



# **FEWS Working Paper**

**A.I.D. Famine Early Warning System**

PN-AB7-644

93162

## **VULNERABILITY AND FOOD SECURITY in the FEWS PROJECT**

### **GUIDELINES for IMPLEMENTATION**

**FEWS Working Paper 2.2**

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**April 1990**

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## I. THE FEWS PROJECT AND THE NEED FOR A CONCEPTUAL FRAMEWORK

The Famine Early Warning System II (FEWS II) Project is the continuation, on a project funded basis, of initially emergency funded activities in response to the African drought induced famines of the early 1980's. Funded by the United States Agency for International Development (AID) FEWS II is an information system designed to:

- (1) **Strengthen** the early warning capability within AID,
- (2) **Reinforce** host country early warning efforts, and
- (3) **Promote** a common approach to early warning in the international community.

FEWS II monitors seven countries in Africa with six FEWS field representatives (FFR) and a Washington based Ethiopian Analyst. The six countries with resident FFR analysts are Mauritania, Mali, Burkina Faso, Niger, Chad and Sudan. The FFR, in collaboration with USAID Mission personnel, is responsible for monthly cable reporting on relevant food security conditions via the Food Security Operations Cable (FSOC). The establishment of a functional early warning system is not separable from the effort to monitor and understand the food security situation. FEWS is viewed as a component of an overall food security effort.

Monitoring supply, demand and utilization within a food system is highly complicated, and in the African case site specific due to the diversity of the physical and socioeconomic environment. Stating that a system, or process, is complicated and diverse implies that there are many variables impinging on that system whose impact and influence are not easily isolated. Site specificity, in turn, implies that analysis cannot be taken out of context and hence is not situation neutral. Analysis of the African food system requires both a multidisciplinary perspective and local analytical expertise.

In recognition of the complex physical, social and economic forces impinging on the food systems of Africa, the FEWS Project has taken a multidisciplinary approach to design and implementation. The diversity of conditions prevailing in the seven countries monitored by FEWS compels this multidisciplinary and decentralized approach. The resultant diversity of approach and paradigm has, in turn, demanded a common conceptual framework to communicate the FEWS perspective, delineate project goals and guide future activities. The concept of vulnerability has evolved to fill this need. This paper is an introduction to present deliberations on the concept of vulnerability, their practical implications via vulnerability assessments and guidelines for their implementation in the FEWS project.

## II. THE FEWS PROJECT AND VULNERABILITY

The FEWS Project is a multidisciplinary undertaking with participants and information sources from a variety of perspectives and disciplines. The project's diversity is reflected in the composition of the FEWS/Washington staff, the six field representatives and the Mission level Food Security Operations Group (FSOG). The home office staff, comprised of both physical and socioeconomic scientists, consists of specialists in agroclimatology, geography, economics and information systems. The six field analysts are composed of a similar diversity of backgrounds ranging from public health to agronomy and anthropology. The FSOGs differ by country but are generally comprised of the different sector development officers (Agriculture, Health, General, etc.) resident in the USAID Mission. The FSOG is tasked with adding content and review to reporting on food security issues, including the monthly FSOC.

The multidisciplinary configuration of FEWS necessitates explicit delineation of a shared paradigm that links physical and socioeconomic data within a consistent conceptual framework. This framework will allow the multidisciplinary actors in FEWS to communicate effectively, monitor project progress and define areas for additional effort. A FEWS conceptual framework must serve to integrate, in a theoretically sound fashion, the variety of data and information regarding food security that FEWS is mandated to follow. The variety of data involved includes, but is not limited to, agricultural production, satellite imagery, rainfall, demographics, prices, health, nutrition, as well as anecdotal information.

### A. Everyone is Vulnerable

The concept of vulnerability has been identified by the FEWS Project as a useful thought organizing tool, particularly for an endeavor tasked to integrate information and personnel from a variety of disciplines. With the advent of FEWS II the concept of "vulnerability to famine" has evolved into a formal framework on which FEWS activities may be organized, presented and understood. Vulnerability to famine, or vulnerability, is a relative term describing the level of susceptibility of people to food insecurity. In the FEWS framework everyone is vulnerable to famine, with people within a country differing through their degree of vulnerability.

### B. Focus on Socioeconomic Groups

Recognition that everyone is vulnerable, but with differing levels of susceptibility to food stress, provokes reflection on the causes of stratification and differentiation within a society. These causes may be bounded by physical, social, economic or cultural constraints that influence the level of vulnerability to famine. Differentiating people within a society by their productive activities, thereby focusing on socioeconomic groups, allows FEWS

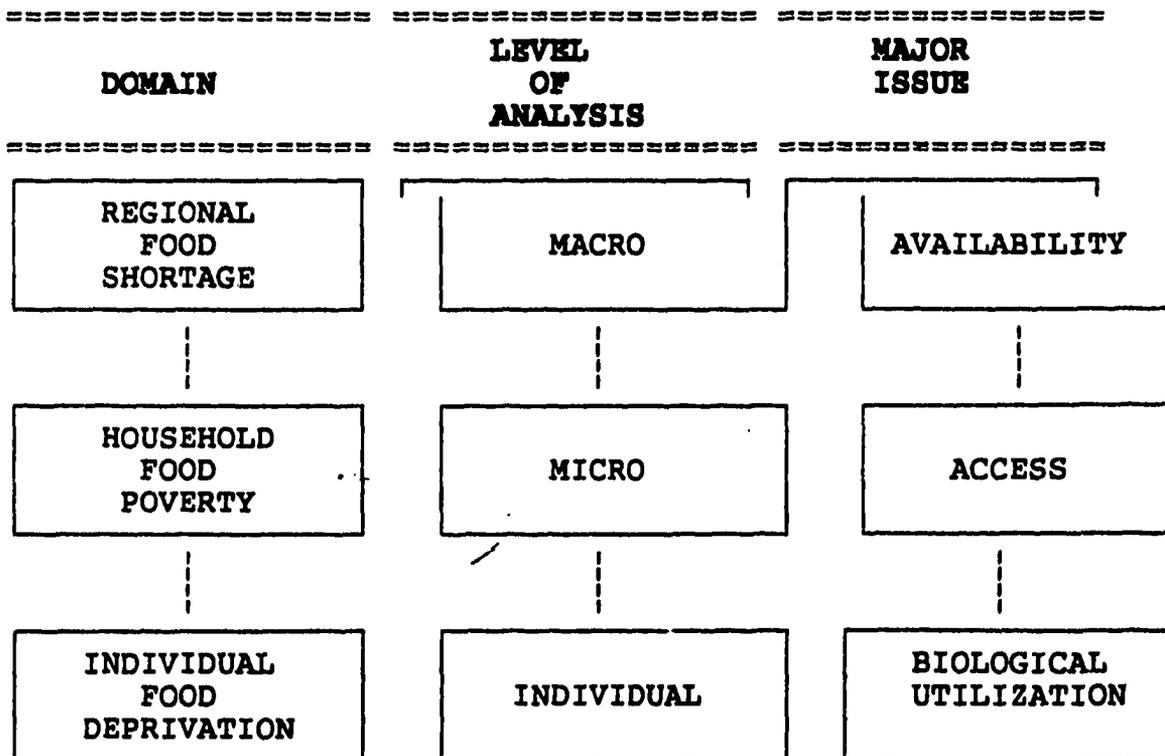
to identify the differing resources that various segments of society command to alter their relative degree of vulnerability.

**C. Three Domains of Food Insecurity**

The identification of the target of vulnerability deliberations as people, their socioeconomic grouping and location, reflects a recent refinement within FEWS. The FEWS Vulnerability White Paper (#2.1) reinforces this notion. The FEWS "vision" is described as the monitoring and foreshadowing of the impact of food stress situations on people. The Vulnerability White Paper has served as a catalyst to initiate the vulnerability concept into operational use.

