: forage production, animal biology, and producer decision-making. (See below for more details about the model.) The model will be useful to better understand how producers who are dependent on natural pastures make decisions in a situation where forage production fluctuates seasonally and annually, but where supplementary feeding is constrained by profitability (output and input prices), marketing opportunities, and availability of financing. The model will also be used to evaluate alternative policy measures that would help the industry restructure efficiently towards a sustainable extensive production system.

Progress. Our progress of 2001-2002 includes: 1) estimation of how sheep and goat producers formed their price expectations; 2) estimation of the levels of privatization transfers from the collectives to individuals; 3) estimation of the source of slaughter; and 4) programming of the sheep simulation model.

1) Price expectation estimation

We hypothesized that producers' price expectations could have played an important role in shaping the transition path in the sheep and goat sector. We also hypothesized that producers' expectations should have changed over time as producers gained more experience and as the economy stabilized. We anticipated that more accurate information would be readily available to producers and that producers would be able to interpret such information better.

In order to test these hypotheses, we used available data and the analytical framework developed by Chavas (2000) to estimate how sheep and goat producers formed their price expectations and how such expectations had changed over time. We assumed that producers formed their expectations using one of three approaches:

- Rational expectations (RE) where the expected prices, conditional upon currently available information and economic theory, equal the future prices.
- Quasi-rational expectations (QR) where future prices are predicted based on past price behavior.

• Naive expectations (NV) where future prices are predicted based only on the current price.

We used the Generalized Maximum Entropy (GME) method due to a lack of observations (11 years). The estimates only reflect the expectations by large farms (former state and collective farms). Estimation of producers' expectation processes for other farm types was not possible due to lack of cost information.

The results were surprising. We expected that most producers would move from using naive expectations toward a more sophisticated expectation formation process, but found instead that the number of producers using a naive expectation process increased at first and then decreased in recent years. (See Figure 1.) We note that Chavas (2000) estimated that even in the U.S. many livestock producers utilized a naive expectations process. His estimates for the U.S. beef cattle sector were 47% naive, 35% quasi-rational, and 18% rational expectation.

2) Privatization transfer estimation

Livestock was the major farm asset that was distributed at the time The results are presented in Figure 2, jointly with our estimates of the number of sheep and goats slaughtered on large farms during the transition process.

• For 1990-1993, the number of animals transferred was rather constant at a moderate level. Private farming was first allowed in 1990. The early peasant farms were provided with subsidies and other privileges.

• Large-scale privatization of agricultural enterprises started in 1994 and the number of sheep and goats transferred to small private farms jumped. Subsidies for new peasant farms were terminated.

• By 2000, the transfer of animals had almost ended since there were few animals remaining on the former state and collective farms. The process of privatization was nearly complete.

We estimate that large farms liquidated their flocks mainly by slaughtering their animals (66% of flock reduction), with transferring animals to small farms responsible for the rest (34% of flock reduction) between 1990 and 2000.

3) Slaughter estimation

Using aggregate statistics, we estimated a regression to determine the slaughter of sheep and goats based on a given farm's stock at the beginning of year, births (which depends on flock composition as well as total numbers),

Figure 1 - Price Expectation Estimation

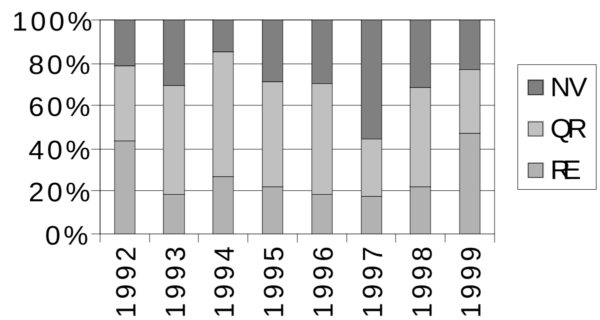


Figure 2 - Slaughter on and Transfer from Large Farms (million head)

