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

Narrative Summary

The Livestock Early Warning System (LEWS - http://cnrit.tamu.edu/lews), currently under development in East Africa, involves linkage of several new technologies capable of predicting forage supply relative to long term productions and trends in future body condition of livestock using a network of carefully selected households reflecting a variety of effective environments across diverse landscapes of East Africa. These tools include spatially coherent satellite-based weather data and NDVI greenness data, geospatial tools such as ArcGIS, GS+ and Almanac Characterization Tool (ACT), fecal profiling technology near infrared spectroscopy (NIRS) linked with a livestock nutritional model (NUTBAL PRO), and a point-based biophysical grazingland model using PHYGROW. GIS co-kriging and kriging techniques are used to extrapolate point-based model output to non-monitored areas.

Spatial stratification of regions forms the sampling frame for defining "effective environments" or climatic clusters where sampling points are assigned throughout a given monitoring zone. Specification of actual monitoring points is targeted for maximum impact and representation of variations across the region. The focus is on accessible pastoral households, which share common climatic, edaphic, and production system attributes distributed throughout a region. For each sampling point, dominant landscapes are assigned modal or typical plant community which would fill the "pixel" of the 8x8 km grids generated from the METEOSAT satellite data and the AVHRR NDVI greenness data.

Once a sampling point has been defined (geo-referenced) and modal vegetation characterized, herd populations are estimated based on the sample of the household herd and known livestock population densities in the grazing radius of the household. In zones with sufficient human resources within the network, fecal samples are collected monthly from these households, sent to a national NIRS fecal profiling lab to determine diet protein and energy, and ultimately projections are made for animal performance and body condition, with advisories provided to the livestock owners, pastoral organizations, and village institutions.

Critical to the process is automation of the modeling process of linking biophysical models with satellite monitoring weather systems in collaboration with FEWS NET, EROS, and NOAA RFE satellite-based weather data. These automated products are found on the following web sites http://cnrit.tamu.edu/aflews and http://cnrit.tamu.edu/rsg/rainfall/rainfall.cgi in which daily deviations in forage production are computed along with daily satellite weather and dekadal NDVI or greenness data, processed by Texas A&M University Center for Natural Resource Information Technology and the ASARECA Crisis Mitigation Office. Model output is

channeled through key regional organizations, national EW agencies, district officers, NGOs, and community-based organizations.

Research

Problem Statement. 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 small holders, 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 area-specific 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 (e.g. NOAA RFE, NASA NDVI) offers information on locations of "initiating conditions" while the on-ground monitoring programs of markets, human conditions, and animal herd situations mainly reflect 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 emerging monitoring and analysis system, based on NIRS livestock fecal profiling technology and point-based biophysical modeling of emerging forage and animal conditions, adds 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, or 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 ecosystem integrity by allowing more rapid response after droughts have run their cycle.

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 and forage supply 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. The foundation of this process is the use of the same suite of tools (routine monitoring and management advisory systems) used by outreach organizations (e.g. NGO, Extension).

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 relatively simple monitoring and decision support tools integrated in a low-maintenance computer automation system whose output is linked to relevant organizations at the international, national, and local level.

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 advance the notice of emerging negative trends on the current early warning systems in East Africa to allow more timely decision making and support decision making of pastoralists under normal and abnormal conditions.

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 Almanac Characterization Tools (ACT) used to assist in the characterization of the selected zones, (2) the Nutritional Management System (NIRS/NUTBAL PRO) for monitoring feed quality from feces of the ruminant livestock, and (3) Plant Growth/ Yield/Hydrology Simulation Model (PHYGROW) for monitoring grazingland herbage and crop production, respectively. A complete description of these tools can be viewed at http://www.brc.tamus.edu/lews.

Progress.

Activity One: Institutionalization Process for LEWS

Objective: Fully operationalize rangeland/ livestock monitoring systems in each of the LEWS regions in Kenya, Uganda, Tanzania and Ethiopia to initiate the institutionalization process in order to better support the needs of early warning, relief, and crisis mitigation agencies.

The LEWS system was fully operationalized using the updated PHYGROW automation module with 10-d updates and can be viewed on the web (http://cnrit.tamu.edu/aflews) for all of the zones originally proposed: Southern Ethiopia, Northern Kenya, Southern Kenya, Northern Tanzania, Central Tanzania, and Southwest/Central Uganda. The African LEWS data on forage conditions is reaching 49 countries with over 1200 daily hits and over 2.1 GB of data downloaded on forage deviation and supply. Kenya, Tanzania, and Uganda are the largest users of the forage deviation and map data in East Africa. The use of the METEOSAT RFE data is working out very well. The weather data provided at the African Weather site that was created by LEWS (http://cnrit.tamu.edu/rsg/rainfall/rainfall.cgi) experienced over 24 MB of download requests to 17 countries in

the last eight months. A single grid download of a given grid location is approximately 10K. Kenya and Tanzania are the largest users of the weather data in East Africa.

LEWS staff was stabilized and rapidly brought up to operational capacity in Northern Tanzania. We have recently worked out an agreement with the Oromia Regional Agricultural Research Institute to install one of their staff from Adami Tulu in the Southern Zone of Ethiopia after the departure of the EARO staff person located there. All five NIRS labs are fully operational in the four countries with all staff trained by TAMU experts. We successfully expanded monitoring zones into Northeastern Kenya, Laikipia district of North Central Kenya, and the Afar region of Northeastern Ethiopia as indicated in our 2001-02 workplan. FarmAfrica is managing the Afar zone for LEWS. A new zone was just recently started in collaboration with Save the Children-UK in the northern part of the Somali region of Ethiopia (Fig. 1). We have not been able to get the Western Tanzania site fully functioning due to limitations in staff skills to conduct rangeland surveys at this ASARECA-funded site. We plan to facilitate Northern Tanzania LEWS to assist them in setting up the sites. Maps and tabular analysis are distributed via the Internet and Worldspace satellite radios using container capacity of the Arid Lands Information Network and RANET. ALIN has worked with LEWS to install satellite radios in 25 key NGO and government agencies located in pastoral communities in East Africa (Fig. 2). The information is also distributed via the jointly produced "Greater Horn of Africa Early Warning Bulletin" with FEWS NET, USGS, RCMRD, DMC, and WFP. LEWS provides the pastoral component to this regional newsletter. Over 400 decision makers receive this newsletter.