The Vulnerability White Paper provides the link between the FEWS notion of vulnerability and the Alan Shawn Feinstein World Hunger Program's (WHP) efforts at defining hunger research. Their research defines a conceptual structure of hunger composed of three domains; food shortage, food poverty and food deprivation. The domains correspond to three different scales of social organization; region, household and individual. The corresponding levels of analysis for the three domains are macro, micro and individual which focus attention on questions of availability, access, and biological utilization of food. A schematic for the three domains of hunger is presented in Figure 1 below.

Figure 1



The analytical focus at any of the three levels is not limited to a particular type of data although the macro, micro and individual levels will concentrate on physical, socioeconomic, and health and nutrition information, respectively. Other factors from different disciplinary realms may influence at each level. For example, monetary policy at the macro level may influence prices thereby influencing household decisions with subsequent ramifications at the individual level. The link that binds the three domains is the household level focus on food poverty.

#### D. Linkage via Income Based Household Models

After identification of socioeconomic groups for a particular country (see Appendix A) and seeking information relevant to the three domains of hunger, the analyst is still faced with the daunting task of integrating an excess of information in a coherent interpretive framework. The analyst must assimilate and communicate a country specific interpretation of the food security situation from disparate data. Further progress in delineating this task from the concepts of vulnerability and domains of hunger was achieved at the 1990 FEWS II Workshop held in Tunis. A permutation of income based household models was identified as the appropriate vehicle for organizing information for vulnerability assessments.

Within the context of the proposed vulnerability framework information at the broad regional scale is most readily available on factors influencing food availability such as rainfall, agricultural production and NDVI. Information at the specific individual level is also available, but frequently involves point survey data from health and nutritional clinics or surveys. Neither of these two domains is appropriate for guiding the identification and implementation of responsive interventions. The broad regional level may be too immense to identify specific locations and the individual level information is difficult to generalize to an implementable social or spatial area. Effective intervention is often community based which requires a better understanding of household behavior and illustrates the importance of focus on the household.

Differential levels of vulnerability are due to varying household resource endowments across and within socioeconomic groups. The full complement of household resources consisting of physical, human and social capital are employed to respond to situations of food stress. Distinguishing response to shocks by different socioeconomic groups and households implies that responses are constrained by the resources at their command. A convenience analytical construct to capture a portion of these resources available to the household, particularly physical and human capital, is to focus on the household income and wealth situation.

Augmenting the vulnerability concept towards focus on income possibilities by socioeconomic group explicitly recognizes that households utilize different means to alleviate the stress of an

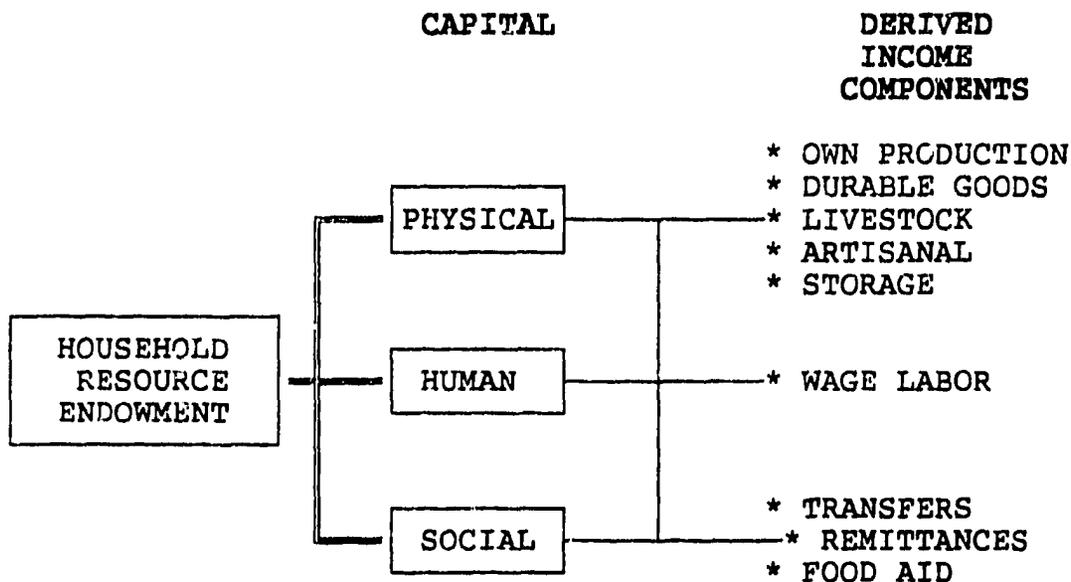
unanticipated shock to their "normal" economic situation. The key addition to the vulnerability concept is the differentiation of income in Africa, reflected through and within socioeconomic groups. It is often assumed that incomes are quite uniform across socioeconomic groups, particularly in the rural African sector. However, substantial differences in income and wealth exist in the rural sector that distinguish and differentiate society. Anthropologists have long been aware of the differential incomes and economists with field experience support this view.

Advancing the focus from the more aggregate socioeconomic groups to the household level provides a useful tool in interpreting the influence of various factors on vulnerability. Socioeconomic groups, identified by principal production choice, are distinguished in their level of vulnerability through the diverse resources and coping strategies they utilize to provide household level access to food. Households will employ different strategies for expanding their income generating possibilities to contend with food system shocks across and within socioeconomic groups. By interpreting information in the framework of an income based household model the analyst is obliged to make the needed distinctions across socioeconomic groups.

Recognizing that socioeconomic groups are a natural differentiating factor within a society, vulnerability differentials become a function of the differential resource endowment among households. Income possibilities are derived from combinations of the resources that the household commands. Income can be derived directly or from combinations of the household capital resources; physical, human and social. The derived and potential income from each of these three components can be utilized to counter shocks to the household's well-being. A convenient conceptual framework for capturing the major income generating possibilities for the household via its expanded income is the income based agricultural model. In these models household production and consumption decisions are inextricably linked. Production and consumption decisions will have subsequent impact on health and nutritional status within the household. Agricultural household models incorporate both supply and demand information that reflects household resource access to produce or provide food. (see Appendix B for a formalized treatment).

In the FEWS monitored countries the major household economic activity is in the agricultural sector. The bulk of the people in these societies are rural agriculturalists and pastoralists within an agricultural sector that is principally household and subsistence based. The principle income source within an agriculturally based economy is from the agricultural sector which utilizes physical (inputs, land, livestock, etc.) and human capital (labor, level of education, etc.) to derive income.

Figure 7, Resource Endowment, Capital and Derived Income Components



Income based agricultural household models are unique in that they incorporate both physical and socioeconomic data in a conceptual whole. Connecting the physical and socioeconomic sides of the FEWS mandate introduces a bridge between the macro and micro domains and brings a structure to the profusion of information involved in food security assessments. At the center of the agricultural household model is the income constraint which is the central idea behind the model of differentiated behavior across socioeconomic groups.

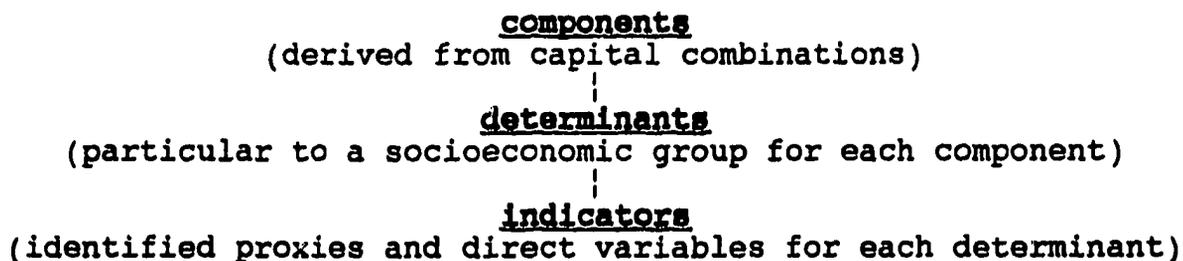
For example, own production could consist of both agricultural and non-agricultural activities. Agricultural production activities include income from food crops, cash crops, and livestock. Non-agricultural income would consist of artisanal and off-farm labor income (i.e., wages). In a more pastoral society livestock income may be more important than income from crop production. In other areas agriculturalists may need to be distinguished between cash crop and food crop producers. The analyst is assigned to identify the various components of derived income for the socioeconomic classifications in their respective FEWS countries.

