

# **A PROFESSIONAL REVIEW FOR INTEGRATION OF EARTH OBSERVATIONS INTO FEWS NET DECISION SUPPORT**

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## **ABSTRACT**

The Famine Early Warning System Network (FEWS NET) provides early warning support to decision makers responsible for anticipating and responding to famine and food insecurity events. This early warning system utilizes a variety of data types, including satellite remote sensing data, to assess climatic hazards that threaten adverse impacts to the food security of agricultural and pastoralist livelihoods. The National Aeronautics and Space Administration has recently funded activities to enhance remote sensing inputs to FEWS NET. A professional review was conducted to elicit Earth observation requirements for FEWS NET. It focused upon operational requirements of FEWS NET end-users to determine qualities of useful remote sensing data and data products. In this manner, properties of certain biophysical predictions that would be beneficial as FEWS NET supplementary inputs could be ascertained. Reviewers were asked to evaluate the importance of environmental variables and spatio-temporal requirements for Earth science data inputs, particularly for rainfall and vegetation products. The review was implemented in 2007 as an online questionnaire and was completed by more than 40 experts from around the world. This professional review questionnaire was shown to be a viable tool for the rapid derivation, compilation, and analysis of requirements necessary to enhance FEWS NET. Overall, information related to both rainfall and vegetation remotely sensed data and data products were valued most highly for providing actionable food security information. Notionally, the incorporation of this information will enhance this decision making system.

## **INTRODUCTION**

The Famine Early Warning System Network (FEWS NET) was created in 1985 by the United States Agency for International Development (USAID) to improve its emergency response capabilities in Africa, which includes disseminating information and increasing food security (Brown, 2008). FEWS NET was defined, implemented, and evolved from a number of approaches and methods designed for early warning and for food security and vulnerability monitoring and assessments.

Effective early warning goals include timely and effective delivery of information that enables affected individuals to both (1) take action to avoid and/or reduce their risk, and (2) prepare for effective response (Buchanan-Smith and Davies, 1995). Successful early warning systems include (1) accurate forecasts of an event's consequential effect upon humans when predicting its location, time, and severity; and (2) timely dissemination of warnings so that populations at risk can take appropriate action (Davies et al., 1991). The intent of FEWS NET is to play a global role in meeting USAID information and decision-making needs in early warning, in food security and vulnerability assessment, and in improved humanitarian response (U.S. Department of State and USAID, 2007). Therefore, FEWS NET uses a suite of information products that support decision-making on anticipating and responding to episodes of food insecurity so the human and financial toll of the disaster can be reduced. USAID uses this information to manage the risk of food insecurity. This monitoring information includes Earth science remotely sensed data and ground-based meteorological, crop, and rangeland conditions. To increase the functionality of FEWS NET and to address new institutional needs, additional types of Earth science data are required. However, the individuals who actually provide these data types are generally not those who define the underlying requirements, such as optimal spatial or temporal resolution.

The National Aeronautics and Space Administration (NASA) has recently funded activities to enhance remote sensing inputs to FEWS NET. Before these enhancements could be incorporated, NASA and its partners needed to define the requirements for FEWS NET analyses and to learn how the U.S. Geological Survey's FEWS NET Africa

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Data Dissemination Service (ADDS) was currently used. Therefore, a professional review was conducted for FEWS NET. The review took the form of an online questionnaire that was distributed to expert end-users and to experts in Earth science information content.

### **FEWS NET and Biophysical Remote Sensing Data**

FEWS NET uses an integrated approach to continuously evolve and improve its capacity for vulnerability and early warning food insecurity assessments. Almost all field offices produce monthly food security situation reports for vulnerable countries. Also, based upon the FEWS NET watch, warning, and emergency criteria, the USAID determines when food security status in an area is a problem and prepares alert reports. To help understand food production, threats to pastoral resources, wild food availability, and ultimately the agricultural economy as a whole, FEWS NET interprets the food security significance of biophysical and climate data based on year-to-year variations (Brown, 2008). This information is integrated with socio-economic monitoring data (Verdin et al., 2005). When available, FEWS NET relies on vegetation, temperature, and rainfall data derived from remote sensing, atmospheric models, and local measurements to identify abnormally wet and/or dry periods. Presently, FEWS NET early warning is characterized by a weekly weather hazards assessment process that includes members of NASA, National Oceanic and Atmospheric Administration (NOAA), U.S. Geological Survey (USGS), U.S. Department of Agriculture (USDA), USAID, and a variety of technical specialists in Africa, Central America, and Afghanistan.

