

Early Warning System for Monitoring Livestock Nutrition and Health for Food Security of Humans in East Africa

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Narrative Summary

An innovative livestock evaluation tool designed to enhance early warning systems is being developed for East Africa. It will provide the capability of detecting changes in the well-being of free-ranging livestock six to eight weeks before they are currently being detected by the pastoralist or livestock advisor. This tool, or sub-system with respect to the Greater Horn of Africa Famine Early Warning System, involves the integration of near infra-red spectroscopy (NIRS) fecal profiling technology with advanced grazingland and crop models. Texas A&M Agricultural Experiment Station (TAES) scientists developed this technique and, to date, it is being deployed in the USA for the prediction of dietary protein/energy status of cattle, sheep and goats on grazinglands.

The foundational technology is comprised of the African 5 km² gridded Geographical Information System (GIS) dataset used by the Spatial Characterization Tool (SCT) which provides spatial analysis of weather, soils, terrain conditions and human and livestock populations. A network of effective environments has been established in Eritrea, Ethiopia, Uganda, Kenya and Tanzania. Sampling locations (zones) and household units have been selected within effective environments to establish a route system for collecting fecal samples and critical herd/household information. Through a consortium of scientists in Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) and the International Livestock Research Institute (ILRI), university professors, NGO staff and local pastoral organizations, six validation sites were established in four of the five countries to ascertain predictive capacity of the fecal NIRS profiles for determining animal performance and model validation forage and crop production. The NUTBAL nutritional decision support tool along with simulation-modeled forage and crop production from the PHYGROW, APEX and EPIC spatially explicit modeling systems will offer a mechanism to project likely responses of animals and forage balance with 6-8 weeks advanced notice of the current warning systems. The spatially explicit analyses will be tempered by probability analyses using an updated ENSO index for East Africa. A NIRS laboratory has been established at ILRI - Debre Zeit, Ethiopia.

A pastoral coping mechanism survey is currently underway with expected completion date of November 30, 1998. The survey is for the purpose of collecting livestock population inventories and household coping mechanisms, for the environmentally stressed periods of the 1995-97 drought and 1997-98 floods. Seven hundred (100 per site) household surveys were stratified by pastoral ecoclimatic zones, climatic clusters within zones and cattle density within climatic clusters in the arid, semi-arid and savanna zones of Ethiopia, Kenya, Tanzania and Uganda. The data, with respect to household coping mechanisms include strategies for minimizing risk and managing loss, the effects of the coping mechanisms, types of assistance provided to mitigate the effects of drought and flood and household demographics. Results from the survey will be used in the Livestock Early

Warning System (LEWS) project to enhance the strategic planning of effective and timely responses to these environmental stresses imposed upon the pastoralists.

The resulting information on emerging problems will be provided to in-country policy makers, international monitoring network allowing for multi-directional flow of critical information. Timely spatial information on trends of livestock well-being allows for greater learning among pastoralists and policy makers leading to more rational decision making and reduced land degradation risk.

Research

Problem Statement

The recurrent drought and famine, followed by floods are regular features that induce limitations within the natural environment in East Africa. The chances of drought occurring in parts of the Greater Horn have increased from a probability of one in six years to one in three years for areas affected. Repeated occurrences of drought and high variability in precipitation have reduced the ability of many smallholders, such as pastoralists, to maintain their assets or respond when conditions are good. The phenomenon reduces livestock productivity and threatens food security of pastoral communities in the regions. Other natural disasters, such as pest infestations and periodic flooding, destroy areaspecific production levels. Migration, as a coping mechanism, causes conflict/ethnic strife over available resources, such as grazingland and water. Crisis prevention involves the ability to foresee and the means to prevent, prepare for and mitigate, or resolve, crisis and conflict. Effective prevention requires monitoring and analytical capacity at the regional, national and local levels, as well as the ability and desire to respond to warning signs of all kinds. The current set of weather and remote sensing information generated by donor-based monitoring programs offers information on locations of "initiating conditions" while the on-ground monitoring programs of markets, human conditions and animal herd situations reflect, mainly, a "post-effect" appraisal system. However, many of the problems besetting livestock (e.g., weight and body condition loss) have already occurred before the human eye can detect the response. Other human indicators are further down the food chain within the pastoral ecosystem and offer even more delayed post-effect monitoring of emerging crisis. Analysis of these factors supports arguments for a more effective early warning system in the region, especially as it affects livestock throughout the pastoral and mixed farming region of East Africa.

The proposed monitoring and analysis system, based on NIRS livestock fecal profiling technology and spatially referenced modeling of emerging forage/crop conditions, can add a new dimension to the existing monitoring programs in East Africa. The ability to predict responses, such as impending livestock mortality by kind and class of animal, losses in forage supply and decline in milk production allows more flexibility in decision making from the household level to the policy maker. A more timely destocking strategy will allow pastoralists to maintain their assets through crisis. It will also aid in the assurance of greater ecosystem integrity by allowing more rapid response after droughts have run their cycle. When properly implemented, the system will provide an additional 6-8 weeks advanced notice on the current early warning systems in East Africa. When linked with the suite of simulation models on animal nutrition, developed by the Center for Natural Resource Information Technology at TAMU (i.e., grazingland forage growth/hydrology and mixed farming crop models), analytical capacity of existing early warning infrastructures will fill a much needed niche. This niche can bridge distant monitoring and on-ground surveys of emerging effects of drought and other stress conditions associated with pastoralists in East Africa; thus, providing a valuable missing link-type enhancement to the mitigation process.

The challenge is to demonstrate the usefulness of these technologies, in East Africa, while organizing a critical mass of personnel and institutions for the mitigation of nutritional crises among livestock and humans and the resultant social conflicts, in a manner that provides timely and high quality information on trends in the well-being of livestock. Also, it will be demonstrated that this information can reach all levels of decision making, including the pastoralists, national policy makers and international assistance/monitoring organizations.

Approach

With respect to the LEWS project, warning signs refer to livestock nutritional well-being and forage imbalance, in a timely and appropriate manner. A number of nutritional crises among humans and their livestock and the resultant social conflicts can be mitigated if empirical relationships between weather, livestock feed resource base and animal performance and productivity are established. One of the most innovative methods, to date, involves the systems approach being taken in this LEWS project - a supplemental monitoring mechanism that will be readily incorporated with already instituted monitoring programs. The sustainability of the system requires simple monitoring and decision support tools and active participation of pastoral communities.

The major goal, reflected in the project's approaches, is to mitigate nutritional and social crises for humans in pastoral areas, who are dependent on livestock for the majority of their livelihood. The approaches to this goal involve the development of tools and institutional capacity to predict impending crisis in livestock nutrition, in East Africa. These approaches are designed with the intent to add 6-8 weeks advanced notice on the current early warning systems in East Africa.

To establish empirical relationships between weather, vegetation and regrowth potentials, soil and climate dynamics and nutritional status and livestock productivity, tools for monitoring these components have been implemented. These same tools are also being used to establish an inventory of indicators for impending nutritional and livestock health crises. The tools include: (1) the Spatial Characterization Tool (SCT) used to assist in the characterization of the selected zones, (2) the Nutritional Management System (NIRS/NUTBAL) for monitoring feed quality from feces of the ruminant livestock and (3) Plant Growth/Yield/Hydrology Simulation Models (PHYGROW and APEX) for monitoring herbage and crop production. For a complete description of these tools see the 1997 Global Livestock CRSP Annual Report for the LEWS project: "Early Warning System for Monitoring Livestock Nutrition and Health for Food Security of Humans in East Africa."

Modifications

The problem approach modifications included (1) a survey to evaluate existing indigenous knowledge and coping mechanisms used by pastoral communities in mitigating drought and flood crises for the purpose of enhancing the LEWS project's strategic planning of effective and timely responses to these environmental stresses imposed upon pastoralists and (2) the participation of the Eritrean team in the project.

Pastoral Coping Mechanisms Survey

In the planning process of the LEWS project, it was recognized that a socio-economic survey at the beginning of the project would reveal critical issues and/or constraints on technological development. Mitigating crises and optimizing early warning systems, in

East Africa, requires an understanding of the pastoralists' complex livestock production systems and inter-relationships between livestock and people, as well. Historically, livestock and household inventories had not been documented for the overall spectrum of drought, nondrought (normal) and/or flood phases.

In seven sites in the pastoral ecosystems of East Africa, community-based field enumerators are conducting the survey by personal interview with pastoralist households. The purpose of the survey is to investigate the responses of pastoralists to the environmental stresses affiliated with the 1995-97 drought and the 1997-98 floods. This survey is also setting the baseline information for the pastoral fecal profiling routes that will be designed in next year's work tasks. The survey addresses (1) the effects of the environmental phases, drought and flood; (2) pastoralists' coping mechanisms to the stresses associated with the phases; and (3) the efficacy of the coping mechanisms as perceived by the pastoralists. Livestock population inventories and household coping mechanisms in the arid, semi-arid and savanna zones of Kenya, Tanzania, Uganda, and Ethiopia are the overall categories of the survey. The data concerning livestock populations include (1) livestock herd size; (2) livestock herd situation (e.g., births, deaths); (3) livestock sales and purchases; (4) livestock nutrition; and (5) livestock diseases, conditions and treatments. The data with respect to household coping mechanisms include (1) strategies for minimizing risk and managing loss (e.g., herding, transhumant movement, and supplementary feeding); (2) the positive (e.g., survival) and negative (e.g., increased vulnerability to hunger) effects of the coping mechanisms upon the household; (3) types of assistance provided to mitigate the effects of drought and flood; and (4) demographics with respect to household (e.g., number, age, sex of the people within the household).

