GLOBAL LIVESTOCK CRSP

# Integrating Information and Communication Technology for the Livestock Early Warning System (LEWS) in East Africa

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*The GL-CRSP Livestock Early Warning System project in East Africa has developed a methodology and technology to address the informational needs of pastoral communities relative to changing forage conditions. The LEWS team, led by Texas A&M University in collaboration with a large network of NARS, NGOs, and development agencies in Ethiopia, Kenya, Tanzania, and Uganda, has assembled an integrated suite of technology that provides estimates of livestock forage availability, deviation from normal, and a percentile ranking for a large portion of these four countries. When coupled with a 90-day forecasting system, information such as current forage conditions relative to historical conditions, conditions at the same time during the previous year, and likely forage response in the next 90 days can be provided. Since the human element in complex technology can be a major constraint for deployment in developing countries, LEWS has attempted to devise methods by which data is automatically acquired, analysis is conducted by resident programs scheduled to run unattended, and output information is generated and disseminated to outreach partners in the region. This information is updated every 10 days with situation reports and maps distributed via WorldSpace radios, email, internet, CDs, and newsletters, impacting over 400 organizations and 300 decision makers in the region.*

## Background

Pastoral communities in East Africa have traditionally relied on historical memory, cloud behavior at given times of the year, atmospheric effects on star brightness, and behavior of plants and animals to develop coping strategies for crisis situations. However, the frequency of drought episodes affecting the Greater Horn of Africa region is increasing as global climatic patterns change. Smaller intervals between drought episodes mean that herders using traditional early warning methods do not have enough time to recover from one drought before the next one strikes. The effects are cumulative and inversely proportional to the length of intervals between episodes. Herders need analytical systems that help interpret changing climatic systems and provide information on emerging forage conditions and likely near-term responses. LEWS has focused on the design and implementation of a new set of technologies that captures weather responses in near real-time and translates that information into forage response over large landscapes in Ethiopia, Kenya, Tanzania, and Uganda. Given the issues of system maintenance and the sparse and inconsistent reporting in pastoral regions of East Africa, the technology suite was developed using remote analysis techniques. When coupled with innovations in communication technology, this suite translates the changing behavior of pastoral forage-based systems into information that can be distributed and interpreted by governmental agencies, NGOs, district officers, and pastoral community organizations.

## LEWS Technology Suite

<u>Satellite Weather (RFE/CHARM)</u>

One of the major challenges facing the LEWS program was establishing a basis for capturing daily weather data. Initially, 75 on-site weather stations were established in the project; however, due to theft of equipment, vandalism, and inability to communicate data records in a timely manner to the central analysis site, the LEWS team sought alternative weather data sources. Working with the Famine Early Warning System Network (FEWS NET), we were able to establish an automated link to their METEOSAT-based RFE daily estimates of rainfall and temperature for the entire African continent, updated in near real-time. In order to be able to compute deviation from normal forage conditions, LEWS developed monthly average temperatures and rainfall for the East African countries and used them as coefficients in weather generators parameterized for the nearest World Meteorological Organization (WMO) reporting station. Recently, Funk et al. (2003) reanalyzed historical satellite imagery and released the CHARM rainfall data set containing data from 1961 to 1996. LEWS acquired the CHARM rainfall dataset, linked it with the generated temperature data, and now uses this data for computing historical forage response and deviation of forage from normal.

PHYGROW Model

The PHYGROW model is the integration tool of the LEWS system. It uses weather and site vegetation information to derive forage conditions that normally would require much time and expense to collect by hand. The model requires input data on soils, plants, livestock density rules, plant preferences by herbivore, and plant growth attributes by species. The LEWS team gathered the necessary soil data for the model. Interviews with local pastoral households provided the stocking density data reflecting their "decision rules" for movement of livestock. Preference values were derived from a combination of researcher opinions and field interviews with experienced herders. Verification of the model indicates that the LEWS technology can predict forage on offer well within field sampling error (see Research Brief 03-03-LEWS).

