Global Livestock CRSP

Empirical Forecasting of Slow-Onset Disasters for Improved Emergency Response: An Application to Kenya's Arid Lands

Andrew G. Mude, ILRI; Christopher B. Barrett, Cornell University; John G. McPeak, Syracuse University; Robert Kaitho, Texas A&M University (GL-CRSP LINKS Project); and Patti Kristjanson, ILRI Pastoral Risk Management Project

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Slow-onset food crises associated with drought and loss of livestock in Kenya's arid lands routinely require emergency food aid and water distribution, livestock off-take, and other humanitarian interventions. Timely and cost-effective interventions depend fundamentally on accurate advance information of evolving situations. Improved forecasts are one essential element of emergency needs assessments and early warning systems. This brief reports on a newly developed empirical forecasting model that can predict, with reasonable accuracy and at least three months in advance, the expected child nutritional impact of slow-onset shocks such as drought.

Background

The ability to forecast the onset, duration, and severity of droughts, floods, and disease outbreaks with reasonable accuracy—especially in terms of their prospective human welfare effects—is critical to the design of timely and cost-effective early warning and emergency response systems. Better designed systems can minimize the suffering of populations adversely affected by such relatively slow-onset events. As the consensus on climate change and its consequences grows, there is an increasing concern that the frequency of climate shocks will rise, with more frequent and serious humanitarian crises and ensuing demand for emergency response.

Given the finite resources allocated for emergency response initiatives, there is growing demand for the development of timely, rigorous, efficient and practical methods of emergency needs assessment. To contribute to this effort, the research reviewed in this brief develops an empirical forecasting model to predict the human impact of slow onset disasters for early warning and emergency needs assessment.

The research focuses on the arid lands of northern Kenya. Largely populated by nomadic pastoralists and particularly vulnerable to recurring shocks such as droughts and floods, the region is well-suited for the purposes of this study. As part of an effort to address the vulnerability of the region's population, the Arid Lands Resource Management Project (ALRMP) has been collecting data in various communities across Kenya's arid districts since 1996. Data collected include detailed household-level information on livestock such as herd sizes, mortality rates, lactation rates, and managed off-take rates, and child-specific nutritional data, specifically mid-upper arm circumference (MUAC) measures.

The ALRMP data used in this study are monthly observations at the community level collected February 2002 to May 2005 in 54 communities across four districts (Baringo, Marsabit, Samburu and Turkana). The authors supplement the ALRMP data with a rich source of climate and forage availability data collected and produced by researchers of the Global Livestock CRSP Livestock Early Warning System (LEWS) project and its successor, the Livestock Information Network and Knowledge System (LINKS) project. One desirable feature of the LEWS/LINKS data is that they originate with remotely sensed and other data external to communities, so they are information imported into, rather than merely extracted from, the system under study. Lagged values of variables in the ALMRP and LEWS/LINKS data sets, such as changes in livestock fertility, mortality and productivity, and forage and water availability, are combined to predict changes in community-level MUAC measures. The authors designed this study to examine how good a forecast of changing community-level nutritional status we could generate and with what lead time in order to inform effective response to the prospective human impacts of climate shocks that frequently confront pastoralist communities.

Major Findings

Emergency response to widespread acute food insecurity is largely conditioned by the degree and prevalence of gross malnutrition. Acute food insecurity is typically assessed based on the proportion of children whose anthropometric measure(s) of weight relative to height or age reflect widespread high levels of food stress and acute undernutrition, commonly known as "wasting." Mid-upper arm circumference (MUAC), a superior predictor of child mortality, is one such measure. A MUAC Z-score of less than -2 is widely regarded as an indicator of severe wasting (A Z-score is a statistical measure relative to a universal reference population. A Z-score<-2 indicates a child more undernourished than 97.5% of children of similar age.) A food crisis might be objectively defined as occurring whenever twenty percent or more of children are severely wasted.

Using this definition of a food crisis, the authors developed a model to forecast child nutritional status (as given by MUAC) based on movements in key explanatory variables several months in advance. Herd dynamics variables (the size of herds, mortality rates, sales and slaughter rates), measures of food aid, as well as variables capturing rainfall and forage availability were used to predict the prevalence of MUAC, and consequently, the likelihood of a food crisis.