LEWS will contribute to a set of plans (designed to complement a variety of regional drought preparedness programs in livestock systems in the Greater Horn of Africa) for the monitoring, intervention and activities aimed at mitigating the crises of drought and flood. Results from the survey will provide the pastoralists' views, about their situation, that will be used in the LEWS project to enhance the strategic planning of effective and timely responses to these environmental stresses imposed upon the pastoralists. To assess the overall situation, two timeframes of inquiry are being used for the drought phase and three (one overlapping the drought phase end of drought and onset of rains) for the flood phase. The timeframes are (1) prior to the drought; (2) during the peak of the drought; (3) at the onset of rains; (4) during the peak of the floods; and (5) recovery from the floods. The following locations and responsible persons have conducted 100 household surveys in each location using the SCT system to proportionally allocate the samples according to effective environments and livestock density distributions:

- Mwanza, Tanzania - Mr. S. Kaganda and Mr. A. Mwilawa
- Arusha, Tanzania - Mrs. S. Bitende and M. Kingamkono
- Mpwapwa, Tanzani - Mr. A. Mwilawa
- Kajiado District, Southern Kenya - Mr.W. Mnene and Dr. P. Wandera; Kiboko landrover renovated
- Northern Kenya - Mr. P. Kamau, Dr. R. Shavulimo and Mr. Mnene
- Mbarara, Ngaramanga, Uganda - Dr. C. Ebong and S. Beyenkeya
- Adami Tulu, Borana Region, Ethiopia - Dr. Sileshi and Abule Ebro

The coping mechanism survey, sponsored by ASARECA and funded by USAID, was designed by TAMU-LEWS team members and has been initiated with expected completion in November. A survey form with enumerator instructions has been distributed to all the LEWS in-country NAR/University team members, in East Africa. The ASARECA Crisis Mitigation Office at ILRI Nairobi is currently entering the data into a database management application (i.e., Microsoft ACCESS) and has assigned Roger

Kamidi, a statistician, to assist the TAMU-LEWS in data analysis and in the compilation of the final report.

The map below (figure 1) is a sample of the clusters where the survey scheme is being implemented in Southern Ethiopia.

Figure 1: Climatic clusters with roads, Southern Ethiopia

Eritrea participation in the project

Contacts, institutional links, in-country representation on the LEWS team, and validation sites were established in Eritrea, as well as some dispersion of funds. However, Eritrea participation has been temporarily halted due to loss of all contact during the period of war between Eritrea and Ethiopia. Attempts have been made to contact the in-country team leaders of Eritrea as recent as October 12, 1998, from TAMU, USA and ASARECA - the Kenya team has made attempts, as well, to no avail. Thus, reluctantly, Eritrea has been excluded from the 1998-99 budget with expectations of their reentry into the program and budget in 1999-2000.

Progress

The first year of the LEWS project was dedicated to linking the parts of the program and validating the technologies and the development of diet:fecal pairs. Validation sites were established within the 5 countries of East Africa - Eritrea, Ethiopia, Kenya, Uganda and Tanzania. These sites were based on the location and the availability of personnel, facilities and livestock to allow the pursuit of the validation tasks. The purpose of the validation is to be able to measure plant growth and animal performance. Therefore, we needed to have an active plant growing period, as well as a slow growth and nearly no growth period, within the trial. Thus, all validation trials were scheduled to start at the latter part of the growing season and extend into the dry season. Most of the countries in the study experienced unusually heavy rains in 1997/98, which delayed the start of the trials as planned. Data from the validation studies will be used to test predictions from various models. The validation sites are:

- Halhale, Eritrea Semi-arid pastoral ecosystem
- Adami Tulu, Ethiopia Grassland Savanna pastoral ecosystem
- Chemeron, North Kenya
- Arid/Semi-arid pastoral ecosystem
- Kiboko, Southern Kenya Grassland Savanna pastoral ecosystem
- Mbarara, Uganda Grassland Savanna pastoral ecosystem
- Mpwapwa, Tanzania Grassland Savanna pastoral ecosystem

Site validation and paired fecal sampling trials have recently been completed or are in their final stages in all countries, except Eritrea due to a border conflict and war that erupted between Ethiopia and Eritrea. Some of the sites have already sent the data to Texas A&M University, while others are still entering their data in computers provided by the LEWS subproject. The activities in these sites included the characterization of the plant communities, livestock profile and grazing trials and diet:fecal pairs development.

Figure 2: Validation sites and pastoral ecosystems of East Africa.

For all sites, every month, measurements were completed for herbaceous plant standing crop, density, cover, woody plant allometry, browse volume weights, and water adhesion coefficients for each plant species (to improve water balance component of model), and assigning preference status to the plants by growth stage and livestock species.

Characterization of plant communities

Kenya

There are two validation sites in Kenya. They are Kiboko, in southern Kenya, and Chemeron, in northern Kenya.

Kiboko

The validation site, KARI-National Range Research Station, at Kiboko, in south-central Kenya, covers about 31.5 ha (Lat. 502⁰ 15, 212. Long. E 037⁰ 44.092). It is dominated by Commiphora woody species and an assortment of grasses and forbs. The site was deferred from utilization for the month of December, 1997, to allow for full expression of the vegetation.

Total herbage standing crop of 15,990 kg DM (slightly over 500 kg DM/ha) recorded was believed to be enough to support the experimental animals for the planned five month study. Because there was plenty of browse and forbs, goats and sheep had more than adequate dietary nutrients. There were over 16,000 woody plants/ha with the majority (> 80%) of the canopy cover being shrubs. In 1998, abnormally high precipitation resulted in a large annual forb population.

Two structures were identified near the research center: a night holding pen (boma/Kraal) and a roofed and partitioned shed. The former is used by the validation grazing animals, while the latter is used for the diet:fecal pairing. Both facilities were renovated. Cattle, sheep and goats were fed hand-gathered native diet mixtures and generated feces was collected. These diet:fecal pairs were sent to the GL-CRSP NIRS lab, at ILRI-Debre Zeit, Ethiopia, for processing and scanning. Each sample was split and half was sent to TAMU's GAN Lab for further analyses.

Chemeron

A validation range site (N 00° 29.297', E 035° 55.315) was identified at Egerton University's Chemeron Field Station, in the Baringo District, about 13 km west of Marigat Township, toward Kabarnet. The station is approximately 113 km north of Nakuru. The area of the site is approximately 38 ha and consists of multi-aspect slopes. This hilly terrain is mostly dominated by Acacia shrubs, with some forbs and less grasses. The dominant woody vegetation species is comprised of Acacia mellifera, A. senegal, A. hockii, Balamites aegyptiaca and Commiphora spp. Other vegetation species include shrubs, such as Acacia brevispica, Hibiscus micranthus, Pentas spp, Combretum spp and Acalypha fruticosa. Forbs include Hypoestis spp, Justicia spp, Aeva pinnata and Elargia spp.

Since grasses contributed less than 1% of the total canopy cover (i.e., trees, bushes, shrubs and forbs), only sheep and goats were allocated to this site for validation purposes. There were about 2,346 woody plants (mainly, trees) per hectare in the sampling site.

The GL-CRSP team from Utah State University is working in the same area with Dr. Abule, at Egerton University. Our Egerton team members are coordinating efforts with Dr. Abule to assure inter-team cooperation.

Uganda

There are two validation sites in Uganda. They are Nshara and Mbarara. These sites are located in the central part of the Ankole ranching region, which is currently undergoing restructuring of land holdings among pastoralists. The GL-CRSP/IMAS team, from Colorado State University, has co-located personnel and research with us in this region.

Nshara

The grazing validation study, for cattle, was conducted at Nshara Ranch near the Lake Mbuiro game park. The site is a 50-ha paddock on the ranch. We had to modify security for the livestock to reduce leopard predation of the calves, given the site's proximity to the game park.

Nshara Ranch is located in an Acacia Grassland Savanna zone between Masaka and Mbarara in South Western Uganda. Major tree species include: *Acacia hockii*, *Acacia gerrardii*, *Acacia seyal* and *Acacia siberiana*. Dominant grasses include: *Bracheria* spp, *Chloris guyana*, *Hyparrhenia* spp, *Cymbopogon afronandrus*, *Sporobolus* spp, *Cynodon* spp and *Cenchrus ciliaris*. Legume species include: *Crotolaria* spp, *Indigofera* spp, and *Stylosanthes* spp. *Cymbopogon afronandrus* is the dominant grass species. It is unpalatable at advanced stages of growth. *Bracheria* spp were the dominant pasture species of nutritional significance. Others, such as *Hyparrhenia* spp, *Cenchrus* spp and *Sporobolus* spp are important feed resources in the dry seasons.

Mbarara

For the small ruminants, the validation study is located at Mbarara Stock Farm (MSF), near the town of Mbarara. The vegetation is similar to the Nshara site.