Derived from household resource endowments, the expanded income framework assigns paramount importance to own production, either food crop, livestock or other, as this remains the major component (share) of expanded household income. Expanded income possibilities can also be derived from other resources to yield transfer income (including gifts and inheritance), asset income and wage income (see Figure 7, above). Identification of the derived components of expanded income explicitly requires the analyst to acknowledge the diversity of the determinants of household income in the African context.

Derived income components may be further disaggregated into the determining factors, or determinants, that influence the income from that particular component. For example, determinant of the own production component for an agriculturalist would consist primarily of agricultural output. This determinant (e.g., agricultural output) of the major share of household derived income is bounded by the resource constraints on the household. A similar exercise of disaggregation of income components for the various socioeconomic groups yields similar insights into what types of information is needed to assess vulnerability by socioeconomic group.

Taken one step further the determinants (agricultural output) imply the necessary indicators that need to be followed to make informed judgements about the vulnerability status of a particular population. In our recurring example of own production for an agricultural household the indicators for agricultural output might include rainfall comparisons to average, NDVI data, and yield statistics. Once income components are identified for the socioeconomic group under analysis then the determinants of each income component should be isolated and indicators identified.

Figure 2, Components, Determinants and Indicators



The central concept of vulnerability is the expanded potential income derived from the household resource base. Derived from the total resource base, expanded income does not distinguish between the household income represented by food produced for autoconsumption and that from the sale of cash crops used to purchase food. The distinction lies in the different level of vulnerability that the household abides resulting from bounds imposed by the macro environment, household economic choice and the health and nutritional status of individual household members.

#### E. Timeframe of Vulnerability: Current vs. Chronic

The monthly production of country cables on the food security situation is the joint responsibility of Mission personnel and the FEWS field representatives. Three times a year the FEWS Washington Office must present these cables in a formalized report. The resulting trimestral reports cover the pre-harvest situation in October, the harvest situation in January and the vulnerability status in June.

The vulnerability concept embraces the idea of both short and long term assessment of the food security situation. This temporal aspect of vulnerability allows examination of both current and chronic conditions that impact on food security. Continual monitoring of current vulnerability and comparison to the underlying chronic vulnerability permits foreshadowing of potential food insecurity situations for populations in particular areas. FEWS continually monitors vulnerability throughout the year, but the Vulnerability Assessment allows the field to explicitly update and reflect upon the longer term influences on vulnerability status of populations within a country.

Current vulnerability refers to the ongoing monitoring of FEWS countries over the year. Data accumulated throughout the agricultural season prompts continual refinement of judgements to reflect new information. This type of reporting is intra-annual. The October and January reports strongly reflect this continual updating of current vulnerability, monitoring the current situation as the agricultural year unfolds and additional information (rainfall, NDVI, cereal prices, agricultural production, etc.) is made available to revise the assessment. The Pre-Harvest and Harvest assessments focus on the present year conditions that influence the output of the agricultural sector.

Chronic vulnerability implies a longer term perspective on factors affecting food security. It includes physical factors, such as longer term variability in rainfall, and socioeconomic phenomena, including changes in economic regimes or preference patterns. Both physical and socioeconomic factors affect change in the structural base of a society's resources and constraints.

The Vulnerability Assessment is completed for publication in June in order to provide an updated baseline from which to assess incoming information as the agricultural season progresses. By providing for a reflective examination of long-run trends, the Vulnerability Assessment is the point of reference for interpreting current information as it becomes available within the evolving agricultural season. The Vulnerability Assessment affords the analyst the opportunity to examine the "underlying process and causes rather than the immediate events".

Accumulation of information over years (chronic) rather than within a year (current) is used to reframe the analysts understanding of the food system in their respective countries. The temporal distinction between chronic and current vulnerability implies the utilization of different indicators. Information on chronic vulnerability provides the baseline from which to interpret current vulnerability. This baseline vulnerability sets boundaries, identifies trends and allows comparison of upcoming agricultural conditions for informative and interpretive reasons. The FEWS calendar begins with this annual revision, or "house cleaning", via the updating of each country vulnerability assessment and whose publication corresponds to the beginning of the new agricultural season.

## F. Four Degrees of Vulnerability to Famine

With the identification of socioeconomic groups, the interpretation of information within an income based household model, and understanding the temporal nature of vulnerability assessments the next step is to define levels of vulnerability to famine. Classification of degrees of vulnerability were identified through recognizing that the chosen nomenclature should imply the required response by decision makers. The choice of terminology is driven by the requisite actions needed in response to the subjectively appraised vulnerability status.

Ordinal rankings were chosen in order to emphasize the relative nature of vulnerability. An ordinal ranking implies relative comparisons across groups without quantifying the absolute difference between the groups. An ordinal ranking will indicate whether someone is more vulnerable than someone else, but not necessarily how much more vulnerable. A distinctly comparable cardinal scale would imply greater accuracy and reliability of the available data than actually exists. Data presently available to FEWS will not support an absolute objective statement of comparison. The vulnerability assessment must rely on the subjective assessment and subsequent rankings of the field analyst.

The four ordinal states that evolved from the FEWS Workshop in Tunis for use in the 1990 version of the Vulnerability Assessment are outlined in the table below. Implicit in the delineation of a vulnerability continuum is the idea that famine is a state whose underlying process may be entitled "enfamishment". Note that food security monitoring via vulnerability assessments is a continuing process and people in regions may move from one degree of vulnerability to another over time as circumstances change.

TABLE 2, The Levels of Vulnerability

VULNERABLE STATE		ACTION REQUIRED
(1) <u>famine</u>	e n f a m i s h m e n t	* <u>too late</u> (for preventative action)
(2) <u>extremely = at-risk</u>		* <u>immediate action required</u> (econ. or nutritional)
(3) <u>moderately</u>		* <u>under surveillance</u> (targeted monitoring)
(4) <u>slightly</u>		* <u>regular monitoring</u>

## G. Summary

A summary of the key ideas that influence and direct FEWS II activities through the vulnerability conceptual framework is presented below.

### KEY IDEAS REGARDING THE FEWS II CONCEPT OF VULNERABILITY

- 1 - **Everyone is vulnerable to food insecurity**  
Vulnerability is a relative term in that different individuals will have differing degrees of vulnerability to famine that are determined by the resources they command in facing food stress situations.
- 2 - **Analytical focus on socioeconomic groups**  
Resource endowments are influenced by choice of productive activity which determines socioeconomic groups. The most frequently encountered socioeconomic groups are agriculturalists and pastoralists although country and subregion permutations exist (ex., miners, fisherpeople, wage laborers, etc.)
- 3 - **Three Domains of Food Insecurity**  
Three analytical domains of hunger can be identified that encompass regional food shortage, household food poverty and individual food deprivation.
- 4 - **Vulnerability and the Income Based Household Model**  
Derived from the household resource base, expanded potential income is the core of the FEWS vulnerability Assessment methodology.
- 5 - **Temporal aspects of vulnerability analysis**  
Vulnerability must be examined in a temporal context. Short-term current vulnerability requires monitoring due to changing situations as the agricultural season progresses. Long-term underlying chronic vulnerability provides the context for interpreting information and the link to strategic developmental intervention as opposed to emergency intervention.
- 6 - **Four levels of vulnerability**  
The establishment of a common nomenclature for the levels of vulnerability is as follows:

=====	=====
STATUS	ACTION REQUIRED
=====	=====
(1) famine	* too late to act
(2) extremely = at-risk	* immediate intervention required
(3) moderately	* under surveillance
(4) slightly	* continued monitoring

### III. VULNERABILITY ASSESSMENTS

Examination of the timing of publication of Vulnerability Assessments provides insights into their intended function. The agricultural season, from planting to total disbursement of the harvest, generally begins in May and ends in April. Published at the commencement of a new agricultural year (i.e., June), Vulnerability Assessments are distributed during the overlap between successive agricultural seasons. Thus, Vulnerability Assessments are intended to foreshadow upcoming problems for the emerging agricultural year having been promulgated too late to be identifying areas in need of immediate intervention to relieve food stress. They may also be used to justify having expended resources on particular regions and peoples throughout the past season.