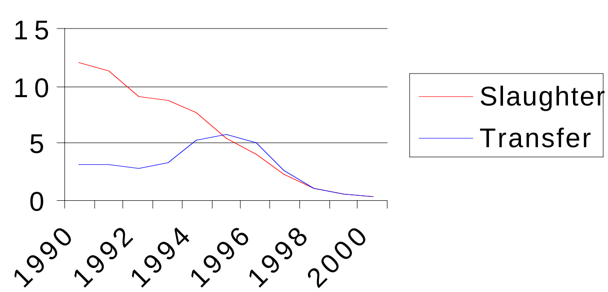


Table 1 - Estimated Slaughter Rate out of Initial Stock, Births, and Transfers

	Initial Stock	Births	Transfers
AE	31%	27%	-34%
KX+LPX	36%	31%	88%

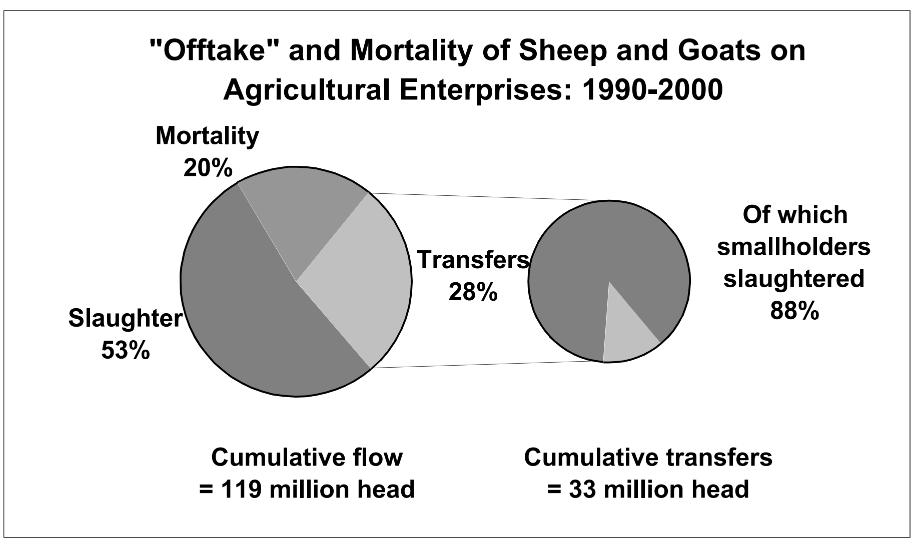
and the animals lost or added as a result of transfers to/from another farm. The results (Table 1) indicate, for example, that an agricultural enterprise (AE) slaughtered, on average, about 31% of its beginning flock during the year. More importantly, while agricultural enterprises reduced slaughter by about 34% of the animals transferred to small farms (KX+LPX = peasant farms and subsistence households combined), small farms slaughtered nearly 90% of the animals that were transferred to them. Since a large number of animals were transferred, the high slaughter rate out of transfers greatly contributed to the overall flock reduction. Indeed, cumulatively for 1990-2000, 41% of the slaughter on small farms, or 29 million head, were sheep and goats transferred from AE.

4) Sheep simulation model

Extensive livestock production systems, such as the one in Kazakhstan, face fluctuations in the natural (as well as socio-economic) environment and this can cause major impacts on production. Accordingly, we have incorporated the stochastic nature of forage production into our simulation model. The structure of the bio-economic simulation model for extensive sheep production in Kazakhstan is depicted in the figure below.

(1) Random natural climate (mainly rainfall) determines (2) the forage production

Figure 3 - Slaughter and Privatization Transfers: Agricultural Enterprises



1990 stock = 31 million; 2000 stock = 948 thousand at the village level. Based on (3) socio-economic environment (input and output prices, and institutions), producers make decisions (4) about how many animals to keep or sell and how much supplementary feed to use. Individuals' decisions will determine (5) the stocking rate and thus the forage availability per head at the village level. This will determine (6) the animal productivity, together with other decisions made at the farm level. A producer makes decisions each year based on his expectations about the natural and economic environment and the livestock that he has at the beginning of each year. This in turn depends on what he did in previous years.

