The Famine Early Warning System Network and NASA Earth Science Data

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Abstract – Solving complex human-environment problems has increasingly required that organizations employ interdisciplinary strategies. The United States' Agency for International Development's Famine Early Warning System Network (FEWS NET) provides early warning information for a diversity of stakeholders, including the United States government, concerned national and local governments and a wide variety of non-governmental organizations. FEW NET's interdisciplinary decision support system achieves consensus with partners and decision makers by providing integrated biophysical and socio-economic information at a variety of scales. As an interdisciplinary project, FEWS NET has a long record of successfully using the sophisticated satellite remote sensing, locally measured biophysical indicators with state-of-the-art social science to provide critical information to policy makers at the local, national and international arenas. Examining FEWS NET from a decision support system viewpoint, we will suggest lessons that can be learned from FEWS NET on how large, interdisciplinary programs are conducted and how to foster active collaboration between disciplines.
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Keywords: *Rainfall, NDVI, early warning, decision support systems, food security*.

1. INTRODUCTION

For nearly two decades, the United States' Agency for International Development's Famine Early Warning Systems Network (FEWS NET) has advised local, national and international partners on African food security issues. During the past four years, this program has expanded to two more regions and will soon be available to those countries worldwide who request the program. A founding partner of the program, NASA has contributed real time satellite data for rangeland health, cropped area and rainfall estimation. FEWS NET has implemented a new approach to quantifying food security that incorporates food prices, wealth ranking and levels of vulnerability with agricultural production information. This integrated approach, called a livelihoods-based food security early warning system, is an analytical framework designed to help decision-makers understand the effects of different 'shocks' on household-level livelihood options. Based on a food economy approach, the livelihoods analysis is used in a broader early warning system that organizes information about people living in rural and urban households and, when necessary, connects it to decision makers providing different types of assistance in support of their lives. The quantitative representation of the different food and cash income options available to different types of households in a particular geographic area is typically presented in a baseline report and a food economy spreadsheet designed to facilitate food security outcome analysis. NASA data can be used in each level of the food security analysis once the baseline study on food economy has been conducted. Satellite derived products contribute to estimates of the area of food crops planted in a particular year (LandSAT data), monitoring of crop health throughout the season (TRMM), estimates of the percent of normal production harvested (MODIS, AVHRR), development of rangeland depletion curves (MODIS, TRMM), and inputs to models projecting food price changes over the coming year (AVHRR, SPOT Vegetation). This paper will summarize the livelihoods-based food economy approach. and describe the contributions of NASA satellite data to early warning of food security crises worldwide.

2. FEWS NET, DATA AND LIVELIHOODS

As a long-standing US Agency for International Development funded project, the Famine Early Warning System Network (FEWS NET) provides an example of the processes and methodologies required for a large interdisciplinary decision support system. Since its inception in the mid-1980s to its recent re-authorization through 2009, FEWS NET has used state-of-the-art social science methodologies for food security monitoring, coupled with meteorological, vegetation remote sensing and GIS technology for monitoring threats to food production. Supporting the decision-making needs of local government officials is met through local FEWS NET representatives, often host-country nationals. These representatives conduct food security analysis which forms the basis for reports coming out of FEWS NET in Washington D.C., and are the primary distribution method for products aimed at local institutions that need decision support information in the field. FEWS NET has implemented a systematic approach to fostering collaboration between the social and physical sciences, enabling improved analysis for policy makers who must operate in a complex decision making environment.

Early warning systems are governmental or non-governmental organizations that are tasked with identifying populations that may be food insecure due to reduced food production resulting in a decline in food access. Food security is often defined as 'access to enough food at all times for an active, healthy life' (WorldBank 1986). A broader definition of food security involves the concept of livelihoods, or ways people make a living, and this broader definition has been used by FEWS NET since 2000. In non-industrialized countries, low-income people make their living from a combination of food and income-earning activities. Food insecurity results when one or more of these strategies fail and no alternatives can be found (FEWS 2005). FEWS NET uses the livelihood concept to reveal how and why people survive (and fail to survive) in difficult times (Mathys 2005).

The problem that FEWS NET addresses is large: about 800 million people—one-sixth of the developing world's population—do not have access to sufficient food to lead healthy, productive lives. Around 280 million of these food insecure people live in South Asia; 240 million in East Asia; 180 million in Sub-Saharan Africa; and the rest in Latin America, Middle East, and North Africa (United Nations Food and Agriculture Organization).

Early warning systems provide an effective means for identifying and coordinating the response to areas of possible food insecurity, providing the required analysis and information to determine the extent of the problem, recommendations as to types of response, and ensure the consensus of local, national and international governments around these recommendations.