The Vulnerability Assessment is intended to give a look forward into the upcoming agricultural year within the FEWS monitored countries. It is a foreshadowing exercise that recognizes that one must compete for a decision maker's limited time. The Vulnerability Assessment should focus the attention of the reader on what the field analyst perceives as the most vulnerable people and areas in their respective countries. Vulnerability Assessments are not merely descriptive reports as is the case in the Pre-Harvest and Harvest Assessments but are intended to be prescriptive by foreshadowing particular areas and people to more closely monitor in the upcoming agricultural year.

#### A. Importance of Vulnerability Assessments

The purpose of a country Vulnerability Assessment is to determine, as best as possible, in a systematic and eventually reproducible fashion an anticipation of individual reaction to stress events like production shortfalls, civil unrest and pest attacks that may lead to or culminate in famine. However, these assessments can also play a role in food security and general development strategies.

The creation of a common conceptual and methodological framework through the concept of vulnerability insures some level of similarity across and within countries for comparison and standardization purposes. The purpose of a Vulnerability Assessment is to integrate the various information collected in the FEWS effort into a logical framework for analysis. Even if the assessment remains a subjective analytical exercise there will be some common structure across countries and years that will allow comparisons. Furthermore, previously unrecognized vulnerable groups and areas may become apparent.

The Vulnerability Assessment allows the different analysts to reflect upon and interpret information, within a common framework, that has been collected throughout the previous years. This allows time for identification of more long term trends that are often overlooked in the day-to-day effort to meet recurrent demands for

information. Scheduled to appear before the onset of the busy agricultural season the FFR is tasked during the "dry" season with reflection and writing about the food security situation of their countries.

The FEWS Vulnerability Assessment addresses other specific targets and broad strategies of the Development Fund for Africa (DFA) Action Plan than the explicitly mentioned increased famine preparedness (Target 4.2) and focus on the income of at-risk groups (Target 4.3) through ongoing early warning monitoring and the longer term Vulnerability Assessments. Both activities are important components of the broader "priority concern" of food security (Strategic Objective IV). Specifically through the vulnerability efforts FEWS can have information input into the improved management and efficiency targets in natural resources (Strategic Objective III) and economic growth (Strategic Objective I), respectively. The long-term outlook of vulnerability assessments allows their information to be used in a developmental context through the identification of trends and chronic patterns that need specific intervention rather than emergency programming.

Appreciation of the temporal aspect of Vulnerability Assessments highlights their role as the institutional memory of FEWS. By codifying the subjective interpretations of the field analysts the human capital that their subjective experience represents is embodied in a yearly report that can be used for effective communication. Similarly, the data collected and catalogued during the vulnerability exercise represents a yearly updating and augmentation of the FEWS database. As the project progresses and personnel change both in the field and in the home office (FEWS and AID) the Vulnerability Assessments will embody the experience and data from the field. In the long-run the vulnerability database, analytical techniques and products could evolve into an expert system.

Vulnerability Assessments are intended to predispose readers to follow certain people within particular regions in a country. Foreshadowing particular problems through a Vulnerability Assessment will predispose readers to pay attention to a particular region, occupational group or people. As the agricultural season progresses and more information becomes available to refine judgements the Vulnerability Assessment reader will be predisposed to react to this information by earmarking time and resources.

#### B. Audience for Vulnerability Assessments

Vulnerability Assessments have a dual role of familiarizing both the reader (consumer) and producer of the report. The targeted consumer audience consists of decision makers not immediately familiar with the circumstances of a particular country who are, nevertheless, charged with making decisions concerning assistance to a country. Vulnerability Assessments should be of particular interest to those charged with decision making but who do not have the luxury of extensive field experience and knowledge of the

countries involved. They will serve as background reading to inform and eventually predispose readers to ask the appropriate questions and make better informed decisions affecting food security in the FEWS monitored countries.

The producers of the Vulnerability Assessment (Mission personnel in collaboration with FFRs) will also gain insights into the food security situation in their respective countries for identifying areas for increased monitoring. The exercise of producing a logical document in a consistent analytical framework will synthesize the shared and conventional wisdom of country resident experts and help identify previously unrecognized vulnerable groups and/or areas.

Through the consensus seeking process inherent in multidisciplinary work and the implementation of the vulnerability conceptual framework, Missions should be able to communicate their intended message more clearly, particularly to those whom they want to influence or seek response from. Vulnerability Assessments should enhance the communication between the field and the center.

Mission personnel and FFRs will benefit through the debate and discussion involved in producing a Vulnerability Assessment. The resulting report will set the context for field judgment of the country level impacts of shocks to the food when, and if, they occur during the year. Over the course of three annual vulnerability the accumulated information regarding the food security status of a country reports can be applied to country level development planning.

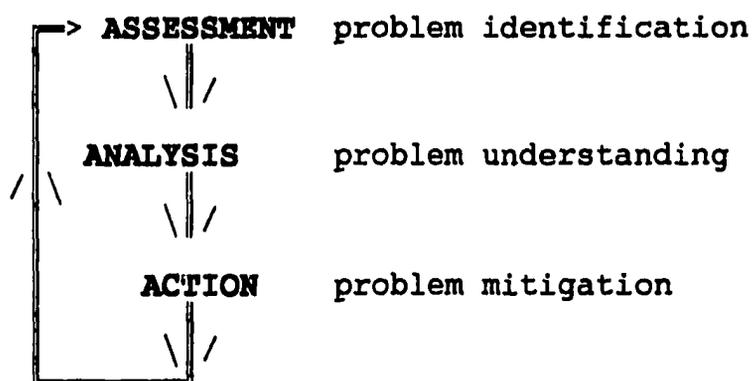
The purpose of Vulnerability Assessments remains informing and predisposing both the reading and producing audience within and without the country of assessment. The subjective assessment of the field analysts, vetted by the USAID Mission's multidisciplinary FSOG prior to publication, will provide readers and producers information on the vulnerability status of a country and its people, within a consistent conceptual framework.

Reports should always be written with prospective audiences in mind in order to facilitate communication of the intended message. FEWS recognizes that the attention and time of a decision maker is limited. Information for decision making is best utilized when the length of the report corresponds with the available time to read. For example, within the agricultural season bulletins are emphasized because they are quick 10 minute reads. Vulnerability Assessments require communication of a greater amount of information implying a longer length. However, they should not exceed a total read of 20 to 45 minutes, depending on how many country reports are read. An individual country report should be an approximate ten minute read (2 to 3 pages).

### C. Distinguish Vulnerability and Vulnerability Assessments

A Vulnerability Assessment is a product, a report appearing once a year in June. This should always be distinguished from vulnerability as a useful concept for organizing disparate information into a logical theoretical framework. It is also useful to distinguish between assessment, analysis and action in dealing with problem solving exercises. Assessing is the act of problem identification while analysis is problem understanding which in turn results in action to mitigate the identified and understood problem. Figure 2 presents this process in a flow diagram.

Figure 2, Assessments, Analysis and Action



The FEWS Project is mandated to create, develop and implement an analytical methodology for assessing vulnerability to famine. This task has imparted a simultaneous research design and program implementation role to the Project. A merger of the typically distinct order of assessment and analysis can be accommodated if one takes an experimental approach to research design. experiential

In experimental research design the normal order of assessment and analysis are accelerated to accommodate the need for information. Under such circumstances the design must offer an organization for one's thinking and not a rigid document of instructions. The design should be flexible to allow experimentation for testing of that design as it may not be correct under all circumstances. Opportunity for testing must be available in a variety of settings over a variety of implementation scenarios. The FEWS Project implementation environment fits this description.