Dr. Ebong, Uganda's in-country coordinator, is designing a science project with the local grade schools to create the woody biomass allometry equations for the project. This science project will make contribution to the fecal profiling project, next year. Dr. Ebong has agreed to report the outcome to the entire team and suggest approaches for the other LEWS team members.

Tanzania

Mpwapwa

The LEWS team, at Mpwapwa, selected an area of 15 ha (300m x 500m) on the Iloilo farm, at the Livestock Research Institute, Mpwapwa. The institute is situated in the semi-arid zone at 900m above sea level. The average rainfall ranges from 400-650mm and varies greatly in distribution and amount from year to year. Drought years, with low erratic rainfall, are frequently experienced. About 90% of the rain occurs between December and April, with a dry spell in February, for most years. The average minimum temperature is 15.5 C, with August being the coolest month (13.8 C). The average maximum temperature is 27.5 C, with November being the warmest month (30.2 C). Generally, soils in the region are sandy loam on the slopes and clay loam along valley bottoms. Soils are low in nitrogen and phosphorus, but adequate in potassium. The topsoil pH ranges between 5.6 and 7.7, while that of the subsoil is between 5.3 and 8.6. The main tree and shrub species are: *Adansonia digitata*, *Acacia tortilis*, *Acacia nilotica*, other *Acacia* spp, *Lannea* spp, *Sena siame*, *Faidhebia albida*, *Markamia* spp, *Delonix elata*, *Albizia* spp and *Combretum* spp. Grass species include: *Cynodon plectostachyus*, *Cenchrus ciliaris*, *Panicum maximum*, *Chloris*

gayana and *Heteropogon contortus*. Given the high level of rainfall during 1998, the site had a high population of large annual forbs.

SOIL PROFILE

Location:	Ilolo farm, Mpwapwa, Tanzania (06° 21'S., 036° 28'E)
Landform:	Alluvial plains
Parental material:	Alluvial deposits of red brown soils
Topography:	Almost flat
Slope:	0-2%, straight
Altitude:	915 m
Soil:	Very deep, well-drained, dark red, loamy sand topsoil, over dark red and red sandy clay and sand clay loam subsoil. The site experienced a moderately rapid run-off during early rains.
A 0-10cm	Dark red (2.5YR 3/6, dry) and dark reddish brown (2.5YR 3/3 moist); loamy sand; weak to moderate, fine and very fine subangular blocky; slightly hard to hard when dry, very friable to friable when moist, slightly sticky and slightly plastic when wet; many, fine and medium pores; many, fine and medium roots; clear and smooth boundary.
Bt1 10-21cm	Dark red (10R 3/6, dry) and dusky reddish brown (10R 3/4, moist); sandy clay; moderate to strong, fine and very fine angular and subangular blocky; slightly hard to hard when dry, friable to firm when moist, sticky to very sticky and very plastic when wet; many, fine and medium pores; common, fine and medium roots; few, faint clay cutans/pressure faces; few, fine soft rounded clay nodules; few, fine and medium rounded weathered gravel (0.2 - 2.0 cm); clear and smooth boundary.
Bt2 21-58cm	Dark red (10R 3/6, dry) and dusky red (10R 3/4, moist); sandy clay loam; moderate to strong, fine to medium angular blocky; hard when dry, friable to firm when moist, sticky to very sticky and plastic to very plastic when wet; many, fine and medium pores; common, very fine and fine roots; common, distinct clay cutans; common, medium soft rounded clay nodules; few fine and medium subrounded weathered gravel (0.6 - 6.0 cm); clear and smooth boundary.
Bt3 58-96cm	Red (10R 4/8, dry) and dark red (10R 3/6, moist); sandy clay loam; moderate to strong, angular blocky; hard when dry, friable when moist, sticky and plastic to very plastic when wet; many, fine and medium pores; few, very fine and fine roots; many, distinct clay cutans; many, medium both hard and soft rounded clay nodules; very few, fine and medium subrounded weathered gravel (0.2 - 2.0 cm); clear and smooth boundary.
Bt4 96-129cm	Red (10R 4/8, dry) and dark red (10R 3/6, moist); sandy clay loam; moderate to strong, angular blocky; slightly hard to hard when dry, friable when moist, slightly sticky to sticky and plastic when wet; many, very fine and fine pores; very few, very fine and fine roots; many, distinct clay cutans; common, fine both hard and soft rounded clay nodules; very few, fine subrounded weathered gravel (0.2 cm); clear and smooth boundary.
Bt5 129-164cm	Red (10R 4/8, dry) and dark red (10R 3/6, moist); sandy clay loam; weak to moderate, angular and subangular blocky; slightly hard when dry, very friable to friable when moist, slightly sticky to sticky and slightly plastic to plastic when wet; many, very fine and fine pores;

very few, very fine and fine roots; many, distinct clay cutans; many, medium both hard and soft rounded clay nodules; very few, fine subrounded weathered gravel (0.2 cm); clear and smooth boundary.

Table 1: Soil classification and profile, Ilo Farm, Mpwapwa, Tanzania.

Ethiopia

Ethiopia has one validation site located at the Ethiopian Agricultural Research Organization Research Center at Adami Tulu .

Adami Tulu

Adami Tulu Research Center has provided 20 ha of grazing pasture for the validation study and other activities of the LEWS project. This validation site is in a Rift Valley sandy loam-ash soil, gray in color, and shallow with poor water holding capacity location. The site was fenced and deferred from grazing December, 1997, to May 21, 1998. Currently, a separate area of 16.47 ha is being grazed for the validation trial. The site is located in a grassland savanna, dominated by *Acacia tortilis*. Dominant tree species include: *Acacia tortilis* (the most dominant species), *Acacia seyal*, *Acacia mellifera*, *Acacia senegal*, *Dichrostachys cinerea*, *Balanites aegyptica*, *Opuntia spp*, *Acacia siberiana*, *Capparis tomentosa*, *Commiphora habessinica*, *Solanum incanum*, *Acacia nilotica*, *Combretum spp*, *Comberatum spp*, *Euphorbia candelabrum* and *Euphorbia abyssinica*. Dominant grass species are: *Heteropogon contortus*, *Cenchrus setigerus*, *Pennisetum stramineum*, *Pennisetum ezianum*, *Eleusine multiflorum*, *Harpachne schimperii*, *Cynodon dactylon*, *Sporobolus spp* and *Aristida adoenis*.

Table 2: Mean monthly and total annual rainfall (mm) for Adami Tulu validation site from 1981-1998

Samples were taken to estimate standing crop biomass for the determination of the stocking rate and productivity of the validation site, in terms of its carrying capacity. A double sampling method was employed for the calculation of the standing crop for the herbaceous component using a 1m x 0.5m quadrat. Four quadrats were systematically sampled from each 50m x 1m along predetermined line transects within the site. Standing biomass was estimated in each of three quadrats and the fourth one was estimated and clipped. Plant species in those quadrats were also identified.

Table 3: Percent cover (%) for the herbaceous plant species at Adami Tulu validation site

A soil profile pit of 2.6 m deep was dug and soil samples were taken from the horizons. Characterization of the horizon thickness was made and the soil samples were submitted to Holetta Research Center for detailed laboratory chemical analysis. Prior to this study, soils at Adami Tulu center had never been analyzed.

A detailed topographic survey of site boundaries and elevation was conducted at 30m intervals to construct a contour map for the site. The boundary of the site was surveyed to determine its exact area. The elevation of the compound (measured with an altimeter) was about 1670 m above sea level, at benchmark.

The soil profile (Table 4) has an abrupt wavy boundary to the horizon below. The H₂O pH (1:1) is alkaline. There was a strong pH increase with depth in the profile and the increase is explained by the Ca distribution down the profile, which was observed during the

sampling. Available P (Olsen) was higher in the surface layers, showing a sharp decrease at the middle of the profile, and an increase below the root zone from 120 to 260 cm. The P amounts and distribution patterns are not uniform.

Table 4: An example of soil profiling at the Adami Tulu validation site.

Pedon Description	
Location	Adami Tulu Research Center, Ziway, Ethiopia
Coordinates	N 07 ⁰ 51" 354' S 38 ⁰ 43" 2173'
Physiography	On nearly flat area
Relief	Almost a level of topography of about 0-0.5% slope
Drainage	Better
Parent material	Natural pasture, mainly for grazing of goats and cattle
Water table	None was detected at sampling time to a depth of 2.60 m
Date of sampling	1 April 1998
Depth of the horizon(cm)	Description of the profile
0 - 20	Ashy, many fine roots, big tree roots, dry, abrupt wavy boundary to horizon below
20 - 45	Ashy, silt, very fine roots, dry, big tree roots, indistinct boundary, shells of snails
45 - 75	Dry, silt, fine roots, very fine coarse sand, shells of snail, distinct layer, Ca particles
75 - 120	Dry blocky angular very fine grain size particles, very few fine roots, stones, coarses and ashy
120 - 190	Fine coarse sand, dry, granular grain size Ca particles, very fine roots, dry to moist
190 - 220	Blocky angular fine grain size particles, no roots, no clear demarcation, gray, dry to moist
220 - 260	Blocky angular, no roots, stony, coarse sand, gray, dry to moist

Percent total surface nitrogen (N) is low. Total N distribution pattern decreased with depth. This is linked with low organic matter of the soil. Organic carbon also decreases with depth. In general, the inherent fertility status of this soil is poor. The amount of

exchangeable cation is a good indicator of the fertility status of the soil. The CEC is higher in the surface soils than at the lower horizons. The CEC of this soil is to the lower side.