Effective response to food crisis requires early warning of emergency conditions so as to mobilize resources. Two forecasting models are developed: a one-month forecast and a three-month forecast for the prevalence of severe wasting. While a one-month forecast will typically be more accurate, the short lead time leaves little leeway for food security managers to make effective use of the forecast. The longer, three-month forecast horizon, however, comes at a cost of diminished accuracy. The inverse relationship between forecasting horizon and forecast precision forces an operational tradeoff between models. Different end-users will favor different characteristics and thus different models.

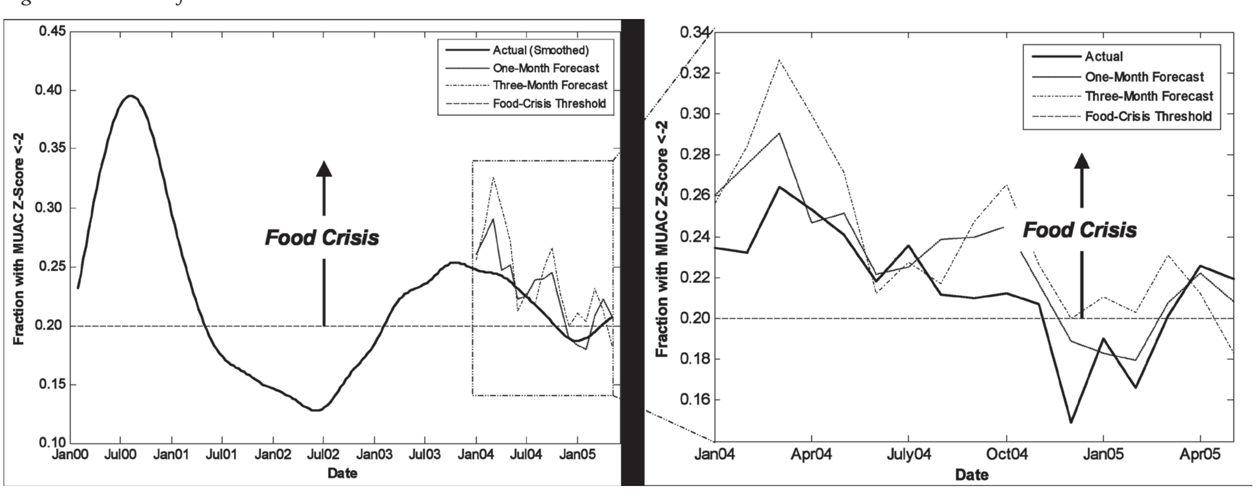
Figure 1 shows the monthly forecasts generated for January 2004 to May 2005 compared against subsequent, actual values. Figure 1(a) presents the forecasts superimposed on the full sample of actual values - the proportion of children with MUAC Z-scores<-2. The values are smoothed to highlight trends, especially the considerable variability in the prevalence of severe wasting. A food crisis existed during and following the 2000-1 drought, then re-emerged in 2003-4 in these northern Districts, then began reappearing last year. Figure 1(b) highlights forecast precision by zooming in on the forecasting period and plotting the unsmoothed actual values against the one- and three-month ahead predictions generated by the forecast model.

Three key points emerge from the figures. First, recall that a food crisis is defined as the state where 20% or more of children exhibit MUAC Z-scores <-2, reflecting severe wasting. Thus defined, the sample sites regularly experienced food crisis over the January 2000 and May 2005 period, but crisis was not constant. Second, the forecasts trace the actual values quite well, and seem to improve with time, as additional data improve forecast precision. Third, while the one-month forecasts outperform the three-month forecasts, the differences are not substantial.

How can policy makers use such forecasts of food crisis to make critical emergency response decisions? Furthermore, how confident can policy makers be in decisions they make based on the model's recommendation? To answer these questions, the authors construct a plausible scenario in which the model's forecasts can be used, and offer a measure of forecasting performance.