### **FEWS NET Current and Planned Datasets**

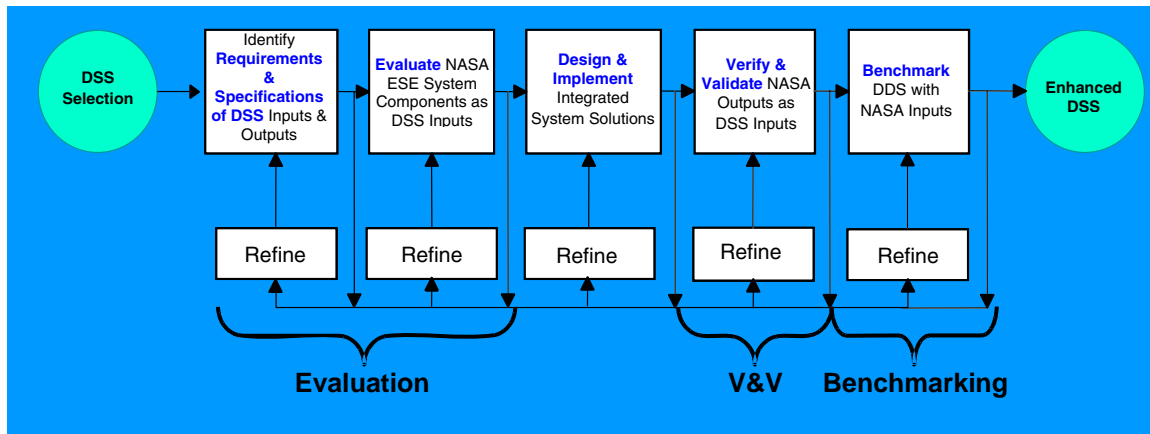
FEWS NET uses extensive data types, including gridded rainfall data and vegetation data derived from satellite imagery, to summarize current climatic situations. Rainfall images drive a variety of models that enable the investigation of the direct effect of rainfall amount on crop production. Vegetation index data derived from satellite imagery can provide insights into vegetative cover response to rainfall. Because vegetation images and rainfall images measure different parameters, both types of satellite observations are needed for hazard identification.

This professional review was initiated to assess what new data could be provided to FEWS NET analysts to improve their decision-making capabilities. Examples include new temperature, precipitable water, and humidity data, as well as more accurate and higher resolution vegetation and rainfall datasets. Accuracy estimates and projections of these datasets 1, 2, and 3 months into the future will help food security analysts provide additional information to decision makers regarding future food aid needs. It is proposed that these new datasets will be available to FEWS NET personnel (and all interested persons) by the end of 2009. By applying systems engineering principles, this questionnaire sought to provide an understanding of the operational requirements that would affect decision maker's choices. Once these details are specified, they eventually will be integrated into the FEWS NET decision support system, with the expectation that this information will strengthen the early warning systems' ability to reduce food insecurity, hunger, and famine. In addition, this information might also serve as feedback for potential future investments.

The enhancement of Earth science inputs and data is initially planned for Africa FEWS NET. As a result, the data will be delivered through the Africa Data Dissemination Service, which can be entered through the "Africa FEWS NET" link on the main USGS site (<http://earlywarning.usgs.gov/>) or directly by its own URL (<http://earlywarning.usgs.gov/adds/>).

### **Systems Engineering Approach**

The questionnaire was designed so that satellite-based standardized products for climate monitoring, that could enhance the FEWS NET Early Warning System, could be determined. Ultimately, it is assumed that these products will enhance FEWS NET decision support by enabling earlier and more accurate decisions regarding impending humanitarian needs by USAID staff and by their local, regional, and international partners. However, it is important to clarify that in this situation, the "requirements" are being described as a statement expressed by professionals of what they believe FEWS NET decision support should provide. To assess this information, this questionnaire is based upon the systems engineering approach, outlined in Figure 1, to enhance FEWS NET and decision support; the intent is to correlate evaluation, verification and validation, and benchmarking to provide guidance and feedback for the project design and implement proposed enhancements. Evaluation is an initial focus to assess end-user requirements, and this questionnaire is meant to reflect an evaluation activity.