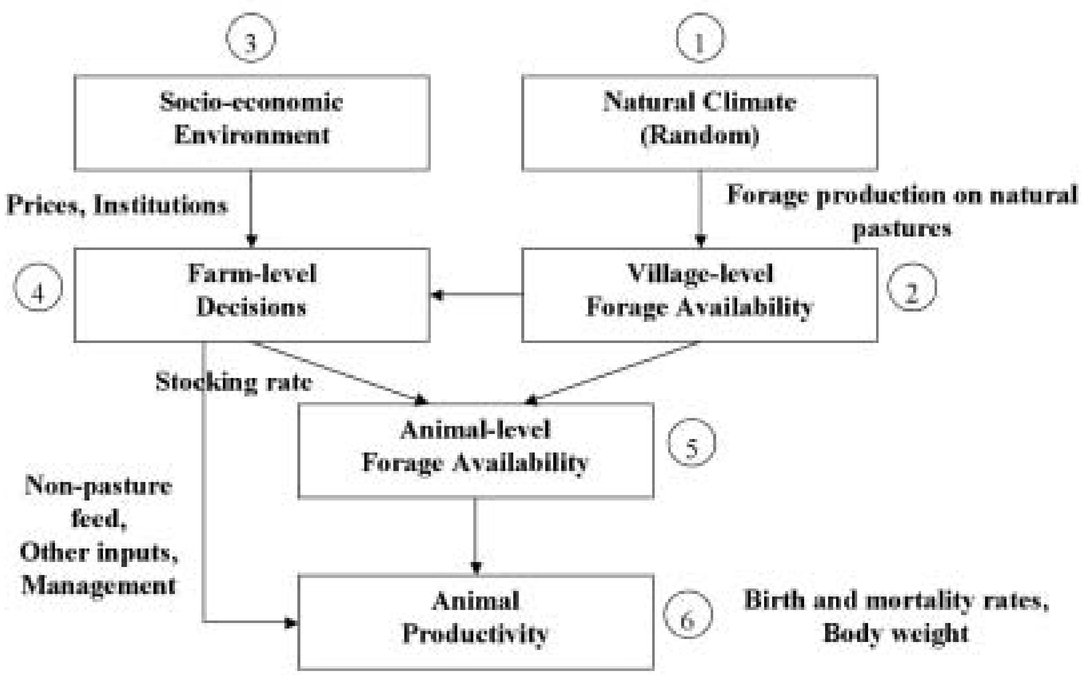
Since decision parameters such as price elasticity of supply of producers are not available, the producer's decisions are determined by optimization. (Therefore, the model is not a pure simulation model.) The producer is assumed to maximize the expected net present value of the enterprise. Solution procedures are comprised of two steps. The first step involves stochastic dynamic programming. We use polynomial approximation of future value function, a technology developed in Howitt et al. (2002). The second step is simulation using the value function obtained in the first step. Currently the model has four state variables, which will be extended to a five state model.

References:

Chavas, J.P. (2000). "On Information and Market Dynamics: The Case of the U.S. Beef Market," Journal of Economic Dynamics and Control 24: 833-853.

Howitt, R., S. Msangi, A. Reynaud, and

Figure 4 - Structure of Bio-economic Simulation Model



K. Knapp (2002). "Using Polynomial Approximations to Solve Stochastic Dynamic Programming Problems: or A "Betty Crocker" Approach to SDP," Selected paper presented at the 2002 American Agricultural Economics Association Annual Meeting in Long Beach, California, July 28-31, 2002.

Key findings of the analysis:

(1) The privatization of state and collective farms and the creation of small-scale individual units did not guarantee immediate improvement in the overall efficiency of livestock production.

(2) The transition process of the livestock sector was distinct from that of the crop sector. Under rapidly declining terms of trade and extreme uncertainty, producers could liquidate livestock capital quickly. It is likely that liquidation overshot the desirable level in Kazakhstan. Since the recovery of the livestock population is biologically constrained to occur slowly, the excess liquidation may involve significant welfare loss.

(3) The decline in Kazakhstan's sheep and goat flock is mainly related to the decline in the livestock sector's terms of trade and to the temporary costs of shifting much of the livestock asset to small farms where many owners are still learning to be effective individual producers and entrepreneurs.

The SE module was also set back due to increased time needed to gather data from Kazakhstan. The GIS module also changed the area in which it collected data. While a necessary decision, that change made it more difficult to develop cartographic models of livestock grazing impact on vegetation and net primary productivity which are inputs to the simulation model being constructed by the SE module.

Dissemination of Results

Host country scientists were briefed and consulted on the progress and plans of the project. Host country scientists also presented results of the LDRCT projects at national meetings in their respective countries.

Several articles were published in the GLCRSP publication "Ruminations." One MS thesis and three articles were produced in this reporting period and project participants attended several conferences where they presented posters. These publications are available through regular library services and through the Internet.