Consider the case of an organization tasked with responding to food crises. This sort of forecast model can provide early warning of a food crisis at a particular site in the form of predictions of specific levels of severe wasting. The organization can decide on the minimum likelihood of food crisis required before they deploy a costly aid package. This policy decision will depend on a range of variables, including the availability of funds to support emergency response, the operational costs of serving the affected population, logistical considerations regarding access, etc. Once such a likelihood threshold is chosen, the organization might initiate response

Figure 1. Fraction of Children with MUAC Z-score<-2: One and Three Month Forecasts.



if the forecast of food crisis reaches or exceeds the pre-determined minimum threshold.

To test forecast performance operationalized in such a way, a minimum response threshold was arbitrarily set at 66% (that is, the organization deploys aid whenever the forecast predicts a 66% or greater likelihood of food crisis). Defining emergency response when there is actually a food crisis, or no response where there is no food crisis, as 'correct' decisions, one can then calibrate forecasting performance by calculating the fraction of correct decisions generated by this decision rule in combination with the forecast model.

The results, presented in Table 1, are quite striking. Decisions based on forecasts are likely to be correct more that 75% of the time -- quite an impressive forecast performance. Moreover, the fairly small depreciation in performance as the forecasting horizon increases shows that these models can be used fairly accurately to provide a reasonable, three-month early warning to help with emergency response to mitigate the consequences of impending crisis.

Table 1. Model Performance in Generating Correct Decision for Famine Response.

FRACTION OF CORRECT DECISIONS	
One Month	**Three Month**
0.786	**0.756**

Practical Implications

Based on data collected from primarily pastoralist communities selected across four districts in Kenya's arid north, the authors have developed an empirical forecasting model that can predict, with reasonable accuracy and at least three months in advance, the expected human impact of slow onset shocks such as drought. Information on herd composition and herd management, climate and forage availability and food aid flows enable reasonably accurate three-month-ahead forecasting of child nutritional status, specifically severe wasting reflect in very low MUAC levels, with impressive precision. Longer lead forecasts may also be feasible and warrant investigation.

These forecasts were generated from a relatively small subset of variables that ALRMP regularly collects, augmented by data collected routinely by LEWS/LINKS. These data are not overly restrictive or costly to collect. Limiting data collection to these set of variables, collected consistently through time, might offer a cost-effective way to provide effective early warning to policymakers and emergency response professionals. The precision of these predictions appears sufficiently high that delays in acting on this information due to concerns over forecast accuracy should be limited. However, there remains work to be done to establish how best to communicate this information in as clear and timely a fashion as possible to appropriate audiences.

The authors recommend that the model be adapted as an effective famine early warning tool. As the model can be easily and regularly updated with new information that should continuously increase its forecast performance, a premium should be placed on developing standardized collection procedures and failsafe methods for entering, identifying and storing the necessary data. Such a forecasting model could prove an invaluable tool for early warning and emergency response to food crises.

Further Reading

Mude, A., C. Barrett, J. McPeak, R. Kaitho, and P. Kristjanson. 2006. *Empirical forecasting of slow-onset disasters for improved emergency response: An application to Kenya's arid north.* Cornell University and International Livestock Research Institute Working Paper. Available at: http://www.cfnpp.cornell.edu/images/wp203.pdf.

About the Authors. Andrew Mude recently completed his Ph.D. in Economics at Cornell University. He is now a Research Scientist at the International Livestock Research Institute (ILRI) in Nairobi, Kenya. Email: a.mude@cgiar.org. Chris Barrett is International Professor of Applied Economics and Management at Cornell University. E-mail: cbb2@cornell.edu. John McPeak is an Assistant Professor, Department of Public Administration, Syracuse University. Email: jomcpeak@syr.edu. Robert Kaitho is a Research Scientist for Texas A&M University. He is a team member of the GL-CRSP Livestock Information Network Knowledge Systems (LINKS) project. Email: rkaitho@cnrit.tamu.edu. Patti Kristjanson is a research scientist at ILRI in Nairobi, Kenya. Email: p.kristjanson@cgiar.org.

The GL-CRSP Pastoral Risk Management Project (PARIMA) was established in 1997 and conducts research, training, and outreach in an effort to improve welfare of pastoral and agro-pastoral peoples with a focus on northern Kenya and southern Ethiopia. The project is led by Dr. D. Layne Coppock, Utah State University, Email contact: Lcoppock@cc.usu.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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