The FEWS Project has the possibility of implementing the experimental system in six or seven different countries with an equivalent number of analysts and will be able to quickly determine what portions of the experimental design of Vulnerability Assessment are valid. What works and what does not work will be identifiable relatively quickly (i.e., after the reports are submitted and reviewed in mid-1990). FEWS has the opportunity to adjust this experimental design with three years of Vulnerability

Assessments (1990, 1991 and 1992) over the course of the project.

Simultaneous implementation of Vulnerability Assessments in different countries under differing conditions, due to country and analyst effects, provides an experimental laboratory for FEWS to determine what does and does not work. The three yearly Vulnerability Assessments over the life of the project allow for modification as FEWS becomes more informed about the usefulness of the reports from user surveys, field analyst comments, and Mission feedback. Review and revision through the institutionalized and regularly scheduled FEWS biannual Workshops should provide the opportunity for interaction between producers and users of information.

#### IV. GUIDELINES FOR IMPLEMENTING A VULNERABILITY ASSESSMENT

Guidelines for implementing a Vulnerability Assessment naturally evolve from the conceptual framework. Acknowledging that everyone is vulnerable, the three domains of food insecurity, that distinguishing levels of vulnerability depend upon socioeconomic groups, the need to interpret information in an income based household framework and the temporal aspect of vulnerability suggest an ordered set of guidelines for performing vulnerability assessments and a structure for reporting.

The following qualitative and sequential guidance attempts to codify the important attributes of the more formal quantitative household model into the vulnerability effort. The resultant protocol for field implementation of a Vulnerability Assessment recognizes the lack of the extensive data needed to implement a quantitative model encompassing the three domains of food insecurity. However, the underlying principles of this tripartite framework can be invoked to guide the analyst's organization of disparate, and often incomplete, data. The focus is on the household level because of its "bridging" role between the regional and individual domains, as well as the emphasis on income components derived from household resource endowments.

The analyst must first identify the relevant aggregate socioeconomic groups resident within a country. A first attempt at this was achieved during the Tunis Workshop (see Appendix A). Socioeconomic groups will differ from country to country and must remain aggregate at this first cut in order to minimize the overload of information that must be integrated. Division of the country population into aggregate socioeconomic groups should, when summed over the country, account for the entire population.

After determining a comprehensive aggregate set of relevant socioeconomic groups the analyst should identify the resource endowments for each group in terms of physical, human and social capital. The derived income components from the specific socioeconomic resource endowments should then be identified.

Equipped with the income components by socioeconomic group the analyst must now list the determinants for each of the components by group. Distinguishing determinants by socioeconomic group will suggest relevant indicators for monitoring and evaluating the status of that component of household income and hence the household's relative vulnerability to an exogenous shock in the upcoming year.

The outlined sequence of implementable steps for the household level provides guidance to the process and structure of the June Vulnerability Report. Reporting should also consider the need for information at each of the three domains of food insecurity. All three levels must be addressed in forming judgements about vulnerability within a particular country.

#### A. Who, What, Where, When, How Many and the Likelihood

A convenient device for organizing the steps for implementing a Vulnerability Assessment is a question word format. By addressing the questions of Who, What, Where, When, How Many and Likelihood, the analyst has a initial guide for ordered thinking on vulnerability. A question word device will assist in organizing and jump-starting the vulnerability thought process and the subsequent allocation of particular groups of people to a level of ordinal vulnerability.

##### (1) WHO: to determine the socioeconomic groups

- \* identify relevant socioeconomic groups for a particular country via their major productive activity
- \* groups should be inclusive of country population

##### (2) WHAT: to determine what information is needed

- \* identify the respective resource endowments by socioeconomic group
- \* identify the resource derived income components by socioeconomic group
- \* identify the determinants of each income component by socioeconomic group
- \* select and interpret indicators for each determinant (may be overlapping across income components and socioeconomic groups)
- \* identify additional information that should be followed over the course of the upcoming season (data needed may or may not be available)

##### (3) WHERE: to determine spatial locations of vulnerable groups

- \* identify the spatial dispersion of each group within the country
- \* determine the vulnerable areas

(4) **WHEN:** to emphasize the temporal nature of vulnerability

- \* utilize information on both a short and long term timeframe
- \* comment on both current and chronic vulnerability

(5) **HOW MANY:** to delimit the number of people affected

- \* identify the number of people in each group

(6) **LIKELIHOOD:** to determine the likelihood of a deterioration of vulnerability status in the upcoming year

- \* designate the level of ordinal vulnerability for each socioeconomic group by spatial location
- \* assign qualitative likelihoods of each group facing a change in this level over the upcoming year due to unexpected shocks to their resource base and subsequent income

Each of the layers of information represented in the question word format are linked by their spatial, temporal and social situations. The specific order of implementation of the information "overlays" or "landscapes" is not important. For example, the WHO (socioeconomic groups) and WHERE (physical or structural locations) information overlays will yield the same result no matter which overlay is first to be considered. However, the disaggregated layering of sequentially more detailed information can be extremely unwieldy and requires some sort of methodological tool to facilitate implementation.

B. Multiple spreadsheets

Due to the unwieldy nature of the multiple layers of information required in making judgements concerning food insecurity a methodological technique of organizing the information is needed. At present, the capacity to organize, analyze and present the multiple disaggregated layers does not exist. In place of sufficient data and resources to implement a formal model of vulnerability the substance of the underlying model can be approximated. The information ordering process represented by the question word format can be approximated by the field analyst through the use of sequential spreadsheets. Spreadsheets assure consideration by the analyst of the various information needed to address the issue of vulnerability at its different levels.

The surrogate methodological device represented by the spreadsheet format involves the organization of information into cells of a matrix. An empty cell serves to remind the analyst that a particular layer of information has not yet been addressed. The spreadsheet format assists the analyst in interpretation of the information by socioeconomic group, component, determinant and indicator. Figure 7 presents an example of the primary spreadsheet that addresses the combination of socioeconomic groups and their

components of income. The secondary spreadsheet would take a particular cell, for example agriculturalists by own production, and disaggregate by either further distinguishing types of agriculturalists or the determinants of income from own production. Sequential iterations on this process would eventually arise at indicators for each determinant of each income component in a socioeconomic group.

FIGURE 2, Derivation of Socioeconomic Group by Income Component Spreadsheet

RESOURCE ENDOWMENT	CAPITAL								
	PHYSICAL			HUMAN			SOCIAL		
GROUP\COMP.	Prod	Assets	Animals	Artisan	Stocks	Wages	Trans.	Remit.	Other
Agri-culturalist	X								
Pastoralist									
Fisherfolk									
Urban Laborers									
Other									

### C. Indicators

The sequential disaggregation of the spreadsheet process culminates in identifying relevant indicators that directly result from the FEWS vulnerability model. These indicators, not to be confused with variables, condense information on causes or consequences of food stress. Indicators are used to infer information about the food system, its operation and the vulnerability status of households. Indicators condense information that is contained in directly measured variables. The distinction between variables and indicators is that the former are measured while the latter are computed. Variables may be either exogenous (independently determined) or endogenous (dependent upon other variables) and hence a variable can be an indicator but not all indicators are variables.

For example, area under cultivation is a variable influencing agricultural output. Both area and output are measured variables. However, yield is a computed value from directly measured output and area (i.e.,  $\text{yield} = \text{output}/\text{area}$ ). Thus, yield is the indicator composed of the variables output and area. Output and area under cultivation are in turn influenced by management practices, household size, weather, etc.