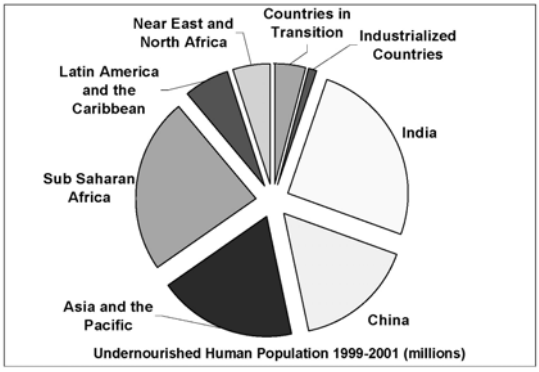

Figure 1. Proportion of Undernourished Population from 1999-2001 (FAO).

1.2 FEWS NET's role in Humanitarian Aid

FEWS NET Early Warning programs provide data and information to governments decision making bodies so response to crises can be early enough to avoid food security crises. This is done through consensus building with a variety of governmental and early warning organizations (Figure 2). Without consensus, no action happens. Remote sensing data of the current environmental situation provides key input to the decision making process, one that is backed up by science and the reputation of NASA, NOAA and the USGS in the United States. It is upon these reputations that FEWS NET has been able to become influential in the humanitarian world.

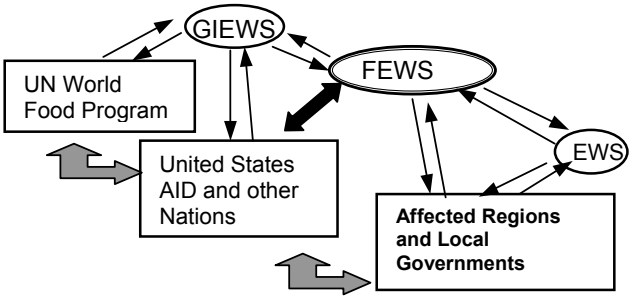

Figure 2. Relationship between FEWS NET and other early warning organizations. GIEWS is the UN's Global Information and Early Warning System, EWS are local and national early warning organizations.

1.3 FEWS NET Process

FEWS NET has a specific process through which it incorporates NASA and other remote sensing biophysical data. The data on rainfall, vegetation and temperature along with socio-economic data on food production, livestock and prices is fed into an analytical process that is primarily conducted by food security analysts. FEWS NET integrates and analyzes physical and social conditions for a region of interest and through a process of periodic reports for a variety of geographic scales, specific recommendations for intervention and management briefings directly to decision makers, FEWS NET is able to provide food security information in a format which is most useful. By continually striving to identify, define and then meet the needs of the users of the information, FEWS NET is able to provide critical input to decision making at a variety of scales.

The ultimate goal of FEWS NET is to influence the annual budget cycle in order for early intervention to reduce the harm to livelihoods. By using science-derived satellite remotes sensing in this complex decision making environment, consensus can be achieved more quickly.

2. NASA Data

2.1 NASA Data Used by FEWS NET

FEWS NET uses a variety of NASA Earth Science data products. Table 1 shows the satellite, sensor and observations/products that are incorporated in FEWS NET's food production monitoring.

Satellite	Sensor	Observations/ Products
Terra/Aqua	MODIS	NDVI, Fire products, Water Vapor
TRMM	Precip.Radar	Precipitation Data
POES	AVHRR AMSU-B	NDVI data from 1981 Humidity fields
JASON-1 TOPEX/ POSEIDON	Altimeter	Reservoir and Lake levels

Table 1. NASA data used in FEWS NET monitoring activities.

Table 2 shows the NASA models used by FEWS NET. These models allow FEWS to move from direct observation to products that are closer to the needs of the decision makers.

Model	Organizatio	Products
NCEP ETA model, NCEP/NCAR Reanalysis I/II	NCAR	Predicted Precipitation, Winds, pressure, relative humidity
TRMM Multiple Precip. Analysis	NASA	Tropical Precipitation
Rainfall Estimate, CMORPH	NOAA	**Precipitation over Africa, Central America, Asia**
ENSO phase and predictions	IRI/Columbia University	SST anomalies and ENSO forecast

Table 2. NASA Models used by FEWS NET.