The texture is

Table 5: Physical and chemical characteristics for the soil profile.

Table 6: Physical and chemical characteristics for representative soil samples.

dominated by silt particles. In the lower parts, toward the parent material sand, is the dominant fractions. On the average, clay particles are about 10 per cent and their distribution is almost uniform. Large particles, such as sand and silt, provide better transmission pathways for water and air. Fertility management will be the major management challenge of this soil. The texture class is silty loam.

Livestock profile for grazing trials

Kenya

Kiboko

Six groups of cattle and one, each, for sheep and goats representing different classes, physiological stages and/or breed types were selected for the validation grazing trial. Three kinds of livestock were used in the grazing and pairing validation trials. East African Shorthorn Zebu cattle, East African goats and Red Masai sheep were selected for the trial. These breed types, of the three kinds of livestock being used in the trial, are dominant in the Kenyan arid and semi-arid areas, as well as indigenous to these areas.

Lactating Boran x Sahiwal cows had an average initial liveweight of 272 kg, Zebu weighed 210.8 kg and Boran 261.4 kg. Zebu heifers averaged 173 kg while Boran and Boran x Sahiwal heifers averaged 116 kg and 182 kg, respectively. Boran x Sahiwal steers had an average initial liveweight of 96.4 kg. All the cows were over five years of age, while the steers and heifers were from recently weaned stock. There were no sufficient lactating sheep to select from, so one group of lactating goats was used. Lactating small East African goats averaged 23.5 kg, while female weanlings of Red Masai sheep averaged 18.6 kg and female small East African weanling goats averaged 14.9 kg.

Grazing began March 11, 1998. Animals were grazed for about eight hours a day (between 8.00 a.m. and 4.00 p.m.). They were handled as a mixed herd of cattle, sheep and goats. There was no water in the paddocks, except some rain puddles, occasionally. Water was only available outside their night-holding pens. So, the animals were allowed access to water for one hour before being penned. Sheep and goats were penned separate from cattle.

Weighing was done using a stationery scale for large stock (cattle) and suspension spring balance for small stock. All animals were weighed on an empty-body basis every week, on Wednesday. At the time of weighing, body condition scoring was done and pictures (slide) of individual animals were taken. Body condition scales for cattle, sheep and goats were 1-9, 1-5 and 1-3, respectively. Almost all cattle scored 4 to 5, sheep scored 3 and goats were about 2. Height, at withers, loin and heart girth, was measured on each animal and repeated monthly.

Lactating animals were milked once a week, on Monday. The dam and off-spring were separated overnight. The weigh-suckle technique was attempted for one week, but proved too difficult, since available scales could not accurately weigh 100-250 gm. Therefore,

starting from the second week of the study, the half-udder stripping technique was used. This technique involved the calf/kid being allowed one side of the udder, as milking continued. Every time, the right side of the udder was milked, while the left was for the young one to suckle.

Fecal sampling was done every Saturday morning. This was the third day after weighing of the animals. The samples are composited by group of animals, generating 10 fecal samples per week. The dry samples were packed and air-mailed to Debre Zeit, Ethiopia, beginning May, 1998. Rectal grub technique was used for the sheep and goats, while fresh fecal piles from cattle were collected.

Figure 3: Body condition vs. livestock weight for mature cows at Kiboko site, 1998.

The health program, for the animals, has included the initial de-worming and routine dipping/spraying with acaricide and inoculation with trypanocide. Mature cattle were dipped, while small stock were hand-sprayed. However, since several clinical cases of tick-borne diseases were observed and later confirmed through examination of blood smears, it was decided that hand-spraying would be used for all animals. It was suspected that the validation site center plunge-dipwash was under-strength (e.g., too low concentration of acaricide). Some of the major diseases included Anaplasmosis and Trypanosomiasis. Some of the test animals experienced wounds caused by photosensitization dermatitis resulting from the consumption of *Cassia mimosoides*. Drugs of choice were tetracycline injectable, ivermectin and tetracycline aerosol. Due to exceptionally wet conditions, some biting flies (larger than tsetse) became prevalent. They not only sucked blood and caused great irritation, but they also caused intensive worry for the animals.

Livestock handling facilities have been renovated. Old equipment was also repaired, including squeeze chutes, scales and chaff cutter to allow monitoring of animal performance.

Chemeron

Given the limited amount of grasses in the region, the study focused only on sheep and goats for the trials. The site for the boma/kraal was identified and constructed. Twenty head of sheep were purchased from the local pastoralists. More photographs of the vegetation and animals in the sampling sites were taken. A weighing scale was purchased and delivered to the site. The general health of the experimental animals was continually evaluated. All the animals were weighed and herdsmen were employed to look after these animals.

Progress at Chemeron seemed behind the other groups. Primary concerns were on developing allometry equations for the major woody species and the browse volume weight measurements. After a visit by the TAMU-LEWS team to the site, it was agreed to discard the initial measurements and start over, given the dramatic change in the availability of browse from essentially no leaves to full expression of leaves.

Uganda

Grazing trials were set up in two sites in Uganda, about 50 km apart. One validation site is located at Nshara Government Ranch stocked with cattle and the other site is at Mbarara stockfarm with goats. Both sites are located in Mbarara district, at the center of the Ankole ranching region, which is currently undergoing restructuring of land holdings among pastoralists. The GL-CRSP IMAS team from Colorado State University has co-located

personnel and research with us in this region.

Nshara Ranch

The grazing validation study for cattle was conducted at Nshara Ranch, near the Lake Mburo Game Park. A 50-ha land area was identified at the ranch and fenced off. Thirty lactating Ankole (Sanga) cattle, with their calves (product of crossing with Friesian bulls) were selected from the government ranch and placed in the grazing area on 11 May 1998. All the calvings were born within the months of April and early May. Initial weights of the dams were taken on 15 May 1998. Calf weights and milk production, determined by weigh suckle method, were initially determined on 16 May 1998. The weights of the dams varied from 286 to 426 kg with the majority being between 300 - 400 kg. Liveweight and milk production were, thereafter, determined after every 2 weeks for 3 consecutive days. Fecal samples were also taken on the same days. The last determinations were done on 22 Aug 1998. Animals that lost their calves or developed serious sickness were removed from the trial. By the end of the trial, there were 21 dams and their calves. Being near Lake Mburo National Park, we were discouraged from putting goats in this trial due to the presence of many predators. The goats were therefore placed at Mbarara Stock Farm about 50 km away.

Nshara Ranch is located in an Acacia Grassland Savanna zone between Masaka and Mbarara in South Western Uganda. Major tree species include: *Acacia hockii*, *Acacia gerrardii*, *Acacia seyal* and *Acacia siberiana*. Dominant grasses include: *Bracharia* spp, *Chloris guyana*, *Hyparrhenia* spp, *Cymbopogon afronandrus*, *Sporobolus* spp, *Cynodon* spp and *Cenchrus ciliaris*. Legume species include: *Crotalaria* spp, *Indigofera* spp, and *Stylosanthes* spp. *Cymbopogon afronandrus* is the dominant grass species. It is unpalatable at advanced stages of growth. *Bracharia* spp were the dominant pasture species of nutritional significance. Others, such as *Hyparrhenia* spp, *Cenchrus* spp and *Sporobolus* spp are important feed resources in the dry seasons.

Mbarara Stock Farm

For the small ruminants, the grazing study was conducted at Mbarara Stock Farm (MSF), near the town of Mbarara. MSF is also the study site for diet:fecal pairing development. About 1.5 ha of land was fenced off at Mbarara Stock Farm. The site was stocked with 25 male Small East African (SEA) goats (about one year old) on 25 April 1998. Due to unavailability of a good weighing balance, the first most reliable weights of the goats were taken on 18 May 1998. Weights varied from 10.2 to 17.8 kg. Most goats weighed between 14 - 16 kg. Weights, condition scores, hip heights, hipbone width, heart girths and crown to tail lengths were, thereafter, taken monthly with the last measurement being on 8 September 1998. Fecal samples were collected weekly.

Dr. Ebong, Uganda's in-country coordinator, is designing a science project with the local grade schools to create the woody biomass allometry equations for the project as a technique to be implemented, next year, for the fecal profiling project. Dr. Ebong has agreed to report the outcome to the entire team and suggest approaches for the other LEWS team members.

Tanzania

Mpwapwa

The grazing experiment started on April 1, 1998. Prior to grazing on the validation site,

the initial weights, for each animal, were determined in the morning. Animals selected for this trial were as follows: cows were Tanzania Short Horn Zebu (5), Boran (5) and Mpwapwa (5); goats were blended (5), Indigenous -Central Zone (5) and Indigenous-Lake Zone (5); and sheep were Black Head Persian (5), Red Masai (5) and indigenous (5).