Satellite Greenness - NDVI

Normalized Difference Vegetation Index (NDVI) provides a measure of green biomass on the ground as seen from the AVHHR satellites. LEWS' automation technology acquires this data every 10 days from the EROS Data Center, which processes it as part of FEWS NET. The greenness data is used in translating the point-based PHYGROW output into maps of forage standing crop and forage deviation from normal. These data are also used in the 90-day forecasting analysis.

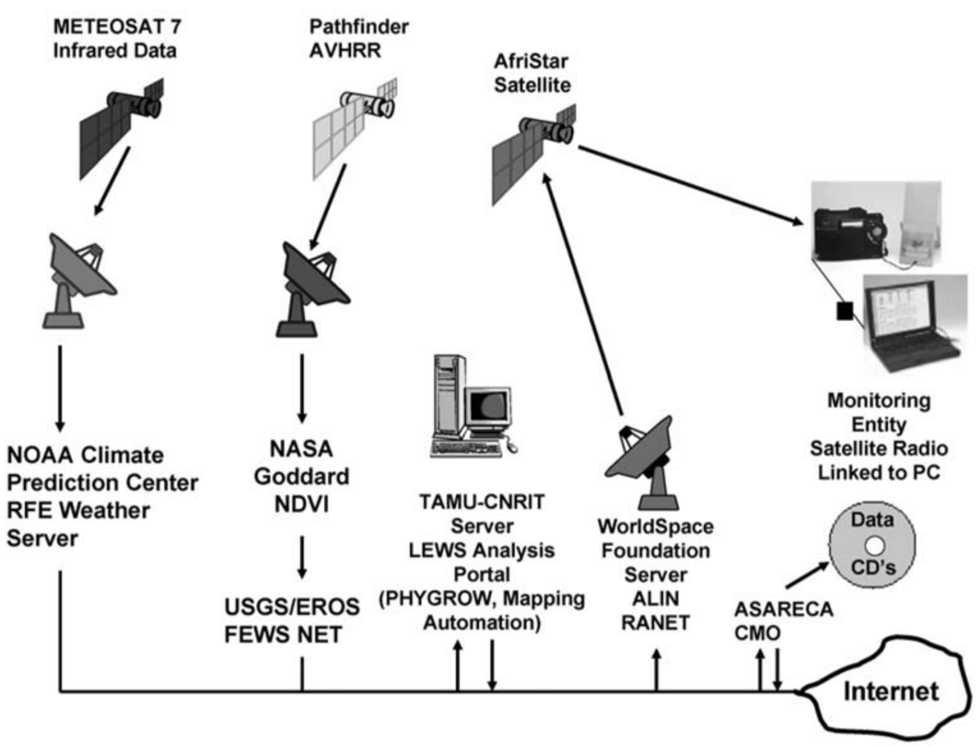
Forecasting Technology

Using the relationship generated by PHYGROW and the CHARM weather data, historically derived forage responses from 1981 to 2002 were coupled with spatially and temporally coherent NDVI data. This coupling allows the LEWS automation system to forecast likely forage conditions up to 90 days in advance with a level of accuracy that is within normal field sampling error (see Research Brief 03-02-LEWS). The forecasting procedure analyzes and projects the data using an AutoRegressive Integrated Moving-Average (ARIMA) model. This approach uses past forage and NDVI conditions along with current forage estimates from the PHYGROW model to predict future grazed standing crop.

Spatial Technology

Mapping of forage supply, deviation from normal forage conditions, and rate of change is conducted using co-kriging between the NDVI data and the point-based PHYGROW analyses. Geostatistics lets us couple biophysical model data collected for a small set of samples in a large landscape with a more spatially rich dataset (NDVI) to interpolate forage responses across a region. For co-kriging to work effectively, a linear relationship must exist between the model forage values and corresponding NDVI data. Since the correspondence between model output and NDVI in co-kriging is spatially dependent, areas where a lack of correspondence exists can be identified, allowing LEWS teams to determine where new sampling points need to be located. Currently, the co-kriging is conducted using

*Figure 1: Analytical and communication components of the LEWS system.*



commercial software (GS+); however, LEWS is designing an automated mapping system based on GSTAT algorithms that will be deployed in the near future.