Figure 1 - Location of new monitoring points established in collaboration with Save the Children - UK in the northern part of the Somali region of Ethiopia.

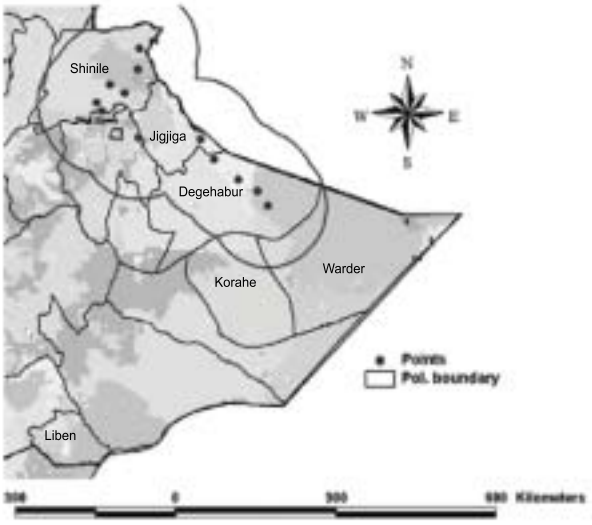

Figure 2 - Location of site where ALIN and LEWS have installed satellite radios to distribute the LEWS situation reports and forage deviation maps.

Activity Two: Spatial Extrapolation Technique Development

Objective: Develop techniques to extrapolate point-based biophysical models to better serve the regional scale livestock early warning systems.

Cokriging has provided a robust method of linking point-based modeling of forage standing crop with NDVI data across the region studied. Cokriging is a geostatistical interpolation technique that takes advantage of the cross-correlation between a spatially sparse data set and one that is spatially rich. For LEWS, biophysical modeling output is the primary variable (spatially sparse) and NDVI is the covariate (spatially rich). The minimum forage available for grazers output from PHYGROW for each monitoring point is paired with the NDVI values on a dekadal (10 day) basis. If high correlation exists between forage and NDVI, cokriging is conducted for the entire LEWS region. Out of 40 dekads analyzed so far in 2001-2002, good correlations existed (r^2>0.6) in 38 of the cases and cokriging did a good job of estimating forage across the region. Ground verification of predicted forage standing crop resulted in R^2= 0.92 and SEP= 262 kg/ha in 82, 8x8 km grid monitoring sites across 8 zones.

We have completed field sampling for 30 locations in Laikipia district and 15 non-sampled areas to test the cokriging predictions. Final analysis is expected to be completed by Zola Gibson in February 2003 as part of her MS thesis.

The regional maps created by the cokriging analysis were able to pinpoint areas of poor vegetation condition and drought and are key components of early warning. Site monitors confirmed the severity of the situation in these hot spots (Fig 3).

A test was conducted in Southwestern and Central Uganda for the 30 households where monthly samples of georeferenced fecal samples were collected, scanned by the NIRS lab in the region, and subsequently cokriged with NDVI data to produce maps of diet quality (Fig. 4). Standard error of prediction of CP was plus or minus 1% units.

Initially we developed a forage deviation projection by summing the precipitation over a 90-d period for each Julian day in the year

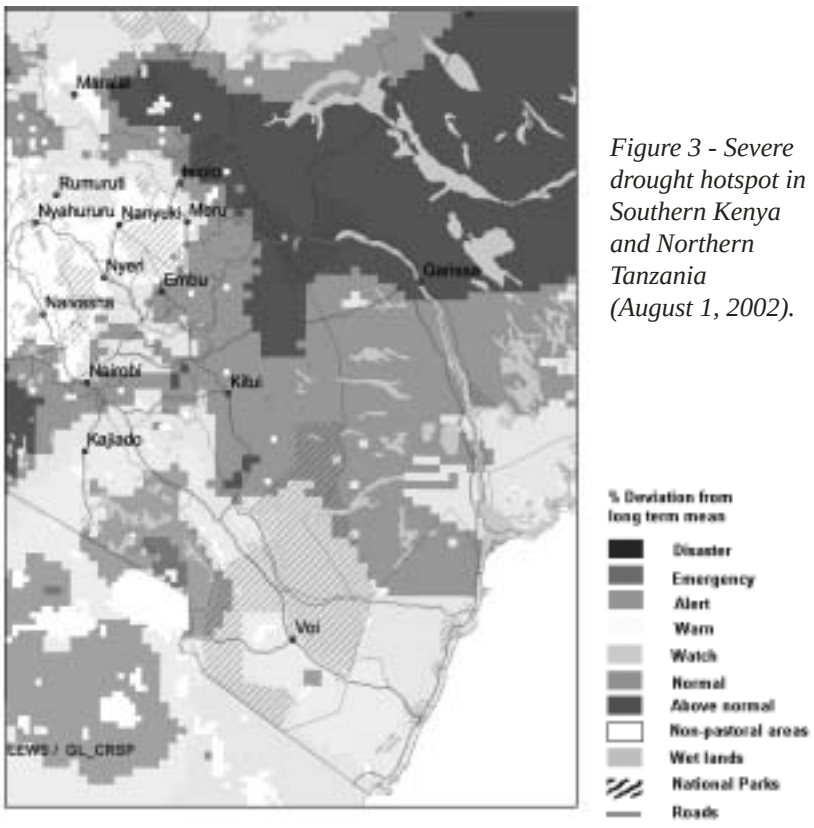

Figure 3 - Severe drought hotspot in Southern Kenya and Northern Tanzania (August 1, 2002).