Specific examples at each of the three domains will help to clarify this distinction. Normalized Difference Vegetation Index (NDVI) and the Consumer Price Index (CPI) are physical and social indicators that have direct influence on the food system. NDVI and CPI are composed of reflectance and price variables, respectively. The variables that compose NDVI are satellite monitored reflectance measurements from the earth's surface in the high visible red and infrared regions of the electromagnetic spectrum. A CPI is generally a weighted average of a group ("basket") of regularly consumed goods. The weights being determined by the importance of that particular good within the consumption basket (its share of the budget or budget share). Individual level indicators, and their component variables, are presented for the nutritional sector in Table 4 below.

Table 4, Variables and Indicators

	<u>VARIABLES</u> (measured)	<u>INDICATORS</u> (computed)	<u>INDICATES</u>
<b>NUTRITION</b>	weight	1) wt/ht	wasting (acute)
	height	2) ht/age	stunting (chronic)
	age	3) wt/age	mixed
	gender		
	arm circumference		
	birthweight		

Variables can be used to construct various disciplinary indicators. For example nutrition, demographics, and economics will have differential use of the age and sex variables. Indicators are

generally disciplinary specific and thus their interpretations may be different, although composed of the same variables.

Indicators condense information of a variety of variables that influence a complicated process or system, like a food system. When the interaction of the independent and dependent variables is not explicitly understood an indicator gives some idea of how a complicated process or system operates. Due to the present incapacity to formally model the entire food system of the FEWS monitored countries, emphasis has been on indicators over variables. In the absence of a concise understanding of how relevant variables interact across the three domains a "convergence of evidence" approach is used to corroborate the multiple information embodied in a particular indicator. Implementation of "reliability through redundancy" averts incorrect judgements due to the incomplete understanding of the process being monitored or observed.

#### D. Macro Factors

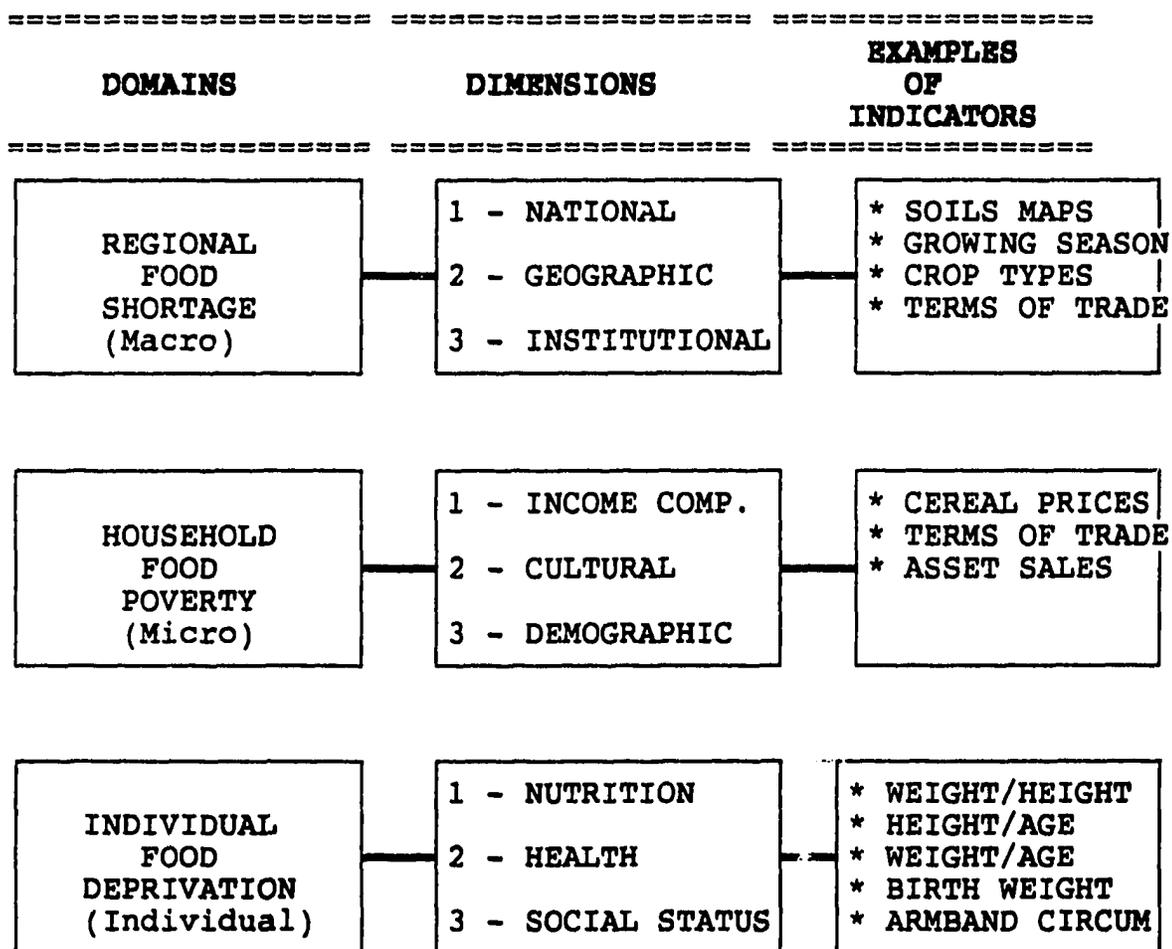
Although the focus of the Vulnerability Assessment is at the household level, the other domains of food insecurity influence the reporting process. The regional and individual domains correspond to macro and individual influences that provide the context for interpreting the household information at the micro level. Macro factors are those variables over which a person has little control through individual action but which influence choices by setting bounds. Appreciation of the relevant macro influences, both physical and socioeconomic, allows appropriate analysis of incoming information. All domains consist of dimensions particular to that domain. Figure 3 demonstrates the progression from domain to dimensions and the different types of indicators utilized to describe each domain.

Macro factors influence the interpretive context brought to the analysis of information. The analyst weighs the impact of the aggregate (macro) information in interpreting other data. The interpretive context bounded by the macro concerns is often as influential as the data itself. Information on the macro environment can be qualitative in nature such as the institutional behavior or national policy that influences interpretation. However, the major influences at this level will be due to physical features.

The idea that macro variables provide the context, or set bounds, applies to both the physical and social spheres of vulnerability. The physical environment of rainfall, vegetative growth, soils and crop sets an upper limit on the potential yield for different crop types. In the Vulnerability Assessment, the upper bound on potential yield can be combined with area under cultivation, calories per crop type and consumption norms to estimate the population carrying capacity based upon agriculture alone, of a particular area. The spatial presentation of derived population carrying capacity compared to regional population

figures may identify previously overlooked regions for increased monitoring of food insecurity.

Figure 3, Domains, Dimensions and Indicators



The upper bound on yield, set at the macro level, can also provide a connection between the regional and household domains of food insecurity. Yield, when converted to output via area under cultivation, links to the household level through the income constraint. Recall that in an agricultural household framework, revenue from own production (output) is the major determinant of household income and hence access to food. This sequence establishes a bridge between the macro availability domain and the micro access domain.

Similarly, macroeconomic prices, such as exchange rates, interest rates and the money supply influence prices, markets and behavior. Other influential macroeconomic examples include the policy environment, changes in consumer preferences, the level of landlessness, market integration, civil strife and level of farm household interaction with factor input (ex. fertilizer) and output

markets.

Specific examples may be informative on this point. Macroeconomic variables such as internationally market determined commodity prices influence cash farmers within and without the FEWS monitored region. The cocoa crisis in Ivory Coast, brought about by reduced global demand, increased supply and inflexible exchange rate policy has caused many migrant laborers to return to their country of origin, putting additional stress on regional, household and individual resources. Entry of non-African meat imports onto West African consumer markets reduces demand for meat products from livestock producers in the Sahel, thereby reducing their incomes. Similarly, the increasing sophistication of Arabian markets and the sluggish adjustment to shifting tastes is causing Sudanese producers to lose market share. The policy environment in Ethiopia has influenced crop choice. Ethiopian producers have been noted substituting away from crops that are sold in highly government regulated markets towards crops that are not as closely regulated.