Biophysical data provides information on the yields of the food production equation and threats to pastoral resources, wild food availability and ultimately to the agricultural economy as a whole. To identify abnormally wet or dry periods, FEWS NET relies on data on vegetation, temperature and rainfall derived from remote sensing and local measurements when they are available. Currently, the FEWS NET early warning function begins with a weekly assessment process that includes members of NASA, NOAA, USGS, USDA, USAID, the University of California at Santa Barbara (UCSB), and a variety of technical specialists in Africa, Central America, and Afghanistan. Table 1 lists the extensive number and type of data used by FEWS NET to summarize the current climatic situation. The data includes precipitation gauges and gridded data from merged satellite models, vegetation data from a variety of sensors, gridded cloudiness products, global climate indicators, precipitation forecasts (24-72 hours), modeled soil moisture, gridded fire products, snow extent products, hydrological models for flood forecasting, and seasonal forecasts.

There has been much expansion of information derived from decadal gridded rainfall data, through the use of models from several disciplines, including agronomic models specifying the moisture requirements of a particular crop given an underlying soil type (Water Requirement Satisfaction Index or WRSI), the flooding potential given the soil water holding capacity and the amount of water that has fallen on a given cachement basin (Basin Excess Rainfall Model or BERM). These modeled products allow social scientists to ask questions regarding the direct effect of a particular rainfall amount on the local population instead of having to infer from rainfall imagery the resulting impact on a particular crop or in a particular flood-prone region.

Vegetation Index data derived from satellites remains an important source of information for the FEWS NET program because it shows results of rainfall on the vegetation. Although rainfall has been used extensively to drive many other models, it is actually far less reliable than directly measured vegetation data as it is prone to errors in approximating the degree of cloudiness, the amount of rain that has fallen from these clouds or the intensity of the rainfall, inadequate capturing of orographic rainfall, sensitivity to the density and accuracy of local rainfall gauge measurements, and other effects which result in significant random error and non-negligible bias (Waymire 1985, Xie & Arkin 1997). Vegetation remote sensing measures directly the stable photosynthetic activity resulting from rainfall and is thus can be more precise (Tucker et al. 1991). Because they measure very different things, both variables continue to be of value to hazard identification.

2.2 Interpretation of Remote Sensing using Livelihoods

In general, FEWS NET uses four steps to connect biophysical hazards with food security outcomes using the livelihood approach:

- Scenario Modeling Baseline – where the baseline information about the communities at risk are set out, including livelihood zone mapping, livelihood profiles, demographic profiles and scenario modeling baseline.
- Hazard Monitoring –monitor both biophysical hazards (climate) and socio-economic hazards (food prices, production).
- Food Security Scenario Modeling – conduct modeling to identify the impact of hazard, the likely food security outcomes for affected populations over a specified time period
- Contingency and Response Planning – work with network partners to identify appropriate response options.

The baseline provides an idea of the 'normal' situation through which anomalies can be interpreted. The baseline consists of livelihood zones and ancillary information called profiles. The zones divide a country into geographic areas with relatively homogeneous ecological and economic characteristics, thus providing a geographic framework and sampling frame for food security analysis (Figure 2). Because it involves biophysical and socio-economic elements, it is by definition an interdisciplinary concept that provides the base for subsequent analysis. Livelihood profiles are developed for each zone, detailing the analysis of localized economic information about how poor, rich and modal demographic groups obtain their cash and food income (Figure 3). These income sources include agriculture, livestock, commerce, services, wage labor and a variety of other activities.

Hazard monitoring uses this baseline profile to determine the normal situation from which the impact of both socio-economic and biophysical anomalies can be measured. It is in the hazard monitoring that much of FEWS NET's active interdisciplinary communication occurs, because understanding how a hazard impacts the livelihoods of the most vulnerable in a particular region requires an interdisciplinary perspective and a wide expertise.

3. FUTURE ROLES FOR NASA DATA

NASA has recently funded a project that will expand the use of NASA data in FEWS NET activities. The new project will significantly strengthen famine decision support by using NASA MODIS-AVHRR NDVI, TRMM-GPCP-CMAP precipitation, MODIS Atmosphere humidity, and NCAR reanalysis I and II products to calculate quasi-global (60S to 60N) standardized NDVI, precipitation, relative humidity, total precipitable water, and projected estimations of these indices one to four months in advance using climatology and a simple statistical approach. We will produce and distribute five operational indices based on global NASA data products: a standardized NDVI index (SNI), a standardized precipitation index (SPI), a standardized relative humidity index (SRI), and a standardized total precipitable water index (SQI). Standardization and broadening of the already used NDVI and precipitation to include humidity and precipitable water will significantly improve the USAID's ability to detect and quantify reductions in food production due to drought and flooding. Short-lag 'projections' of indicators will enable decision makers to look one to four months into the future, enabling better decisions when the political deadline is significantly before the biophysical data can definitively give an estimate for food production in a region. Satellite observations will play a strong role in making these projections.

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