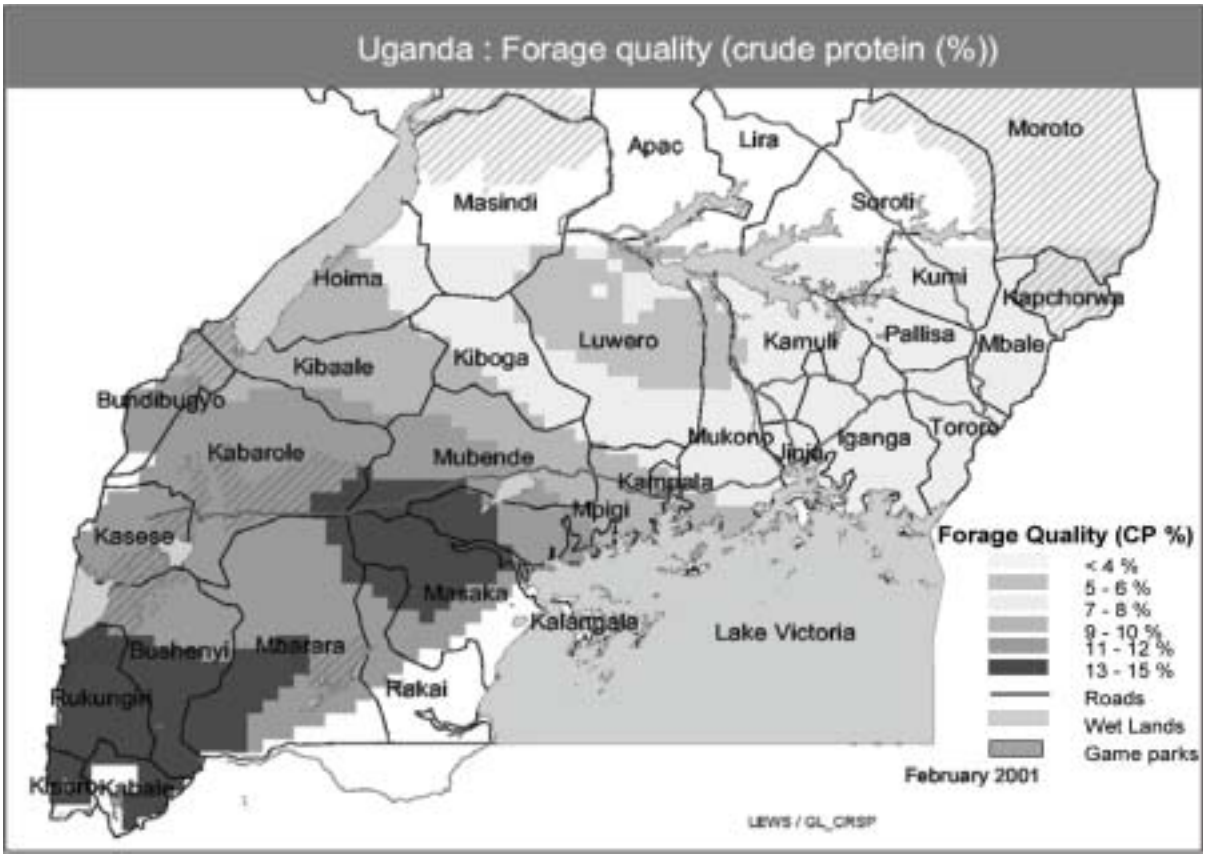

Figure 4 - Map of dietary crude protein of cattle in Southwestern Uganda (8X8 km grid resolution) using georeferenced fecal samples cokriged with NDVI greenness data.

across all generated 30 years. The 25th, 50th, and 75th percentile year was then extracted for the corresponding day of the year for a given projection date and the PHYGROW model run for each of the 250+ points. The results were encouraging, but we experienced several incidences where below normal years produced better forage conditions toward the end of the 90-day projection than above normal years due to the amount and distribution of precipitation events. To overcome this problem, we used a Fourier spectral analysis using additional denoised wavelet analysis to condition NDVI greenness data from 1980 to present to create a Box and Jenkins time series model with the denoised NDVI data co-regressed with the associated point-based model's grazed standing crop using the ARIMA procedure in SAS. This resulted in standard errors of projected standing crop well within sampling error of our teams, out to 65 to 90 days beyond the specified reporting date. This process is fully automated at this time and is part of our distributed products.

We received funding in the last two months of the fiscal year to design and develop a prototype mapserver for all the GIS data in LEWS and to design a mechanism for other projects in GL-CRSP to upload maps for their projects as well. As of this writing, we have implemented the MAPSERVER software from University of Minnesota as recommended by EEP/GL-CRSP reviewer, Dr. Bernard Engel. The site is undergoing design and testing but appears to be robust

enough to allow delivery of all the spatial data in the project. This product will be demonstrated at the October meetings of the GL-CRSP.

LEWS/GL-CRSP was selected as one of 12 projects to be featured at the Geographic Information for Sustainable Development forum in the World Summit on Sustainable Development, Aug. 26-Sept. 4, 2002 (http://www.opengis.org/gisd/default.htm). LEWS was also featured in Asmara, Eritrea on April 3-6, 2002 as part of the GISD/Horn of Africa-Great Lakes-East Africa Partner Meeting along with GSDI training and policy planning for WSSD AFRICOVER regional meetings. In July 2002, LEWS spatial products were featured at the ESRI 2002 Conference as part of the GISD OpenGis forum for Africa.

Activity Three: Enhanced Effectiveness of NIRS Fecal Profiling Monitoring Technology to Improve Livestock Management in East Africa

Objective: Establish regional analytical capacity to utilized NIRS technology for nutritional management of livestock in East Africa.