#### E. Subjective Field Judgements and Need for Review

Lacking a formal model of the interactions between and within the three domains of food insecurity the conceptual framework is driven by the individual assessment of the field analyst. Simulation experiments of the impact of different scenarios on a formally modelled system are foregone and reliance on the interpretive powers of human analysts are correctly emphasized. Interpretive context, skills and expertise may, in fact, be more important than data manipulative skills at the field analyst level. However, it is still a subjective process and dependent upon the analyst's own biases, values and opinions.

The prejudices of subjective analysis can be restrained by insisting on the review of the Vulnerability Assessment by a multidisciplinary group at the Mission before forwarding to Washington (the FSOG). Although not specifically a Mission informing tool, the Vulnerability Assessment should engage debate and discussion within the Mission regarding how their views on the vulnerability status of the people in various regions within their country.

### V. CONCLUSION AND FUTURE DIRECTIONS

#### A. Conclusion

This working paper has presented an argument for the need for a conceptual framework to guide FEWS activities. The concept of vulnerability has been identified as a notion around which a conceptual framework may be constructed. It is in this sense that Vulnerability Assessment is the key annual activity in the FEWS Project.

Three domains of food insecurity were identified that consist of considerations at the macro, micro and individual levels. The

overarching macro environment sets constraints and bounds on possibilities, in both the physical and socioeconomic realms. The individual level reflects the consequences of food insecurity on health and nutritional status. Being either too broad or too specific, neither of these two domains is the appropriate level for responsive intervention. The interpretive focus for guiding responsive intervention has been identified as the household level of analysis. The household unit of analysis provides the tie that binds the three domains of food insecurity. An attempt at providing distinct guidelines for implementing a Vulnerability Assessment in the field has been provided that is based upon the household focus. However, gaps in our knowledge both within and between domains continue to exist and much work remains to be done.

Vulnerability, early warning and the causal structure of food insecurity are linked via an income based household model for different socioeconomic groups. Rationally responding to a variable environment, households are assumed to diversify their income generating possibilities in order to reduce the risk of experiencing food stress. These household decisions are rational when viewed in light of the constraints under which they operate and by which their options are bounded. The framework obliges explicit recognition of the diversity of household income generating strategies in Africa that are a response to a variable physical and socioeconomic environment. In some circles, this prototype of a Vulnerability Assessment may be analogous to food security monitoring.

Implementation of the ramifications of this conceptual framework into field analysis can be accomplished by an ordered set of spreadsheets. Sequential spreadsheets approximate the disaggregation of thinking from region to household to individual level and necessitate consideration of the appropriate information needed to make informed judgements. FEWS vulnerability assessments have components that address social, spatial, and temporal questions of **who** is vulnerable, **where** are they located and **when** can their present situation be expected to change.

The various permutations on the information needed and how it is used becomes too numerous for any one analyst to synthesize and determine patterns. Vulnerability efforts in future years will explore representation of information in a spatial context via the "overlays" of a Geographic Information System (GIS). GIS will provide an additional tool to the vulnerability analyst by allowing for the ordering, processing, pattern recognition and presentation of the abundant information on food security.

The use of verbal argument in this paper is intended to insure the widest possible audience for understanding "what FEWS does" and "how it goes about doing it". The present effort should be followed by a graphic representation (flow diagram) of how FEWS views the African food system. A graphical effort compels specific delineation of the interactions and linkages between sectors and subsystems. The level of understanding and inevitable gaps in the

available information set will be made apparent and serve to identify the direction of future efforts.

In the longer term, as the identified information and causal gaps between sectors are bridged, a mathematical representation of this system could be possible that would codify the perceived linkages and interactions. A mathematical model would provide opportunity to simulate particular scenarios (ex., crop failure of x%, rainfall reduction by y% have a z% impact on household consumption) Simulations allow "what if" scenarios to be addressed and add to our understanding of a system without having to wait for actual data to occur. In an area where extensive historical data is not generally available, simulation could possibly provide an additional tool for understanding the impacts of particular variables in the food system of Africa.

#### B. Future Directions

Although existing project resources and data constraints do not allow serious consideration of a formal mathematical model the graphic vision of the interactions in such a model do provide direction for future activities within set bounds. Vulnerability Assessments are the first step in specifying these interactions and their implementation in seven countries will allow identification of relevant additional information needed to better understand the food system.

The greatest need is for explicit linkage between and within domains of analysis. Variables need to be identified that make meaningful links between domains. For example, a macro to micro linkage via the money supply may exist that has a direct household effect via impact on prices. In the physical realm linkage between gross aggregate output and subsequent impact on household production need to be explored. Progress in the latter area may be provided through the use of specific crop models linking physical variables such as humidity, rainfall and soil type to crop yield. Upper and lower potential bounds on production for a given acreage would then be available. Such models for the major crops of the Sahel already exist and may only need adjusting to fit FEWS needs.

The linkage between household and individual levels also needs to be more explicitly depicted. Additional information on the impact of price and income changes on individual nutritional and health status needs to be identified. Explicit linkage of factors influencing the measures of individual food deprivation need to be included in the FEWS vulnerability framework, the so-called production-consumption-nutrition nexus. This information should allow specific identification of particular groups at-risk other than the already familiar list of pregnant and lactating mothers, children under five, and the elderly. A further area of need is to codify the input that an anthropological perspective can bring to bear in this framework of vulnerability. For example, what is the role of ethnicity in this conceptual framework ?

Within each domain refinement of understanding of the food system should be possible. Information needs to be more fully explored and understood through explicit household models for the various socioeconomic groups (ex., pastoralists), data on the components of income for these groups and the influences of changes in prices and incomes on demand patterns throughout the FEWS monitored region.

The composition of household expenditures would be an important piece of information in this framework. Although information exists on expenditure patterns, it has not been collected and collated into a useable whole for the FEWS monitored region. Information should be available on budget shares for use in computing CPI and interpreting impacts of price and income change on the expenditure components of the household. The budget share spent on food within the household will give some idea of what level of "give" the household has in reallocating its expenditure decisions given an external shock.

## VI. APPENDICES

### A. Identification of Country Specific Socioeconomic Groups

Preliminary Results from the FEWS Tunis Workshop  
(Subject to Change)  
January 1990

#### MAURITANIA

- I. Agriculturalists
- II. Pastoralists
- III. Agricultural Pastoralists
- IV. Fishing Population
- V. Mining Population
- VI. Urban Poor
- VII. Other
  - A. repatriates
  - B. refugees
  - C. date growers
  - D. uprooted

#### MALI

- I. Agriculturalists
- II. Pastoralists
  - A. transhumant
- III. Agricultural Pastoralists
- IV. Fish and Ag. Fishing Pop.
- V. Urban
  - A. wage laborers
  - B. artisans
  - C. beggars
- VI. Other
  - A. rural wage laborers
  - B. market gardeners

#### SUDAN

- I. Smallholder agriculturalists
- II. Pastoralists
  - A. transhumant
  - B. nomadic
- III. Refugees
  - A. economic
  - B. political/international
- IV. Displaced
- V. Other
  - A. tenant farmers
    - 1. irrigated
    - 2. mechanized
  - B. seasonal migrant labor
  - C. urban

#### BURKINA

- I. Agriculturalists
  - A. small - central
  - B. large - southern
- II. Agricultural Pastoralists
- III. Urban Sector
  - A. wage laborers
  - B. migrants living in RCI
- IV. Other
  - A. rural laborers

#### CHAD

- I. Agriculturalists
- II. Agricultural Pastoralists
  - A. irrigated wadi producers
  - B. non-transitory pastoralists
- III. Cash Crop Agriculturalists
- IV. Urban Poor
- V. Other
  - A. rural laborers
  - B. rural fonctionnaires

#### NIGER

- I. Agriculturalists
- II. Agricultural Pastoralists
  - A. Pastoralists (herder/owners)
- III. Urban
  - A. wage laborers
  - B. beggars
  - C. fonctionnaires
- IV. Other
  - A. rural artisans
  - B. rural wage labor
  - C. returning immigrants

## B. Agricultural Household Model

Appendix B is provided for those readers desiring a more formal and explicit delineation of the linkage between physical and socioeconomic data in the context of an agricultural household model. Complete understanding at this level is not a prerequisite for the implementation of a Vulnerability Assessment. However, the underlying model does provide a framework in which to judge the appropriateness of particular information or data in making judgements concerning vulnerability status.