The decision for the selection of the type of animals was based on their wide representation in semi-arid areas of Tanzania. All of the animals were similar to those kept by the pastoralists (e.g., Masai and Barbaig) and agropastoralists (e.g. Sukuma and Gogo), in the region. Mpwapwa cattle and blended goats are popular composites among the agropastoralists of Central Tanzania. All experimental animals were given numbers, in addition to their identification numbers, at the farm for easy identification. The additional numbers were especially important during fecal collection and/or monitoring phases. Animals were weighed every 28 days. Preliminary results indicated an increase in weight, with the exception of the few animals that birthed young. The increase in weight was probably due to good pastures that were deferred until the grazing phase started, in April. Various photos of these animals were taken at different times. Other measurements recorded included body length, height at withers, heart girth and hip height. Also, body condition scores of animals were recorded during weighing. Body condition of livestock was assessed during weighing, using a scale of 1 to 9 for cattle as per ILCA manual, and 1 to 5 for sheep and goats (Australian system).

Animals were taken for grazing between 8:00 a.m. - 4:00 p.m., everyday, and were taken to water around 1:30 p.m. Fecal samples were collected every Wednesday and taken to the laboratory for further processing. All the samples were shipped to NIRS Lab at ILRI-Debre Zeit, Ethiopia, for scanning.

Prior to initiation of the trial, all animals were drenched with Albendazole and Milson to control digestive tract worms and vaccinated against Blackquarter. The animals were dipped, using Stelladone, every Friday to control ticks. One case of death occurred among the goats, due to injury by the cows. The goat sustained injuries that caused internal bleeding of the spleen and liver. A replacement was brought into the study.

Ethiopia

Adami Tulu

Seven goats were allocated from the Center's main herd. Seven sheep and seven cattle were purchased from local surrounding markets. The age of cattle was estimated to be about 5-6 years, while sheep were two years old. All animals used in this study were male. Purchased sheep and cattle were kept in quarantine. All animals were drenched, de-wormed, sprayed and vaccinated against major diseases. After a period of quarantine, animals were kept in the barn, overnight, and the necessary management was provided.

The animals were allowed into the grazing trial on May 5, 1998. A day before entering into the validation site, the animals were fasted and their weights were taken on May 5, 1998, in the morning. The animals were condition scored. The nine-point condition scoring method of Nicholson and Butterworth (1986) was used for cattle and a 5-point scale for sheep and goats. Moreover, heart girth, height and loin height were measured. Slide pictures of each animal was also measured. The animals were moved to the grazing site at 8 a.m. daily and they were returned from the field at 5:00 p.m., for nine hours.

The animals were treated with anti-helminthics before being allowed to graze the pasture. They were watered once a day, in the evenings. Once a week, Friday morning, fecal samples were taken. A composite sample for each species was put in a plastic bag. The

samples were labeled and kept in a deep freeze until they were dried for analysis. Every 28 days, all animals were weighed and condition scored and body measurements were taken (i.e., heart girth, length and loin height). The day before these measurements, the animals were not allowed to drink water for the accuracy of the body weight measurement.

A training session on body condition scoring, heart girth and hoof height measurement was conducted. A technical staff, from Holetta Research Center, trained Adami Tulu research technicians and enumerators that were hired for the project. The training lasted for three days, using 20 steers and 20 goats for practical application.

A total of 31 animals (i.e., 7 cattle, 7 goats and 17 sheep) were presented to the veterinary clinic, at the center, within a 4 month period. Three sheep were treated. One of them was treated for copper deficiency, one for GIT disorder and another for meningitis. The one with copper deficiency died. One goat was treated for ophthalmitis.

Table 7: Body weight (B, wt), condition score, height and loin length of livestock used for the validation trials.

Diet: fecal pairs development

We only had diet: fecal pairs from the subtropics of Texas, USA, and the samples from Debre Zeit, Ethiopia, at the beginning of the LEWS project. Even though these seemed to be sufficient at that stage, the first year was used to expand these pairs to help increase the robustness of the NIRS equations for East Africa. Each of the 4-5 sites has established animal feeding protocols to generate expanded diet: fecal pairs and, in some sites, the animals were fed with fresh forage (or mixed hays) each day for a period of 21 days. Each site selected about 20 diet pairs, based on the dominant plant communities in their respective location, so that the diets would be representative of the various growing conditions. The key was to get diet: fecal pairs across most of the East African region. Some of the countries, in the project, may be more appropriate for the site validation study, while others may be more appropriate for the diet: fecal pairs development. The material consumed will be analyzed for crude protein (CP) and CP fractions. An in vivo digestible organic matter (DOM) protocol will be used to determine DOM value of the forage source, through the measure of intake and fecal output.

These results from the diet: fecal pairs, developed at each of the validation sites in the first year, will be used to verify that the NIRS fecal profiles are predicting correctly. About 80-100 rations are tested for a wide array of forages on cattle, sheep and goats. Moreover, approximately 30 rations have been tested at 3 sites and a comprehensive validation trial was completed at ILRI-Debre Zeit, by a Ugandan Ph.D. student from TAMU supported by Rockefeller Foundation.

Kenya

Kiboko

The renovation of the study shed was completed. Therefore, all the animals were on a concrete floor. Wooden feed troughs were made and water was supplied using buckets.

Table 8: Composition of the various diets and ratios fed in the fecal diet pairing experiment.

Four of each cattle, sheep and goats, were selected for this study so as to intensify the coverage of the range of diets. Young growing animals were preferred. The Kiboko LEWS

team has completed 10 diet:fecal pairs for cattle, sheep and goats, and are planning to do 10 more. The diets used included various combinations of natural forage (e.g., grasses, forbs and browse), as well as crop residues and *Acacia tortillis* pods. The composition of the various diets and ratios fed in the fecal diet pairing experiment is presented in Table 8.

The unique aspect of this trial was that the same 20 rations were fed across species and we will be able to ascertain spectral differences between species with the NIRS system, for the first time. The diet:fecal pairs study was completed and fecal samples were sent to the NIRS lab at Debre-Zeit, ILRI Ethiopia.

Chemeron

New facilities (e.g., feeding pens) were constructed for diet:fecal pairs, at Chemeron, for sheep and goats. The team selected 20 head of sheep and goats. They accumulated a large quantity of annual forbs that represent the flush of growth with recent rains. They also accumulated various *Acacia* leaves, small stems and pods for the feeding trials. Diets were composed of 50-100% browse. The use of high amounts of grass was avoided, given the heavier grass content of the pairs developed at Kiboko. Sixteen diet:fecal pairs were constructed to do 8 animals per species (i.e., goats and sheep) at a time. The site focused on heavy browse content diets, which were more typical of the arid zone. The diet:fecal pairs studies were completed.

Uganda

Diet:fecal pairs were established at two sites, Mbarara Stock Farm and Namulonge Agricultural and Animal Production Research Institute.

Mbarara Stock Farm

Five Friesian cross cattle (yearlings - heifers and steers), averaging 150kg were used in this trial. Diets consisted of fresh local forage species both grasses and leguminous cut and collected from around the farm each day. The grass species included: *Bracharia* sp., *Chloris gayana*, *Cynodon dactylon*, *Hyparrhenia* sp. and *Digitaria scalarum*. Leguminous species both herbaceous and shrubs included: *Lablab purpureus*, *Desmodium uncinatum*, *Macroptilium atropurpureum*, *Gliricidia sepium*, *Sesbania sesban*, and *Leuceana leucocephala*. Each animal consumed a different diet. Different combinations of the forage species and quantities were made. The trial was initiated on 23 April 1998 and by the end of it on 30 July 1998, 24 diets had been offered. On each day, the forage feed was harvested in the morning, chopped up and thoroughly mixed. A sample was removed for quality and dry matter determinations. The rest was weighed and then placed in the feed trough. At the end of each feeding day, the refusal was also weighed and a sub-sample taken for dry matter calculations and later laboratory analysis. All the feces for the day were collected and weighed and a sub-sample taken for oven drying.

NARO veterinary research officer to Mbarara station, Dr. Julius Tuhumwire, was assigned as the administrative head. He provided animal health care to the project and also assisted Mr. Stephen Beyenkya, the LEWS program coordinator, at the site with sampling activities. The diet:fecal pairs studies were completed and the fecal samples were sent to the NIRS Lab, at ILRI-Debre Zeit, Ethiopia.

Namulonge

Diet:fecal pairs trial here started on 17 April 1998 and ended on 30 July 1998. 24

diet:fecal pairs were collected at this site during the trial period. Twelve (12) Small East African goats (all males, about one year old) were used at this site.

The diets consisted of leguminous fodder shrubs in combination with grasses i.e Pennisetum purpureum (elephant grass) and Bracharia sp. All species were offered in fresh and dry form. The leguminous fodder shrubs included: Calliandra calothyrsus, Gliricidia sepium, Leuceana diversifolia, Albizia chinensis, and Sesbania sesban. Two goats were offered the same diet daily. The grass and the legume were offered separately.

The feed both the offered and refusal was weighed and sub-samples taken for oven drying. All the feces were collected on a daily basis, weighed, and sub-samples taken for oven drying. Total urine was also collected at this site and sub-samples kept awaiting laboratory analysis.

Tanzania

Mpwapwa

The diet:fecal pairs study was done in feeding pens, at the main farm of the Livestock Research Institute, Mpwapwa, with minimum repairs, especially for cow pens. A total of 23 diet-rations were used in this study, which included Cenchrus ciliaris, Panicum maximum, Cynodon plectostachyus, mixture of annuals, Heteropogon contortus, Chloris gayana, browse (leaves/pods), maize and sorghum stovers and a grass mixture. The rations from the grass species formed the basal diet and the tree leaves/pods were used as supplements.