All the NIRS labs have been put in place on schedule as per our proposed timetable in the original grant. Staffing is in place, all equipment installed, and an MOU has been signed with each institution. The Kenya lab has been expanding its capacity to private ranchers,who have requested forage tissue analysis and assistance on chicken nutrition.

A fecal solar drier was designed by engineers at Egerton University and further modified by our LEWS teams across East Africa. These devices help move drying to the location of the site monitors and cut delivery costs by eliminating the use of ice and ice boxes. These driers have been used for forage drying as well. No significant differences were detected between oven dried and solar dried samples for crude protein and digestible organic matter as predicted by the NIRS equation implemented in Kenya.

Working with the teams in East Africa, an updated NUTBAL PRO METRIC version of the software was deployed on August 1, 2002. The following functions were improved in the system: degree of fatness adjustment to gain efficiency and intake, and correction to the fecal output algorithm for high quality diets with DOM > 64% DOM/CP ratios <4 for mature, non-lactating cows. The milk partitioning function was adjusted for East African breeds.

A fecal NIRS calibration equation for Africa was developed which allows prediction of dietary crude protein (CP) and digestible organic matter (DOM) of free ranging livestock with a high degree of accuracy. Cattle calibration was CP R^2= 0.95 SEP=0.87, DOM R^2=0.90 SEP=2.89; Sheep calibration was CP R2 = 0.97 SEP=0.78, DOM R^2 = 0.94 SEP=2.26; and Goats CP R2 = 0.97 SEP= 0.79, DOM R^2 = 0.95 SEP=2.86. New data from other grazinglands of the world are currently being integrated into the system to release a global calibration equation for use worldwide.

Activity Four: Institutional Capacity Building

Objective: To build technical support staff skills in use of the LEWS toolkit for active monitoring and decision making in national EWS agencies, IGAD and FEWS NET, and critical NGOs.

To assist in development of the monthly "Greater Horn of Africa Early Warning"

newsletter produced in conjunction with FEWS NET, USGS, Regional Center for Mapping Resource Development, Drought Monitoring Center (DMC) and World Food Program, LEWS placed a more advanced computer with desktop publishing software in DMC to insure the newsletter can be produced without computer problems. LEWS/GL-CRSP provides the pastoral conditions component of the newsletter. This newsletter goes out to well over 400 key decision makers in the Greater Horn of Africa.

We were able to establish a WorldSpace radio unit and facilitate connection to the internet for the Kenya Ministry of Agriculture's office responsible for communicating warnings to and from extension personnel throughout Kenya. Our situation reports for Kenya are distributed every 10 days to all extension personnel in pastoral and agro-pastoral regions of Kenya.

We conducted training for all staff in all zones in setting up sites and conducting field verification of forage standing crop predicted by the PHYGROW model coupled to the METEOSAT RFE weather data. We currently have over 250 sites implemented in the region and 90 have been verified to date.

Working with ALIN and ASARECA CMO's Communication Officer, Rapheal Marambii, we were able to set up WorldSpace radios with data links to computers in the following locations: 5 units in the Arusha region of Northern Tanzania, 5 units in Central Tanzania, 3 units in Laikipia District of Kenya, and 5 sites in Northern Kenya. Once a day, these units allow a 15-minute download of our regional maps and analysis by ALIN and daily situation reports by RANET in .pdf format.

We also established a mechanism to produce a series of 10-day situation reports distributed via WorldSpace satellite radios on the RANET network (http://www.meteo.go.ke/ranet/lews/lews.htm) and Arid Lands Information Network (http://www.alin.or.ke/data/partners.htm). During the last year, RANET and ALIN collaborated with us and placed over 80 satellite radio information nodes in East Africa and currently mirror our website and broadcast our reports monthly in the case of RANET and decadal in terms of ALIN.

LEWS was selected as one of 12 projects in Africa as an example of "low hanging fruit" using GIS as a development tool as part of the Geographic Information for Sustainable Development (GISD) Forum at the World Summit on Sustainable Development in Johannesburg, South Africa. See page 13 of the information brochure currently distributed by USAID at (http://www.opengis.org/gisd/docs/GISD_booklet_02_bf.pdf).

The information flow of the LEWS reports impacted a large number (>600) of NGOs, pastoral organizations, EW agencies, and government organizations. This is provided below.

Tanzania (Northern)

Margaret Nana Kingamkono, SARI/ Arusha, Female
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Marcelina Minja, SARI, Female
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Martin Halid, DALDO, Male
Reginald Swai, DALDO, Male
Enrisha Msangi, DALDO, Male
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Dr. E.P. Osanga, DALDO/Same, Male
Dr. Rwegasira, DALDO/Monduli, Male
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Dr. Uliky, DALDO/ Hai, Male
Dr. Tigwela, DALDO/Mbulu, Male
Mr. Simon Soinda, Ngorongoro District Council, Male
S.A. Msuya, Mwanga District, Male
Mr. Lucas Ole Mukusi, Simanjiro District, Male
Mr.Bakari Lukuni,Same District, Male
Mr. Gabriel Bukhay, Babati District, Male
Mr. Leonard Ulotu, Hai District, Male
Mr. Isaac Bayo, Mbulu District, Male
Mr. Lembile S. Kone, Kiteto District, Male
Wilson Rutta, WorldVision/Arusha, Male
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Martin Ole Saning'o, ILARAMATAK LORKONEREI/Arusha, Male

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Christopher Ulime, Senior Livestock Field Officer, Male
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Antalo, DALDO/KONDOA, Male
Manetho, DALDO/KILOSA, Male
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E.N. Pallangyo, RAA/Dodoma, Male
Musa Midugu, RAA/SINGIDA, Male
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*RLA = Regional Livestock Adviser to Regional Commissioner
*RAA = Regional Agricultural Adviser to Regional Commissioner

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Chris Erukudi, World Vision/Lodwar, Male
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Allyce Kureya, SNV, NDO/Nairobi, Female
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Rose Omaria, NARO, Female
Steven Byenkya, NARO, Male
Grace Ebiyau, NARO, Female
Charles Sudhe, NARO, Male
Everlyn Komutunga, NARO/Agro-metereology, Female
William Olaho-Mukani, MAAIF, Male
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Mr. Majugu A.W., Department of Meteorology, Male
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Andrew Mutengu, FEWS NET, Male
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Bugeza J., Site Monitor/Lwampanga, Male

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Activity Five: Pastoral Livestock Marketing in Northern Kenya and Southern Ethiopia (joint with PARIMA)

Objective: Identification of priority interventions to promote more timely livestock sales in relation to stress periods.