**Figure 1.** Systems engineering approach (adapted from Bahill and Gissing, 1998).

Systems engineering principles are being applied to this process to help assess whether these evaluations actually lead to actionable changes made by decision makers. This information, in turn, can contribute increased successful outcomes of future goals and objectives associated with FEWS NET and decision making output.

## DESIGN AND ADMINISTRATION OF PROFESSIONAL REVIEW

To quantify FEWS NET satellite remote sensing requirements, a fact-finding professional review in the form of an online questionnaire was distributed to FEWS NET expert end-users and experts in Earth science information content. The end-users included FEWS NET and USGS field personnel associated with country and regional offices. The Earth science information content providers included experts in such areas as hazards, meteorology, and agriculture. The reviews contributed to a systems engineering approach of addressing necessary requirements in two ways: (1) collecting support requirements, and (2) establishing a baseline for the benchmarking effort.

The questionnaire addressed user requirements in three broad sections: (1) general requirements, (2) rainfall requirements, and (3) vegetation requirements. The general requirements section included identification and ranking of environmental variables and the spatio-temporal properties needed in those variables. The rainfall requirements section covered particular needs associated with both measured and predicted rainfall. The vegetation requirements section focused on vegetation monitoring and proposed predictions of vegetation status. The rainfall estimate being evaluated was NOAA's Rainfall Estimate (RFE) (Love et al., 2004), normalized difference vegetation index (NDVI) (Tucker, 1979) from the Global Inventory Modeling and Mapping Studies Advanced Very High Resolution Radiometer (GIMMS AVHRR) NDVIg 8 km dataset (Tucker et al., 2005), 1 km data from SPOT Vegetation (Maisongrande et al., 2004), and 500 m data from the Moderate Resolution Imaging Spectroradiometer (MODIS) (Huete et al., 2002).

Additionally, the questionnaire addressed the usefulness of FEWS NET decision support elements. This second, larger component of the questionnaire established a baseline for future benchmarking efforts so the effect of the proposed FEWS NET enhancements could be measured and assessed. This systems engineering approach has been utilized to coordinate the evaluation, verification and validation, and benchmarking components necessary to improve FEWS NET decision support so that guidance and feedback for the project's enhancements (which are now being implementing) could be provided. Evaluation is an initial focus, illuminating end-user requirements and potential NASA inputs.

The review questionnaire was made available in June 2007, and responses were accepted through July 2007. Over 60 reviewers were invited to participate; 43 participants provided complete responses. Of these respondents, 20 were field personnel: 5 working in Central America/Haiti and 15 working in Africa. The remaining 23 respondents were U.S. government and contractor personnel from the 5 associated FEWS NET agencies. Forty-four percent of the reviewers had between 6 and 10 years of FEWS NET-related experience and almost 35% had over 10 years of experience. The reviewers had a variety of educational backgrounds: 32% had an agriculture degree and 21% had a degree in remote sensing science. Most respondents had either on-the-job training or some formal training in meteorology, remote sensing, or geographic information systems.

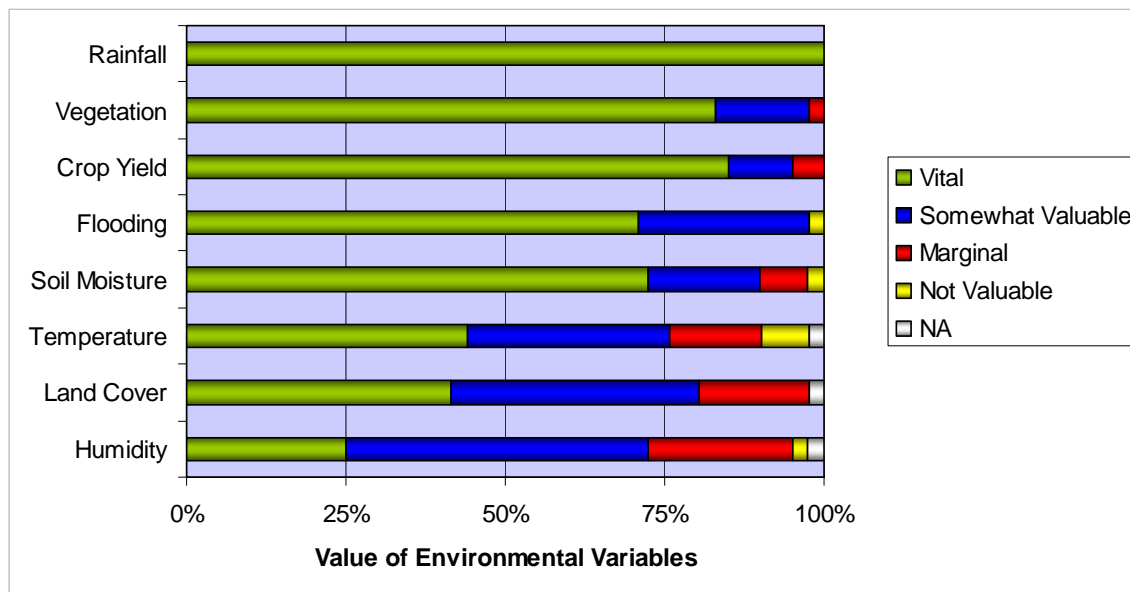
The questionnaire was developed based upon a suite of satellite-based standardized products specific for climate monitoring. However, because the users were familiar with both the strengths and weaknesses of different remote