The proportions of the rations implemented were as follows:

- R1 = 50% CC + 50% PM;
- R2 = 50% CC + 50% CP;
- R3 = 50% CC + 50% AA;
- R4 = 50% PM + 50% CP;
- R5 = 50% PM + 50% AA;
- R6 = 50% CP + 50% AA;
- R7 = 75% R1 + 25% CG;
- R8 = 75% R2 + 25% CG;
- R9 = 75% R3 + 25% CG;
- R10 = 75% R4 + 25% CG;
- R11 = 75% R5 + 25% CG;
- R12 = 75% R6 + 25% CG;
- R13 = 75% R1 + 25% HC;
- R14 = 75% R2 + 25% HC;
- R15 = 75% R3 + 25% HC;
- R16 = 75% R4 + 25% HC;
- R17 = 75% R5 + 25% HC;
- R18 = 75% R6 + 25% HC;
- R19 = 13% R1 + 25% R2 33% AA + 12% PM + 5% CG + 7% HC;
- R20 = 14% CC + 14% CP + 20% AA + 10% PM + 5% CG + 7% HC + 30% Browse (Leaves/pods).

NOTE:

Cenchrus ciliaris (CC);

Cynodon plectostachyus (CP);

Heteropogon contortus (HC);
Browse (Leaves/pods) (BR);
Sorghum stovers (SS) ;
Panicum maximum (PM);

Mix of Annuals (AA):

Chloris gayana (CG)
Maize stovers (MS)
Grass mixture (GM)

Concerted efforts were made to make sure that each ration was properly composed and that the ration was used throughout the 12 days of the trial period. The first seven days were used for familiarization to the diet and fecal samples were collected in the last five days of the trial. All of the 23 rations have been fed to cows, i.e., each ration per cow for 12 days. The rations were also fed to goats, with additional browse material, where the rations formed the basal diet and the tree leaves/pods were used as supplements.

Almost all of the feed rations were in the form of chopped hay, initially baled according to species. Fecal samples were shipped to the NIRS lab, at ILRI-Debre Zeit, Ethiopia.

Ethiopia

Adami Tulu

Diet:fecal pairs were conducted for goats, donkeys, cattle and sheep. All diet:fecal pairs collections for cattle (10), goats (12), sheep (12), and donkey (19) were completed. Fecal samples were sent to ILRI-Debre Zeit, Ethiopia.

A batch digestibility trial was conducted, for each species, in such a way that each animal was assigned to one ration. Each animal was weighed, after an over-night fast, during the morning hours prior to feeding and watering. Then, they were randomly allocated to the dietary treatments. The supplements were calculated based on live- weight. Basal feeds were chopped using a chopper to minimize selection. All animals, of each species, were adapted to the test diet for 14 days to adjust to the rations. The actual collection period lasted 7 days. The basal diets were given ad libitum. Water and mineral licks were available at all times.

Donkeys and cattle were placed in individual feeding pens with concrete flooring. Water was provided using a metal bucket. The sheep and goats were placed in a house, where individual partitions were made of wood. Water was provided using small plastic buckets. Feces for sheep and goats were collected in fecal bags. The concentrate mixture for cattle and sheep contained wheat, bran, wheat middling, noug cake and salt. For donkeys, mixtures were composed of wheat bran, wheat middling, noug cake and salt. Most of the supplemental feeds for goats consisted of leaves and twigs of different browse plants collected from the grazing field and sun-dried.

Feed intake of the basal diets and the supplements were measured on a daily basis. The feeds were measured using a sensitive balance. Supplements were offered to the animals at 8 a.m., daily. At the same time, the animals in the control groups were given their respective basal diets. In most of the cases the animals finished their supplements within an hour (in case of concentrate feeds as in donkey diets). It has taken a longer time in case of browse supplements. After finishing their supplements, the respective basal diets were offered. Refusal of the basal diets and the supplements (usually most supplements were eaten easily) was weighed at 7 a.m., the following morning. Sub-samples of offered feed

(basal and supplements) were taken daily from the mixed bulk, whereas refusals were taken daily for each animal.

The daily fecal output was collected in plastic buckets. Daily, the total quantity of feces collected was weighed, thoroughly mixed and 10% of the daily fecal output was sub-sampled; then, the sub-sample was placed into a plastic bag and frozen. Plastic buckets and metal scrapers were cleaned daily to be ready for the following day, i.e., each animal was provided with two plastic buckets throughout the experimental period. After the end of the collection period, the animals were weighed. Then, the frozen fecal samples for each animal were thawed over-night and sub-sampled. Duplicate samples of 100-150 gm, per animal, were oven-dried at 60 C for 48 hours. Finally, oven-dried samples were put in paper bags and sent to ILRI-Debre Zeit, Ethiopia, for analysis.

Gender and Child Issues

There are two categories of women that the LEWS project is having an impact upon. They are the in-country women team scientists and in-country women within the targeted pastoralists' families.

In-country Women Team Scientists

The program has seven women scientists/technicians directly involved in the Livestock Early Warning System project. One of the female scientists is the country coordinator for LEWS in Ethiopia. Three of the women are zone coordinators, another woman is a science advisor and the other two women are site managers. The following are their specific responsibilities, by country.

Ethiopia

Zinash Sileshi, Animal Scientist, is the in-country coordinator. A NIRS lab is scheduled to be functioning at the research station where she is located, by year four of the project. The time in which her project duties will include the coordination of that laboratory. She was recently appointed as the director for the National Livestock Research Program under the newly re-organized Ethiopian Agricultural Research Organization (EARO).

Tanzania

Stella Bitende, Forage Scientist, is the Arusha Zone coordinator. She has relocated to Arusha and holds the position as Zone Coordinator for Northern Tanzania. Margaret Kingankono is Site Assistant to Stella Bitende.

Uganda

Sarah Ossiya is a PhD student as part of a NARO training program, funded by the World Bank and Rockefeller Foundation, and studying at Texas A&M. She is conducting diet:fecal pairs analysis at ILRI-Debre Zeit, Ethiopia. Sarah is designated to setup and operate the NIRS lab in Uganda, in 1999. Grace Ebiyau is a Site Assistant/Technician. She has been a member of the LEWS team from its beginning. Grace collected and processed a major portion of the original samples and data from Uganda. Dr. Emily Twinamasiko coordinates a sampling zone in Uganda. She is the National Research Coordinator for veterinary medicine and animal health.

In-country Women as Target of Project

The LEWS program is designed to be sensitive to types of livestock and sources of feed. In many of the geographic areas encompassed by the program, livestock ownership and management is a gender issue with women owning and having access to income from small livestock and chickens, while the males control the larger animals. The program will address gender issues as they relate to these and other socioeconomic practices.

Policy

It is important that the governments develop flexible contingency policies, or storage plans, that they can implement as needed. The LEWS team views this issue important because certain population segments (e.g., pastoral communities) may be more vulnerable than others to small variations in conditions. Thus, researchers and policy makers must be conscious of how pastoralists (as well as other socioeconomic groups) respond to climatic shocks.

Contributions to Policy

This project will contribute to policy that relates to food security of pastoral and mixed farming populations in East Africa. It will help reduce risk of loss of livestock populations and human life in the arid, semi-arid and savanna regions of East Africa. Timely analysis of livestock and human security in the pastoral regions of East Africa are critical for famine and drought mitigation policy within national governments and international donors/food relief organizations. This state-of-the-art technology will help address a critical component of the necessary infrastructure to address this identified policy need. The project is designed to provide national and international policy makers with innovative decision support information systems, tools and methodologies for an increased early warning capacity for the pastoral communities in East Africa.

Steps taken to insure policy makers involvement

The crisis mitigation program in ASARECA will be the primary mechanism used to establish critical communications between the on-site monitoring program and in-country policy decision-makers. The main step is the inter-regional coordination of key NAR personnel involved in the livestock early warning system program and the establishment of the needed NIRS laboratories and analytical capacity of each country's team members. The LEWS team will work intensively with the ASARECA organization infrastructure to foster interregional coordination as part of their crisis mitigation program. As far as establishing NIRS labs and analytical centers throughout the region, the LEWS team will work with ASARECA to coordinate the needed dialogue to insure NAR organizational cooperation across regions in setting up the labs, assigning key personnel and maintaining the necessary equipment.

Each in-country team has determined an action plan to work with the appropriate decision making bodies in their respective country. In-country teams, individuals involved in policy making in their governments, and local community leaders within each explored option for the best linkages with the project activities.

A National Workshop on "Early Warning System For Monitoring Livestock Nutrition and Health in Ethiopia", was held in February 4, 1998 at Ethiopian Agricultural Research Organization, Addis Ababa, Ethiopia. National, regional government and non-government organizations attended the workshop. Drs. John Corbett and Jerry Stuth of LEWS-TAMU group presented papers. One of the resolutions of the workshop was the establishment of a technical committee to work on Livestock Early Warning System in Ethiopia. The

committee will work under the overall auspices of the National Disaster Prevention and Preparedness Commission.