We have assembled a series of GIS and spatially relevant tabular data on livestock populations/market sales updated by LEWS teams in Northern Kenya and by agencies in Ethiopia and the transborder region of Somalia. Other spatial data for both teams

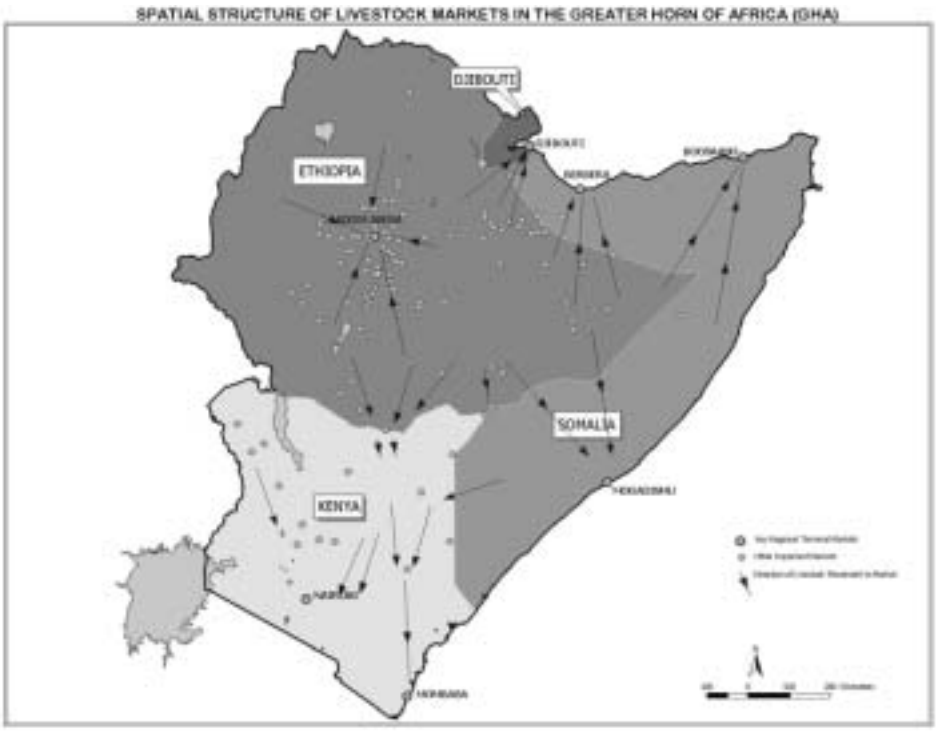

Figure 5 - Spatial structure of livestock markets in the Greater Horn of Africa

included: movement patterns, water resources, market location/prices/flow, forage resources (LEWS standing crop data back to 1998), conflict zones, disease hot spots, disease constraints, cross border trade volume/ locations, export locations and volume, abattoirs, quarantine locations and loading pattern, and locating of carcass chilling plants. Most of this data has been processed into ARCVIEW/ARCINFP 8.2. The MAP-SERVER software has been acquired from University of Minnesota and set up on the LEWS SunServer to accommodate all the GIS data on livestock markets as well as the array of LEWS map products. This allows LEWS and interested users to configure maps in any manner they wish to include in custom reports in the region. The basic framework of design of the spatial model has been completed with the CNRIT-LEWS programmers, and discussions with Chris Barrett and Peter Little have resulted in a consensus on how the spatial model should incorporate decision rules emerging from PARIMA. A rule-based object oriented framework was designed and coding is currently underway with a target completion in August 2003.

Gender

There are two categories of women that are impacted by the LEWS project: the United States and in-country women team scientists, and in-country women within the targeted pastoral communities. This past year, we had two female graduate students and one female systems analyst working in the TAMU-LEWS project in the USA. Currently, there are seven in-country women team scientists involved in the LEWS program. Two of the female scientists are country coordinators for LEWS in Ethiopia and Tanzania. Three of the women are zone coordinators and the other two women are

site managers. The following are their specific responsibilities, by country.

United States. A female M.S. graduate student, Ms. Zola Gibson, is nearing completion of her MS program at TAMU with graduation in May, 2003. She verified the prediction of PHYGROW in Laikipia district and surveyed pastoral communities on perception of drought. She worked with the Mpala Research Centre (http://www.nasm.edu/ceps/mpala) in Central Kenya.

Ethiopia. Dr. Zinash Sileshi, Animal Scientist, is the in-country coordinator for Ethiopia. Dr. Sileshi has been a member of our LEWS team in Ethiopia since the beginning of the project but was promoted to a National Coordinator in 1998. She is also the Director of Livestock Research for the Ethiopian Agricultural Research Organization (EARO).

Tanzania. Ms. Stella Bitende is the National Coordinator of LEWS in Tanzania. She is Assistant Director - Livestock Research, Ministry of Agriculture & Co-operatives, Division of Research & Development. The position is intended to provide a focal point for consultation on technical and operational details of the relevant commodity and research for the sub-program. Ms. Bitende, in her capacity as a Lead Scientist, represents the sub-program on collaboration issues with external partners in research and development as the need arises. Margaret Kingamkono, Ministry of Agriculture in Arusha, is the LEWS Northern Tanzania coordinator.