The Kazak version of a handbook for small producers in Kazakhstan was completed under the direction of Dr. N. Malamkov and in collaboration with ILRI. Several hundred copies of the book were distributed freely to small producers.

The ACT A-Where software was distributed to representatives from government, research and non-governmental agencies in Kazakhstan, Turkmenistan and Uzbekistan. The ACT workshops were reported on in the local press and media.

Gender

Data from this project will provide information that will benefit both the male and female portions of the general population in the region. Results from the project will hopefully encourage women in host countries to become involved in further research that will enhance rangeland primary productivity, develop the livestock sector, and affect regional policies.

This project has continued to support women at all levels: as direct beneficiaries of the research results, as employees to support regional activities (Sidelnikova, Dolgikh, Mamedova, Raushan, Kernshakaya), as collaborating scientists (Karibayeva, Shabanova, Soyunova, Lebed, Gaziantz, Young), as graduate students (Olmstead, Kobayashi, Toderich), and as student assistants (Darmina, Maze).

Policy

Important linkages developed in the past and reported last year continued to operate.

One of the aspects of our research that has attracted the most interest from policy-makers has been the study of Central Asian rangelands as potential carbon sinks. We envision that the database collected from the CO_2 flux monitoring sites in Central Asia will serve as the foundation for the development of a technological package to identify, evaluate, and monitor "carbon credits". Regional scientists, international collaborators, and policy-makers are just beginning to seriously consider agricultural ecosystems as potential sites for mitigation of climate change. We informed regional scientists and policy-makers about these possibilities, and have obtained significant leveraged funding to create a regional network for carbon flux measurement and modeling.

In addition to the regional policy aspects, our project, with strong support from the ME, developed an integration between the US and Central Asian networks of carbon flux measurements in rangelands. This unprecedented effort successfully connected several universities of the US, USAID-GLCRSP, USDA-ARS, USGS-EDC, and the Central Asian network established a few years ago. This network will share data to produce robust methods to estimate carbon flux in rangelands based on remote sensing. We expect the overall results to have a major impact on the regional, national, and international policies related to carbon sequestration and rangelands.

Outreach

Outreach was directed at producers, regional students, and research institutions of the region. In continuation of the program partially funded by IFAD-ICARDA and the GL-CRSP, students from the Kazak Agrarian University visited producers every 2 months to discuss production issues and to gather information. These students are in the process of writing their final reports for their degree. Producers were also benefited by the distribution of several hundred copies of a sheep farmer's manual prepared with funding leveraged from ILRI. Numerous young scientists and doctoral candidates associated with the Baraev Institute of Grain Farming, the Sheep Breeding Institute of Kazakstan, the Karakul Sheep Institute of Uzbekistan, the Uzbek Academy of Sciences in Samarkand, and the institute of Deserts Flora and Fauna of Turkmenistan were supported and given research opportunities through the LDRCT project.

A research collaboration between LDRCT and the World Bank-Global Environmental Facility (WB-GEF) has been established in a demonstration project to assess and quantify the rates of carbon sequestration in various ecosystems such as good-condition rangelands, degraded rangelands, abandoned croplands, and rehabilitated rangelands. The proposed target site for this demonstration project is the Shetsky Raion in Kazakhstan. Thus, the data collected from the CO_2 module of the LDRCT project will provide key baseline information that will be helpful in establishing the research and rehabilitation activities of the WB-GEF project, which will be implemented in 2002. The PI of the LDRCT continued to provide technical support to the preparation of the DMP. E. Laca traveled to Astana and spent a week writing a paper on potential impacts of the DMP and preparing a plan for monitoring of the DMP. The DMP has been funded.

Developmental Impact

The GIS tool and information distributed will support and facilitate decision-making and development policies. The integrated activities in the carbon-flux module will contribute significantly to the assessment of rangelands as globally important carbon reservoirs and active sequestration agents. Once this takes place, there will be a strong motivation for all projects that link development and positive global impacts to focus in more arid areas instead of northern and tropical forests.

The animal production project will contribute to the long-term sustainable production of livestock in Central Asia. The project is producing data essential for an improved match between animal genotype and environmental resources in Central Asia. The planning and analysis tools that will be developed will assist policy makers in Central Asia to address the grave environmental problems of livestock production on Central Asian rangelands.