Preparations are underway for an early warning workshop for policy makers in East Africa to enlist their support and to work with our various in-country teams. The workshop is intended to make stronger linkages with the people in the project's household monitoring systems and the key government policy makers in each country. Participants from the targeted countries, NARS researchers within these countries and staff in ILRI and Texas A&M University are expected to participate. It is believed that discussions among national decision-makers, policy advisors and the collaborating NARS researchers should be initiated at the outset of the research. The reason is that this will ensure that the research is influenced by policy needs and that, in turn, the technical results and recommendations have an impact on innovative development policies for pastoral communities. The workshop will, therefore, focus on an agreement of mechanisms for a two-way information flow between researchers and decision-makers in the region.

Outreach

Involvement of local extension officers were an integral part of the pastoral monitoring network. To establish the pilot collection routes, local extension officers were contacted and met with the in-country NAR, university or ILRI coordinator to help locate high impact sampling sites (e.g., water points, routing concentration points), identify herders and introduce the samplers to the herders to facilitate fecal collections and herd profiling interviews. In some instances, extension officers identified villages where the livestock were corralled at night and interviewed the families for in-depth characterization of the herds sampled. The optimum organizational structure is still being finalized for the rural monitoring networks. The strongest probability for people to handle the logistics are extension, NAR and NGOs to be integrated to cover the geography of the monitoring system. People within rural schools and clinics are, eventually, likely to be involved along with NGO and PVO on-site personnel.

Development Impact

In the section of development impact are the environmental impact and relevance, agricultural sustainability, contributions to U.S. and host countries agriculture, linkages and networking and collaboration with international research centers.

Environmental Impact & Relevance

Some environmental impact will be realized in the decrease of land degradation by notifying pastoralists of the changes (decreased nutrient composition) occurring to the range 6-8 weeks earlier than the current information provides; thereby, leading to the rotating (migrating) off the affected range before an irreversibly detrimental trend intensifies.

Agricultural Sustainability

The rangeland will become more sustainable for the pastoral way-of-life with timely livestock movement and destocking 6-8 weeks advanced notice of forage defoliation and significant weight loss in livestock, from the affected rangelands and resultant decreased land degradation. The rangelands will become more capable of sustaining long-term quality grazing from livestock, because with the livestock being removed from the affected range 6-8 weeks prior to detectable poor conditions, the higher quality forages

will not be selected to the point of no return. Also, there will be less erosion since the soils will be more stable due to higher forage cover.

Contributions to U.S. Agriculture

The establishment of improved NIRS predictions of diet quality of livestock will have significant impact on the quality of predictions provided to ranchers throughout the USA via the national service lab at the Grazingland Animal Nutrition Lab, at Texas A&M University. Currently, this lab provides nutritional advisories to over 1300 ranchers throughout the USA via the NIRS/NUTBAL nutritional management system. The linking of the incoming weather data on a near-real time basis for both the PHYGROW and APEX models will help build the foundation for regional drought and stocking advisory systems currently being proposed for the USA. Development of the methodology for the classification of effective environments through the use of the SCT tool will lead to more robust impact assessment of technologies in a more spatially explicit manner in the USA.

The technologies assembled and used in this project will be directly transferable to USA grazinglands. The new emerging Grazing Lands Conservation Initiative (GLCI) will be a direct beneficiary since the technology can be directly adopted by NRCS for application nationwide. This should reduce drought and market induced risk to USA livestock producers and improve production efficiencies, all objectives of the new Farm Bill and the Funds for Rural America program.

The LEWS team believes that the technology package designed for East Africa will help address rangeland health issues in the USA and help establish regional stocking advisory systems. It will also provide a framework for remote client monitoring system for technical advisors (public, private, corporate) and enhance development of science education programs for rural America.

Furthermore, stable societies in Africa are both a direct and indirect benefit to the USA in terms of direct aid costs and costs of political instability. This project is expected to provide US policy organizations with more timely information to allow a more precisely measured response to developing conditions.

A series of USA-based corporations will provide the technical equipment needed in the project, including NIR spectrophotometers, computers, GPS units, etc. When fully implemented, the system established in East Africa will likely be repeated in many other regions of the world, increasing international sales of these USA-based companies.

Contributions to Host Country

The contributions to the East African nations involved in the LEWS project include the ability to foresee and prevent, prepare for and mitigate or resolve crisis and conflict in a more timely manner than currently. The current set of monitoring programs offers information of initiating conditions (e.g., weather and remote sensing information) and a delayed post-effect (e.g., cattle weight and body condition loss) appraisal system. The innovative LEWS state-of-the-art contribution, based on NIRS livestock fecal profiling technology and spatially referenced modeling of emerging forage/crop conditions, will add a new dimension to the existing monitoring programs in East Africa. The LEWS addition to the current monitoring programs allows more flexibility in decision making from the household level to the policy maker by providing the ability to predict responses, such as impending livestock mortality by kind and class of animal and losses in forage supply and decline in milk production. Thus, more timely destocking strategies will allow pastoralists to maintain their assets through crisis and assure greater ecosystem integrity to

respond more rapidly after droughts run their cycle.

Also, during this first year, the LEWS project has focused on the formation of human capital through a network of scientists and organizations across the East Africa region, which is founded on a common purpose and protocol to establish an advanced livestock early warning system that is regionally cohesive. Educational and technical contributions include one NIRSystem laboratory established in ILRI - Debre Zeit, Ethiopia, and technicians trained to use the instrumentation and various workshops designed to establish validation sites and protocols. Other equipment (e.g., GPS units, computers, software, etc.) has been provided to the in-country team leaders and zone coordinators.

Linkages and Networking

The LEWS project is co-located in an office in the ASARECA office, at ILRI, Nairobi, Kenya, as part of the Crisis Mitigation Program. A portion of a program manager's time has been allocated from ASARECA crisis mitigation funds to serve as an ASARECA-CRSP-LEWS coordinator. This person works under the supervision of Dr. Jean Ndikumana, executive secretary for ASARECA.

FEWS and GIEWS have identified key contact people to work with the national data center. Sampling zones have been established and key on-site personnel for both organizations have been identified. A visit to Djibouti established linkage with IGAD as it relates to the Greater Horn of Africa Program and ASARECA's role in crisis mitigation.

We established contact with USAID mission in Kampala, Uganda. We met with Ron Stryker, Chief-Agriculture and Private Sector Office, USAID, Gaudensia Kenyangi, USAID liaison with Heifer International, and David Mutazinawa in June 1998. Mr. Mutazinawa was designated as our primary contact person at Kampala for the LEWS program given his connection with the FEWS program. Ms. Kenyangi was provided as our contact for potential training opportunities within the Heifer International program. The entire LEWS-Uganda team attended the meeting at USAID as a show of solidarity within the project. Ron Stryker provided us names of critical contacts at the mission including Rob Rose (FEWS Contact) and Mike Foster (Global 2000 contact).

Computer systems were sent to East Africa and were established to foster electronic mail capacity at validation sites. The search is in progress to locate other organizations in the proximity of the sampling zones that could be linked for e-mail capacity.

Some specific international donor organizations were targeted to develop collaborative efforts. Some of the organizations were ILRI, Rockefeller Foundation, Danish International Development Agency (DANIDA) and International Center for Research in Agroforestry (ICRAF) in the region, as well as NGOs such as FARM AFRICA, PENHA and World Vision. Linkages with the various international research organizations are critical to provide the nucleus of infrastructure for the more advanced technologies in the early phases of the project and assist with building robust sampling routes within each country.

Collaboration with IARCS and Other CRSP's

The LEWS project has integrated its activities with ILRI in the development of the ASARECA crisis mitigation. Other collaborations include chronic under-nutrition studies in livestock and enhanced NIRS fecal profiling.

Other Contributions

Support for Free Markets and Broad-based Economic Growth

An early warning system will allow a broader assessment of emerging conditions, which will increase the level of preparedness and allow mitigation of the effects of droughts. This reduced drought risk will help promote the pastoral assets, which in turn can bring about a local economic growth and purchasing power. It will also allow the local governments to concentrate on development rather than relief. This is likely to result in increased trade and emergence of agricultural enterprises.

Contributions to and Compliance with Mission Objectives

Achievement of food security and improvement of the livelihood of the people in the Greater Horn of Africa by mitigating the effect of recurrent droughts and famine has been an important objective of the Greater Horn of Africa Initiative spearheaded by the USAID. It is anticipated that the development of an improved early warning system, and finding better ways of linking it to responses from government and various donor agencies, will go a long way in meeting this objective.

Concern for Individuals

The project is designed to secure working relationships with households and individual pastoralists. The project staff is sensitive to the fact that the pastoralists, whose livelihood depends on livestock, are the keys to the success of the project. To a large extent, the outcome of the project will depend upon the participation and the commitment of the local people and the ability of the project personnel to empower, motivate and involve them.

Support for Democracy

A livestock early warning system will improve the capacity of the peoples in East Africa to monitor and understand the dynamics of food security within their borders and throughout the region. Alerts, with respect to droughts and other natural disasters, from a livestock early warning system will reduce mass movements of people and livestock, which have been traditionally sources of conflicts. An improved early warning system, such as this, will create more stable and democratic societies where individual opportunity for prosperity and well-being is greatly enhanced.

Humanitarian Assistance

The need for humanitarian assistance usually emanates from poverty-related degradation of natural resources. An early warning system for livestock is essential both for food security by protecting the natural resource base and disaster preparedness. A proactive early warning system will help in making people in the region less vulnerable to disasters by alerting them of impending crisis and provoking a humanitarian assistance response from local and international relief systems (e.g., governments, donor and NGOs).