Uganda. Grace Ebiyau is a Site Assistant/Technician in Uganda. She has been a member of the LEWS team from its beginning, collecting and processing a major portion of the original samples and data.

Dr. Emily Twinamasiko coordinates fecal sampling activities in southwest Uganda. She is the National Research Coordinator for veterinary medicine and animal health.

DANIDA is funding a Ph.D. program at Makerere University for Ms. Rose Omaria, who is a practicing veterinarian in Uganda.

Ms. Omaria was provided intensive training funds by LEWS to come to TAMU to learn how to use the NIRS technology to develop pregnancy-testing calibrations for cattle and goats. Recent breakthroughs in pregnancy testing with NIRS at GANLab makes this a very important training event.

Two female technicians at Namulonge Agricultural and Animal Production Research Institute (NAARI) have been active on the project. They are Ms. Agnes Namagembe and Ms. Clementine Namazzi. They have participated in vegetation characterization, training of field staff, and fecal sample collection and processing. Three of the nine weather stations monitors are women.

Kenya. Mrs. Jane Sawe, a lecturer at the Department of Animal Science, Egerton University, has joined the LEWS zonal team in Northwestern Kenya. Ms. Elizabeth Muthiani has taken over coordination of the southern Zone of LEWS in Kenya.

Pastoralist Women. All of our Zonal and Country Coordinators have been advised to be gender sensitive in employment for the project activities and in planning training and technology development for livestock production. This was done in recognition of the important role that women play as livestock resource managers within pastoral societies in the target. Accordingly, the LEWS program addresses itself to various types of livestock and spatial/temporal availability of feed.

Within many pastoral societies, livestock ownership and management are typically specific, with women owning/gaining income from small types of livestock and men controlling the larger ones. Engendering LEWS efforts facilitates the integration of socioeconomic concerns such as division of labor and equitable access to resources.

In addition, many of the site monitors selected for monitoring in the pastoral areas are women. Extensive efforts have been made to identify households headed by women for selection into our monitoring route programs in all of the host countries. Three of the 15 households in SW Uganda are headed by women. However, women are known to be key players in livestock management and husbandry in East Africa even in the households headed by men.

Policy

Processes of Institutionalization of LEWS in East Africa

Based on early feedback from the ME, PAC, and EEP of the Global Livestock CRSP, the LEWS teams were challenged to design institutionalization plans for the coming years of the next funding cycle. These plans are summarized below by country. LEWS works closely with the Ethiopian Livestock Working Group (LWG). The LWA includes Ethiopian government agencies, United Nations agencies, and Non-governmental Organizations involved in livestock issues. The LWA is coordinated by FAO.

Kenya. In Kenya there is an extensive planning program underway to reorganize information flow from different EWS organizations in Kenya under a single, self-reliant unit called the "Early Warning and Food Information System Unit (EW&FISU) in the Ministry of Agriculture and Rural Development (MoARD). The MoARD has submitted a TCP to FAO to help this process to go forward. LEWS representatives, including the PI of the LEWS project, have met with Mr. James Oduor, coordinator in MoARD to discuss how LEWS could best be institutionalized in the reorganization process. The Arid Lands Resource Management Project (ALRMP) is being viewed by MoARD as a good working model to integrate LEWS technology in the EW&FISU framework. Several meetings have taken place with Mr. Oduor and Mr. Maalim, National Coordinator of ALRMP in the Office of the President to discuss institutionalization of LEWS in Kenya. As of this writing, we have verbal commitment to identify key people in MoARD and ALRMP to liaison with LEWS teams and arrange training, set up networks, and establish computing capacity for the unit. The EW&FISU framework would insure that all zones are covered by LEWS technology, considering that the mandate of ALRMP would be expanded to all pastoral regions of Kenya. Other collaborating organizations in the EW&FSU would include Kenya Meteorological Department, Department of Resource Survey and Remote Sensing, Central Bureau of Statistics, Ministry of Health, FEWS NET, FAO, and Arid Lands Resource Management Project.

Uganda. NARO has been identified as a focal point for LEWS because of its comparative advantage. NARO is under the Ministry of Agriculture Animal Industries and Fishery (MAAIF). MAAIF is mandated to collate and collect early warning products in agriculture and pass trends and recommendations to the Ministry of Disaster Preparedness, which is mandated to coordinate

responses on anomalies in the country. LEWS has also developed reliable linkages with Makerere University (Department of Animal Science), local government through district veterinary officers, NGOs, and CBOs in pastoral areas.

Ethiopia. LEWS continued dialogue with the national Early Warning Department of the Drought Preparedness and Prevention Commission (DPPC) of Ethiopia. DPPC has requested LEWS to train members of their staff and allied NGOs on LEWS tools and technology. It is expected that the technology and training will move forward once the systems function has been tuned to Ethiopia's extensive conditions and EARO has been set up with a functioning NIRS fecal profiling lab.

Tanzania. The Ministry of Agriculture has an established crop monitoring and livestock disease-monitoring program. The livestock component is linked with OAU-IBAR. We are targeting the LEWS technology suite toward the OAU-IBAR. The national coordinator of LEWS, Stella Bitende is heading up the discussion with the Ministry of Agriculture, the Ministry of Water and Livestock Development, and OAU-IBAR representatives. Recent reorganizations of the ministries and senior officers in the ministries has created a communication gap and discussions are underway to streamline the information flow. This discussion is in its infancy and we cannot provide any more insights on progress at this point in time.