Automated Computational Systems

Most of the automation has been completed with the exception of the mapping technology. Human intervention is required to select the best model fit for the co-kriging process. This procedure is currently being researched for eventual automation. The LEWS automation system is located at the Texas A&M University Center for Natural Resource Information Technology (CNRIT). CNRIT has a large on-going program in information technology and therefore provides a minimal cost locale to ensure that the data is acquired, analyzed, and disseminated in a timely manner to all partner organizations in East Africa.

Communications Technology and Outreach

Outreach is critical to the success of the program. Currently, LEWS places all analyses on the Africa Livestock Early Warning System website (http://cnrit.tamu.edu/aflews) with 10 day updates. In addition, subsets of the analyses are automatically reconfigured for broadcast via WorldSpace satellite radios using African Learning Channel bandwidth and containers from the Arid Lands Information Network (ALIN) and RANET. The maps and minimal narrative go to ALIN for distribution in their network of 100+ radios across East Africa. The full situation reports are distributed by RANET in their larger container. Communication nodes established across East Africa involve tuning a $65 USD satellite radio linked to an inexpensive laptop or desktop computer via a signal translator ($35 USD) and transferring the reports at a scheduled time each day. Many of these communication nodes are located in NGO offices, district offices, and communication offices of early warning agencies of each country. The LEWS reports are also emailed by UN-Office for the Coordination of Humanitarian Affairs (OCHA) throughout the region. These reports are condensed versions of the situation reports created by country-level information officers in UN-OCHA. A consortium of FEWS NET, U.S. Geological Survey, World Food Programme, DMC, and LEWS also produces a monthly Greater Horn of Africa Food Security Bulletin. LEWS provides the pastoral outlook report within that bulletin.

## Practical Implications

The LEWS technology package demonstrates that satellite weather and NDVI data can be value-added into an analytical system to simulate forage conditions over large regions, map those conditions, and forecast likely responses. This is valuable to multiple-scale decision- makers, such as relief organizations, development NGOs, humanitarian groups, district officers, and pastoral community organizations. The technology translates complex biophysical conditions into timely information that can be transferred through a diverse communication network, from remote NGOs working without electricity to advanced relief organizations with 24/7 internet capacity. More timely and accurate information leads to improved decision-making. Decision-makers can rely on this quantification of data, with a demonstrated consistency in outcome, to formulate decisions that affect the livelihood of pastoral communities. Placing automated information technology in a stable computing environment with very low maintenance needs and linking that output to relevant outreach organizations is a cost-effective mechanism allowing sustained use of advanced technology that maximizes investments on high-impact outreach activities. As institutions in Africa build their human and technical capacity, the system can be mirrored in these institutions and eventually fully transferred. Outreach activities can then be sustained within the existing information infrastructures of these countries without high dependency on maintaining the information technology infrastructure.

Future advances in space-based monitoring technology coupled with new analytical techniques and greater computing power have the potential to vastly improve upon the LEWS technology package. When integrated with other information systems such as those capturing marketing and biosecurity data, the future holds great promise of meeting information needs of developing countries.

## Special Acknowledgements

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## Further Reading/References

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The GL-CRSP Livestock Early Warning System Project (LEWS) was established in 1997 and conducts research, training, and outreach in an effort to provide proactive information on emerging forage conditions and quality to assist pastoralists, NGOs, district officers, and national food security agencies in coping with and mediating emerging drought and rainfall conditions. The project is led by Dr. Jerry W. Stuth, Texas A&M University. Email contact: jwstuth@cnrit.tamu.edu.

The Global Livestock CRSP is comprised of multidisciplinary, collaborative projects focused on human nutrition, economic growth, environment and policy related to animal agriculture and linked by a global theme of risk in a changing environment. The program is active in East Africa, Central Asia and Latin America.

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