sensing datasets and of the currently available dataset selection, respondents tended to express their requirements more in terms of what they knew was possible rather than in terms of what was actually required. Therefore, although the questions were designed to elicit the most candid responses possible, the responses to more specific questions often tended to be based upon knowledge of existing sensor options.

## RESULTS

Overall, rainfall data was regarded as an essential component of famine early warning. A clear majority of respondents felt that data on crop yield estimates, vegetation, soil moisture, and flooding are also vital. However, less than half of the group saw temperature, land cover, and humidity data as vital for early warning analysis (Figure 2). When asked to cite essential requirements of FEWS NET analyses, the professional reviewers expressed concerns associated with the great diversity of food security-related challenges, as well as logistical constraints. Issues were specifically raised concerning both slow-onset concerns, such as drought, and extreme events, such as cyclones and flooding. Varying climate regimes (e.g., too much rain, not enough rain, cyclones) requiring different environmental data to assess the impact of climate on food production and food security were mentioned as well. 1

Figure 2 summarizes the respondents' opinions regarding the value of various environmental variables.



**Figure 2.** Review's responses to general requirements section of questionnaire.

Rainfall was collectively expressed as an essential component for famine early warning. A clear majority of respondents also felt that crop yield estimates and vegetation were vitally important; these results were expected and were corroborated by responses provided in the benchmarking portion of the questionnaire. For example, one of the benchmarking questions asked about frequency of use of specific products provided through the USGS FEWS NET Early Warning System, including both rainfall and vegetation products: the RFE and NDVI. Both of these products were frequently used: 30% used RFE daily and 75% used it weekly; NDVI was not as commonly used on a daily basis, but approximately 60% of respondents used the product on at least a weekly basis.

An unexpected result regarding the latency requirements of USGS FEWS NET Early Warning System users was attained. Responses clearly indicated that 1-day latency was needed to meet analysis and decision making goals. Original assumptions were that multi-day latency would have been sufficient. Project implementation goals were revised based on this new information.

## SUMMARY

In this systems engineering evaluation, a USAID-supported early warning decision support system has been described: FEWS NET. By using the fact-finding questionnaire technique, information regarding user requirements and DSS baselining was obtained. The professional opinions of more than 40 early warning end users pertaining to what they believe to be required properties of FEWS NET information products was provided and summarized. By using this requirements-seeking questionnaire technique, information useful to FEWS NET professionals was obtained. Overall, rainfall and vegetation remote sensing data were identified as being beneficial for providing actionable food security information for FEWS NET. These results corroborated benchmarking information on rainfall and vegetation as demonstrated by self-reporting product usage indicated on the USGS FEWS NET Early Warning System ([earlywarning.usgs.gov](http://earlywarning.usgs.gov)).

This questionnaire analysis revealed key inputs related to and potentially affecting currently planned FEWS NET enhancements. Our expectation is that incorporation and use of these inputs will enhance the character and performance of the decision support system – the USGS FEWS NET Early Warning System. Based upon the outcome of the questionnaire, the overall impact that these enhancements will make upon decision-making activities of the FEWS NET end users should be considered to appreciate the effectiveness of this process.

## ACKNOWLEDGMENT

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