ASARECA Crisis Mitigation Office. GL-CRSP LEWS has invested in intensive training of an information officer and a biophysical modeling technical officer in the ASARECA Crisis Mitigation Office (CMO) located at ILRI-Nairobi (see capacity building section). The TAMU LEWS group has been working with the CMO to help integrate the LEWS concept into the ASARECA AARNET activities. Enhancing/upgrading the information capability of the office has involved collaboration with the International Livestock Research Institute's Information Dissemination Office.

The goals of the ASARECA Crisis Mitigation Information System are:

1. To facilitate data and information flow between the LEWS teams in East Africa (NARS and universities), ASARECA-CMO and TAMU.
2. To facilitate data and information flow between the national and international institutions involved in early warning regarding weather, agriculture, and livestock.
3. To facilitate the dissemination of livestock early warning alerts from LEWS project to pastoral communities, local government leaders, and national policy makers in East Africa.

Forming Linkages with FEWS-NET and Major Regional Organizations

A partnership has formed with FEWS NET and LEWS along with the Regional Center for Mapping Resource Development (RCMRD), Drought Monitoring Center (DMC), USGS FEWS NET, World Food Programme, and Desert Locust Control Organizations to produce a monthly bulletin "Greater Horn of Africa (GHA) Food Security Bulletin." Seven bulletins have been produced as of this writing.

We also have established a working relationship in which the Disaster, Prevention, Management and Coordination Unit of the United Nations acquires our monthly reports to contribute to the Kenya Humanitarian Update.

Outreach

The primary mechanism for outreach has been the establishment of a mechanism to automate and distribute 10-d and monthly situation reports to NGOs working with pastoral communities via the worldspace radio network. In Kenya we have built the capacity for the Ministry of Agriculture and Rural Development to distribute our reports to district officers over most of Kenya's rangelands. Our zonal coordinators serve as an additional mechanism to distribute reports each 10 days and monthly to their network of district officers and NGO organizations working with pastoral communities.

The LEWS Tanzania team established a booth at the National Farm Show in 2002 and was able to brief people on the LEWS program, including the Prime Minister and Minister of Agriculture. LEWS10-day reports on Ethiopia also posted on the e-mail listserve of the Livestock Working Group, which is currently managed by FAO. The Livestock Working Group is a loose association of Ethiopian government agencies, non-governmental organizations, and United Nations agencies involved in livestock issues in Ethiopia.

Developmental Impact

Agricultural Sustainability. Timely decision making by livestock owners concerning availability of forage supply, movement, destocking, and restocking of livestock will be valuable for sustainable livestock production in East Africa. The indigenous knowledge of the pastoral societies regarding range and livestock will be much more effective if they can have access to near real-time information on impending forage shortages for livestock and location of forage supplies that minimize conflict during periods of restrictive conditions. A combination of the indigenous knowledge and modern science can be used by decision makers to formulate clear mitigation strategies to reduce risk from weather extremes. Recent technology breakthroughs in computer modeling, weather monitoring, animal nutrition profiling, and communication infrastructures offer an unprecedented opportunity in accurately assessing impacts of emerging weather events on forage supply for livestock and wildlife and their ability to acquire nutrients to sustain themselves.

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.

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 2,000 ranchers throughout the USA via the NIRS/NUTBAL nutritional management system. The technologies assembled and used in this project will be directly transferable to USA grazinglands. The new EQIP (Environmental Quality Improvement Program) has designated that the NIRS/NUTBAL nutritional monitoring program is eligible for incentive payments for over 35,000 livestock producers.

The USDA Risk Management Agency

(RMA) adopted the concept of the use of biophysical models to generate forage loss assessment as a basis for the new national forage loss insurance program that will affect over $695 million in forage assets of approximately 32% of livestock producers in the USA. USDA RMA has accepted the feasibility study for this technology and is currently setting up a task order for the insurance industry to implement the system over the next four years, with a first generation system tested in 2004 followed with full implementation in 2006.

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. 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 past 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. The project has organized LEWS teams and relief monitoring agencies in East Africa to use the various technical modeling tools. Two benefits that have become apparent in the interactions and exchanges of views between the teams during these gatherings are:

1. Improved collaborative approach and regional outlook on livestock issues among LEWS host countries. An awareness that most of the problems related to livestock production and development are cross-border problems; and
2. Improved shared understanding and recognition of the importance of livestock in early warning systems. As is evident from the national agricultural early systems currently in place, the livestock sector in all of the host countries is either ignored or marginally covered. The policy makers of various livestock ministries in East Africa have intimated that they are looking to the LEWS project to remedy this situation. There seems to be an improved collaborative approach and shared understanding of their livestock systems.

The national outreach specialists of ministries and NGOs were provided training in the use of the various biophysical models and the spatial analysis tools employed for this project. The goal is to enable the national institutions and their staff to become proficient in the use and application of these tools. Other educational and technical contributions include graduate training for some of the

national scientist and technicians trained to use the instrumentation, and various workshops designed to establish monitoring routes 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 at ASARECA and at ILRI, Nairobi 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, ASARECA Animal Agricultural Research Network Coordinator. ILRI has hired an information system manager for the Crisis Mitigation Office to facilitate the dissemination of information and flow between the various LEWS teams, Texas A&M, and national and international organizations involved in early warning.

In Ethiopia, we intensified our working relationships with DPPC and Save the Children-UK.

The LEWS project strengthened linkages with the FEWS regional representative in East Africa and EROS FEWS NET.

Collaboration with International Research Centers (IARCS) and other CRSPs. The primary IARC collaborators are scientists at the International Livestock Research Institute located in Nairobi, Kenya and Debre Zeit, Ethiopia. The first NIRS laboratory was established at ILRI-Debre Zeit. We also assisted ASARECA at ILRI-Nairobi to establish a Crisis Mitigation Office, integrated with the LEWS reporting system as a primary link to NGOs, regional organizations, national policy makers, and international early warning and relief organizations. ILRI has collaborated with LEWS on a SPAN grant with USAID, focusing on capacity building for use of biophysical models.