Leveraged Funds and Linked Projects

Leveraging of funds is an approach that is essential to the success of this project. Corporate entities are involved that have a vested interest in LEWS. Particularly, it was thought that the manufacturer, Foss NIRSystems (formerly Perstrop Corp), would be a key player in equipping the proposed 5 national NIRS laboratories to handle the fecal profiling

system. The plan was to obtain letters of commitment from Foss to allow purchase of the machines at much reduced prices. Also, Dell Computers Inc. was targeted to help provide computing capacity to the sampling locations throughout East Africa, including placement in extension offices, clinics and schools. Dell has targeted East Africa as a market development area for its line of personal computers. To help reduce transportation costs for sampling the regions, we planned to ask major motorcycle manufacturers to help donate or provide motorcycles at low cost to the program. Currently, Dell and motorcycle companies have not responded.

US support for the project was critical, as well. There were plans to work with the Grazinglands Technology Institute, within the USDA-Natural Resource Conservation Service, to help establish a mirror program in the USA, through their agency, to assure that technology developed within LEWS would be directly transferable back to the USA. This would assure that the technologies developed in East Africa would help build an infrastructure, which directly benefited US livestock producers.

Training

Long-Term Training

LEWS has funded academic fees for a Ph.D. program for Mr. Stephen Byenkya in the Animal Science Department at Makerere University under the joint supervision of Dr. Felix Bareeba and Dr. Jerry Stuth. NARO has agreed to pay his salary and provide him the necessary equipment and facilities as well as relief time to pursue research and academic studies. Mr. Byenkya is a critical member of the LEWS team in charge of the coordination of all the field work, monitoring and validation studies. A NARO vehicle was repaired for his use via USAID/ASARECA crisis mitigation funds. A preliminary title for his research would be "Impact of Changing Land Use on Traditional Ankole Pastoralist Systems." The TAMU-LEWS team agreed to prepare a document of understanding outlining the general thrust of the training program for the concurrence of NARO and Makerere University.

Discussions are under way for Angello Mwilawa to get sponsorship for a Ph.D. study under Dr. Jerry Stuth at Texas A&M University through the Tanzanian Agricultural Research Program II funded by the World bank /IDA. A likely scenario will be for Angello to come to Texas A&M for his course work and return to Tanzania for his field work in an area that fits within the LEWS subproject. The topic of his research will be developed jointly the Department of Rangeland Ecology and Management at Texas A&M and the Department of Animal Science at Sokoine University at Morogoro, Tanzania.

A joint proposal by the Animal Nutrition Group of ILRI Debre Zeit and LEWS subproject has been approved and funded by USAID/ILRI/Spain. The study will focus on the use of NIRS for estimating condensed tannins, NDF and intake prediction. There is also a possibility this project will be merged with another one by the ruminant Nutrition Group at the University of Florida. Our counterparts at ILRI have indicated to us that they would like to fund a graduate training (MS) for Dawit Negassa at Texas A&M University under the Joint supervision of Dr. Jerry Stuth and Dr. Victor Ummuna (ILRI Debre Zeit). Dawit was already trained on the use of NIRS machines at GAN lab, Texas A&M and is currently running the LEWS NIR lab at ILRI Debre Zeit, Ethiopia.

Short-Term Training

Training in Design and Implementation of Early Warning and Crisis Mitigation for Livestock in East Africa, November 17-21, 1997. The LEWS project workshop was funded by a grant provided to ILRI as part of the USAID CGIAR-University Collaboration

program on training. This training was attended a team of 25 scientists from five countries in East Africa.

A workshop and hands-on training on Almanac Characterization Tool (ACT) Uganda, a packaged set of spatial data and query tools targeted for use in agricultural and natural resource management activities, was held September 15-19, 1998, Uganda. LEWS - Uganda team members, national Research organizations and NGOs attended the meeting.

A similar workshop and hands-on training on Almanac Characterization Tool (ACT) was held for the Ethiopian team on September 20-26, 1998 in Addis Ababa, Ethiopia.

Ad Hoc GIS Working Group. April 5-6, 1996. Fort Collins, Colorado. The following key individuals, working with GIS applications in their respective subprojects in the SR/GL CRSP program, attended the April 5-6, 1998, meeting:

Texas A&M University: Paul Dyke, Jerry Stuth, John Corbett, Abdi Jama.

Utah State University: Paul Box

Colorado State University: Mike Coughenour, Jim Ellis

University of California Davis: Emilio Laca

University of Wisconsin - Madison: Robert Langstroth

A National Workshop on Early Warning Systems For Monitoring Livestock Nutrition and Health in Ethiopia, February 4, 1998, Addis Ababa, Ethiopia. Sponsored by SR/GL-CRSP and Ethiopian Agricultural Research Organization. Regional and national government and non-government organizations attended the workshop.

Comments

This was a busy year where we concentrated on establishing organizational and communication infrastructure for the teams and setting up the validation studies across the region. A network of core in-country LEWS teams in East Africa were put in place and communication infrastructure to facilitate contacts and exchange of views and information flow was initiated among the LEWS teams in the region and TAMU. Each team initiated contact and worked with the appropriate decision making bodies in their country to enlist their support and to set the stage for a workshop to bring in the full team and those individuals in government (policy makers, decision makers) and local community leaders. We are seeking external funds and have submitted a proposal to USAID/ILRI-SPAN. We believe that it is critical that we bring national decision-makers and policy advisors into discussions with the involved NARS researchers right from the outset of the research. This will ensure that the research is influenced by policy needs and that, in turn, the technical results and recommendations have an impact on new development policies for pastoral communities. The workshop will, therefore, focus on the present objectives of the LEWS project, and on an agreement for mechanisms for a two-way information flow between researchers and decision-makers in the region. We also initiated dialogue and contacts with USAID missions in Uganda and Kenya, IGAD and NGOs in several of the host countries to explore areas of collaboration and information sharing which could assist our common objective of developing solutions to the regional issues regarding early warning and food security.

Site validation and paired fecal sampling trials went well in all countries except Eritrea despite delays due to extended rainfall in most countries. The group at Eritrea had

difficulties getting clearance from their ministry to use the research facilities they proposed and the border conflict with Ethiopia exacerbated the situation. Recent contacts indicated that the situation is stabilizing and our team is returning back to their positions to restart the activities of the LEWS project.

Collaborating Personnel

United States of America

Abdi A. Jama, Assist. Research Scientist, Texas A&M University.

Jerry W. Stuth, Professor, Texas A&M University.

Jimmy R. Williams, Crop Systems Modeler, Texas A&M University.

John Corbett, Research Scientist, Texas A&M University.

Paul Dyke, Research Scientist, Texas A&M University.

Ethiopia

Ato Tesfaye Kumsa, Researcher, Institute of Agricultural Research.

Azage Tegegne, Animal Scientist, International Livestock Research Institute.

Gebre Berhane, Professor, Makelle University.

Paschal Osuji, Coordinator/Animal Nutritionist, International Livestock Research Institute.

Victor Umunna, Animal Scientist, International Livestock Research Institute.

Zinash Sileshi, Animal Production Researcher, Ethiopian Agricultural Research Organization.

Eritrea

Berhane Kiflewahid, Dean of Ag Sciences, University of Asmara.

Negusse Fessehaye, Livestock Scientist, University of Asmara.

Kenya

Henry Cheruiyot, Assistant Director for Range Research. Kenya Agricultural Research Institute.

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Margret Kingamkono, Animal Scientist, Selian Agricultural Research Institute.

Ndelilo Urrio, Tanzania Coordinator, Animal Scientist, Sokoine University.

Rashid Kidunda, Range Ecologist, Sokoine University of Agriculture.

Stella Niyikiza Bitende, Forage Scientist, Selian Agricultural Research Institute.

Suleiman Kaganda, Animal Scientist, Ag. Research & Training Institute.

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Cyprian Ebong, Livestock Production, National Agricultural Research Organization.

Emily Twinamasiko, Veterinary Medicine/Animal Health, National Agricultural Research Organization.

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Abstracts and Presentations

- Jerry W. Stuth, Paul Dyke, Abdi A. Jama and John D. Corbett (1998). The Use of NIR/NUTBAL, PHYGROW, and APEX in a Meta-Modeling Environment for an Early Warning System to Monitor Livestock Nutrition and Health. National Workshop On Early Warning System for Monitoring Livestock Nutrition and Health, Addis Ababa, Ethiopia, February 4, 1998. Sponsored by the Small Ruminant Collaborative Research Support Program (SR-GL/CRSP) in collaboration with the Ethiopian Agricultural Research Organization (EARO)
- John D. Corbett, Jerry Stuth, Paul Dyke, and Abdi Jama (1998). New Tools for the Characterization of Agricultural (crop and livestock) Environments: the identification of pastoral ecosystems as a preliminary structure for use in sample site identification. National Workshop On Early Warning System for Monitoring Livestock Nutrition and Health, Addis Ababa, Ethiopia, February 4, 1998. Sponsored by the Small Ruminant Collaborative Research Support Program (SR-GL/CRSP) in collaboration with the Ethiopian Agricultural Research Organization (EARO)