This appendix outlines a simplified version of a theoretical, and conceivably empirical, approach to deal with agricultural households which are both producers and consumers of goods that originate from the firm-household. A theoretical model is presented that integrates both the production and consumption aspects of household behavior in developing countries.

### 1. Introduction

Neoclassical microeconomic theory concerns the firm in production and the household in consumption. In developing countries the majority of agricultural households act as both a firm and a household. They provide their own labor and consume the bulk of their own production. Within household based economies decisions concerning production, consumption and labor often influence each other.

The agricultural household in a developing country is unique for several reasons. First, the agricultural household consumes a major part of its own production. The food crops produced in an agricultural household are partly consumed by that household while some is marketed to provide income. Other types of households do not generally consume part of that which they produce. Hence, in an agricultural household the output of the "firm" can greatly influence income and hence consumption choices.

A second reason why these agricultural households are distinctly different from other households is that they provide their own labor as a major part of the inputs used in the production process. The combination of being the major provider of inputs and the major consumer of output influences the economic behavior of the agricultural household.

A third distinguishing characteristic of agricultural households in developing countries is the nature of the management process. For example, in a developing country management techniques and practices may involve the use of multiple households acting as one unit, sources of income may be determined by kinship patterns and cultural practices and preferences may influence choices.

Theoretically, the problem of modeling an agricultural household can be treated as one of constrained optimization. The household can be assumed to optimize a utility function, subject

to a series of constraints. These constraints include information concerning the limitations on behavior due to income, time, and technology.

Consisting of a variant of consumer choice theory in which the production technology is represented in the income constraint via a profit function, agricultural household models are within the neoclassical paradigm. It is through the income term that the two sides, production and consumption, are linked. For an agricultural household that obtains the preponderance of its income from the sale of agricultural commodities, it is the production technology that dictates income. However, once this income level is established, it becomes an argument in the determination of the level of indirect utility via consumption choices. The result is a recursive model where production decisions precede and delimit consumption decisions, but not vice versa. Recursive decisions are often described as separable because one set of initial decisions are assumed to be made separate from subsequent decisions.

Although the extensive data needed to empirically implement such a model is not presently available to FEWS, the structure of the model provides an organizational tool for understanding the disparate information that FEWS is mandated to follow. The theoretical restrictions of this model further limit its empirical usefulness due to assumptions regarding the existence of competitive commodity and labor markets. Empirical implementation of such a model in FEWS vulnerability assessments is also constrained by lack of information at the household level in the monitored countries. Due to the plethora of social and economic structures in FEWS countries, there is a lack of basic descriptive information on agricultural households in different regions. Requisite price and income elasticities would be needed in order to describe the behavioral responses of household producers and consumers to exogenous shocks to the economic environment.

## 2. The General Model

The general model can be succinctly written as a constrained optimization problem as follows:

$$\text{MAX } U = U(X_a, X_m, X_l)$$

subject to:

Income: (i)  $P_a X_a + P_m X_m + w(L-F) \leq P_a Q$

Time: (ii)  $X_l + F = T$

Technology: (iii)  $Q = Q(L, A)$

maximizing utility subject to constraints due to income, time, and technology, respectively.

#### a. Utility Function

The maximization of a quasi-concave, increasing utility function by the household is assumed to be a function of the goods consumed by the household. The goods consumed are the crop produced by the household,  $X_a$ ; goods purchased on the market,  $X_m$ ; and the leisure time available to the household,  $X_l$ .

#### b. Income Constraint

The first constraint states that the household expenditures are less than or equal to the income available to the household. The inequality holds due to possible zero level expenditures or savings by the household. Household consumption consists of expenditures on agricultural goods,  $P_a X_a$ ; market goods,  $P_m X_m$  and expenditure on hired agricultural labor,  $w(L-F)$ . The quantity of agricultural labor hired by the household is the difference between total labor input on the farm ( $L$ ) and the total quantity of labor, on and off-farm, supplied by the household ( $F$ ). Here, wage rates are assumed equivalent between on-farm and off-farm labor implying that the household is indifferent between these two types of labor. Household income is derived from agricultural goods whose quantity,  $Q$ , represents gross production. Subsequently, the value of agricultural goods sold by the household,  $P_a Q$ , represents agriculturally based income.

#### c. Time Constraint

The household has the opportunity of utilizing its total endowment of time in either leisure or labor. Therefore, the sum of the amount of time spent in leisure,  $X_l$ , and that spent in family labor input,  $F$ , must be equal to the total time available,  $T$ . This equality holds if one assumes that all slack time is leisure. However, if some slack time is considered lost due to illness, weather or other factors then the equality in equation 1-(ii) becomes an inequality (less than or equal).

Other possible behavioral characteristics can be modelled through the time constraint. One example is the inclusion of a cultural variable,  $C$ , that reflects the minimum amount of time devoted by the household to community or cultural activities. Not all leisure time is devoted to cultural activities, thus  $X_l \geq C$ .

#### d. Technology Constraint

As a measure of gross production,  $Q$  represents the production technology that is employed by the household in combining inputs to produce output. Input arguments in this constraint include, but are not limited to, variable labor input,  $L$ , and fixed area under cultivation,  $A$ . This production function is assumed to be quasi-convex and increasing in inputs. Other inputs might include rainfall, soil type and temperature.

### e. Combining Constraints to Yield Full Income

Substituting both the time and technology constraints into the income constraint and rearranging gives:

$$Y = P_a X_a + P_m X_m + wX_1 \leq P_a Q(L, A) - wL + wT$$

which can be interpreted as Becker's "full income".<sup>1</sup>

The expenditure side of the household's "full income" constraint is now augmented by the value of the household's leisure time,  $wX_1$ . The income side consists of the value of agricultural production,  $P_a Q(L, A)$ , the value of the household's entitlement of time,  $wT$ , and is diminished by the value of total labor utilized by the farm,  $wL$ .

Note that the combined term,  $P_a Q(L, A) - wL$ , on the income side of the "full income" constraint, represents household profits from agricultural activity. These profits,  $\pi$ , can be written as:

$$\pi = P_a Q(L, A) - wL \quad (3)$$

and could be determined via a profit function that can be specified so as to be representative of the underlying technology employed by the household.

### 3. Solving the Model

The agricultural household has choice variables concerning the amount of agricultural goods to consume ( $X_a$ ), amount of market goods to consume ( $X_m$ ), amount of leisure to consume ( $X_1$ ), and total labor input to supply to the farm ( $L$ ), assuming that acreage under cultivation is fixed ( $A$ ). The household, under the assumption of utility maximization, will seek to optimize the levels of the four choice variables which in turn may be solved for the demand equations of the consumed goods.

Solving this model gives the demand equations for the three choice variables. The demand equations can be written as:

$$X_i = X_i^*(P_a, P_m, w, Y^*) \quad i = a, m, l \quad (10)$$

which is the neoclassical result that demand is dependent upon prices and income. However, in an agricultural household the optimized full income variable,  $Y^*$ , is determined by the household's production technology through the technological constraint. In this simplified model the only endogenous variable constraining or bounding household choice is total labor,  $L$ . Production decisions are, therefore, made separate from consumption decisions; they are separable decisions. The recursive nature of

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<sup>1</sup>. Gary S. Becker. "A Theory of the Allocation of Time," The Economic Journal, 75(1965): 493-517.

the model becomes evident as consumption decisions are seen to be dependent upon production decisions, but not vice versa.

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