Because several of our TAMU-LEWS team members are on the global project within the SANREM CRSP, there is strong collaboration between that component and GL-CRSP as it relates to modeling and monitoring technologies. The technical staff working with SANREM CRSP have interacted with the LEWS team members in Uganda, Kenya, and Tanzania as it concerns evaluation of the impact of small holder dairy technology in those regions.

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 help in the level of preparedness and mitigation of the effects of droughts. This reduced drought risk will help promote pastoral assets, which in turn can bring about local economic growth and purchasing power. It will also give the local governments opportunity 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 USAID. It is anticipated that the development of an improved early warning system, and finding better ways of linking it to governments 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 recognizes the fact that the pastoralists, whose livelihood depends on livestock, are the keys to the success of the project. To a large extent, the success of the project and sustainability 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 from a livestock early warning system with respect to droughts and other natural disasters will reduce mass movements of people and livestock, which have traditionally been 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

The LEWS subproject has been able to leverage funds and personnel from multiple sources to ensure that the program is moving forward and up- to-date technologies are being used in the project**.** A total of $694,150 was funded within the group this year alone, not counting the normal cost share funds of TAES salaries noted in the grant budget for 2000-01. Specific grants and funding levels are as follows:

DANIDA - $26,500 - "Ph.D. Training Program for Ms. Rose Omaria." Ph.D. program is funded to develop pregnancy testing calibration equations for cattle and goats to meet both training and science objectives in the LEWS project. She is attending Makerere University with short term training at Texas A&M University GANLAB.

DANIDA - $35,000 - "Ph.D. Training Program for Mr. Steven Byenkya." This is the first year installment on a compressed Ph.D. program at Texas A&M University. Mr. Byenkya is conducting research on modeling effects of brush encroachment on pastoral land capacity and traditional coping strategies as stated in the LEWS objectives.

SANREM CRSP - $170,000 (same as previous year) **-** "Global Decision Support System for Assessing Impact of Policy and Technologies Related to Food Security." Personnel in TAMU-FEWS are value-added funded via funds in SANREM CRSP as many of the technology/methodology enhancements support efforts in LEWS as well as SANREM. A bulk of funding for SWAN crop model, PHYGROW, NUTBAL PRO, and ACT 3.0 came from this funding source. Funded to Drs. Stuth, Dyke, Corbett.

USDA-NRCS - $25,000 - "Development of livestock early warning outreach programs." Design protocols for effective communications

with ranchers as it relates to the Texas Livestock Early Warning System.

Texas Agricultural Experiment Station - $127,650 - Matching funds as part of the unrecovered indirect costs. TAES only places a 10% indirect charge to this project, with at 44.5% overhead normally charged.

USDA-NRCS - $160,000 - "National Nutritional Well-being Program for USA using the NIRS/NUTBAL PRO Nutritional Management System." This is the 4th year of funding. All technology generated in this program is deployed in LEWS. Funded to Dr. Stuth.

EU – ASARECA Crisis Mitigation Office - $150,000 - Funding of the personnel to support crisis mitigation information activities and collaborate with LEWS.

Training

In Progress:

Stephen Byenkya, PhD student, Dec. 2003, Range Science, Texas A&M University.

William Mnene, PhD student, Dec. 2003, Range Science, University of Nairobi.

Peter N. Kamau, PhD student, Dec. 2003, Range Science, Egerton University

Negusse Kadine, PhD student, Dec. 2004, Range Science, Texas A&M University.

Rose Omaria, PhD student, Jan. 2004, Animal Science, Makerere University.

Zola Gibson, M.S. student, Sept. 2002, Range Science, Texas A&M University.

Kosi Awuma, PhD student, Aug. 2003, Range Science, Texas A&M University.

Kristen Zander, M.S. student, Dec. 2003, Ag. Development, Texas A&M University.

Laban Macopiyo, PhD student, Dec. 2004, Range Science, Texas A&M University.

Completed:

Amsalu Sisay, M.S., Dec. 1999, Range Science, Alemaya University.

Sarah Ossiya, PhD, Aug. 1999, Range Science, Texas A&M University.

Mohammad Hamid, PhD, Aug. 2002, Range Science, Texas A&M University.

Short term: Workshops, Short Courses

NIRS Calibration Training provided to Constantine Shiryo and Rose Omaria at Texas A&M University via funding from FAO and DANIDA, respectively. Mr. Shiryo is the lab director for the NIRS lab in Dar es Salaam, Tanzania. Ms. Omaria is working on her Ph.D.

Workshop on Livestock Early Warning Systems conducted May, 2002 in Addis Ababa, Ethiopia and funded by FAO. Approximately 60 participants attended and a proceedings was produced.

Collaborating Personnel

United States of America:

Jay Angerer, Assist. Research Scientist, Texas A&M University

Jim Bucher, Systems Analyst, Texas A&M University

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

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

Robert Kaitho, Assist. Research Scientist, Texas A&M University

Clint Heath, Senior Systems Analyst, Texas A&M University

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

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Suleiman S. Mohamed, Ag. Economist, Save the Children UK

Tesfaye Kumsa, Institute of Agricultural Research

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Dawit Negessa, Lab Technician, ILRI-Debre Zeit,

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Mahboub Maalim, Aridland Resource Management Project, Office of the President

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Peter Wandera, Animal Prod. Scientist, National Dryland Farming Res. Center

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PUBLICATIONS

Issued 7 Greater Horn of Africa Early Warning Bulletins, produced jointly with FEWS NET, USGS, DMC, UNEP, and KMO.

Issued 10 monthly Situation Reports each for Kenya, Uganda, Ethiopia, and Tanzania via RANET, ALIN, and LEWS coordinators that reaches worldspace satellite radios across the zone.

Issued 36 dekadal maps and situational reports over the web (http://cnrit.tamu.edu/aflews), with 2.1 GB of data download to 49 countries.

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