Linkages and Networking

With strong leadership from the Management Entity of the GL-CRSP, LDRCT organized a key linkage between the US rangeland carbon flux network and the Central Asian network. The GL-CRSP provided additional funds that were “matched” by USDA to establish a highly synergistic integration. The US network is benefiting from this integration by receiving the techniques to produce maps of predicted annual C sequestration developed by LDRCT. LDRCT benefits by the access to a much larger and general database with which to develop more robust coefficients for use in spatial extrapolations in central Asia.

Leveraged Funds and Linked Projects

We estimate that we obtained $150K in matching (mostly in-kind) and $300K of leveraged funds in cash. These funds include the cash matching from USGS-EDC and the cash from the ARS-USDA for the integration of the US and Central Asian networks.

Funding from IFAD continued to support the farm monitoring and alternative forage activities of the LDRCT and from ILRI to produce the Kazak language version of the farm manual that was released this year.

The national proposal of Uzbekistan for a Reference Laboratory for Forage was submitted to IAEA in Vienna for funding in December of 2001; the proposal passed technical review and is currently under administrative review. This project was developed by the Animal Production PI in cooperation with Uzbek partners. A final decision was promised for mid November 2002; however, official notice has not been received.

Training

Degree Training:

Karen Olmstead, MS, 2003, Biology and Agricultural Engineering, A Simple Model of Rangeland Productivity in Southern Idaho Using Landsat Images, University of California, Davis. (50% for 3 months)

Mimako Kobayashi, PhD, 2003, Agricultural Resource Economics, Livestock Production in a Transition Economy: The Case of Kazakhstan, University of California, Davis.

Ten Kazak students were supported while working towards a BS degree in agricultural sciences.

Short Term Training:

Alexander Nikolaenko, from the Institute of Ecology and Sustainable Development, Almaty, Kazakhstan. Winter 2002 at the EROS Data Center in South Dakota. Training in Image Processing of SPOT VEGETATION temporal NDVI (1998-2001) with a temporal smoother. ACT-WHERE training at UC Davis.

Dr. B Mardonov, Samarkand Branch of the Uzbek Academy of Sciences (UZ), spent several weeks in the United States in the spring of 2002. He was trained in laboratory methods at the University of California, Davis.

Five Uzbek students were trained by the project in 2001-2002 on range ecology field methods, data entry and preliminary analysis methods, plant and animal sample preparation for laboratory assays, and detailed forage biomass measurements in the lab.

Dr. K. Akshalov, Baraev Inst. of Grain Farming (KZ), and Jorge Perez (PhD candidate, UCD) were trained in the installation of and troubleshooting for the eddy covariance (EC) CO_2 flux measurement systems as well as data collection and processing during Spring 2002.

Drs. T. Mukimov and S. Yusupov of the Institute of Karakul Sheep Breeding and Desert Ecology were trained in data processing, reduction, and quality assurance during Summer 2002.

Two workshops and one scientific meeting were held during the 2001-02 year:

Collaborators from three Central Asian republics participated in a meeting and workshop dealing with GIS and their use in rangeland research. For the period of 5/21-5/26 2002, Alexandr Nikolayenko traveled to Uzbekistan and provided on-site training in GIS (10 persons). Specifically, he trained the participants in the main methods of using and possibilities of the IDRISI software in GIS work, introduction of the possibilities of modeling in GIS, and methods of using the satellite images in GIS.

The meeting of the CO2 network was held May 24 during the training to present and discuss the results of the CO2 flux measurements obtained during the last three years, 1998-2000. Presentations included "The modeling of assimilation CO2 by vegetation of pastures of Kazakhstan on the base of NDVI information" (A. Nikolaenko), "The main directions of dynamic of vegetation of Artemisia-Ephemeroids semidesert in the conditions of grazing by small ruminants" (B. Mardonov), "Perspectives of research of CO2 flax measurements" (M. Nasyrov), and "The main reasons of desertification of arid landscapes and problems of aeol (by wind) salinization of soils," A. Lapas. The workshop was attended by representatives from the Academy of Sciences, Samarkand State University and regional non-governmental organizations.

The ACT-Where workshop, conducted together with CAREC, took place in October 02 in Almaty, Kazakhstan with 33 representatives from Kazakhstan (19), Uzbekistan (10), and Turkmenistan (4). Participants each left with the software and a manual translated into Russian.

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