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FINAL REPORT

Panel on the National Oceanic and Atmospheric Administration Climate Impact Assessment Program for Africa

Board on Science and Technology
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PANEL ON THE NOAA CLIMATE IMPACT ASSESSMENT PROGRAM FOR AFRICA

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EXECUTIVE SUMMARY

The U. S. Agency for International Development (USAID) requires information on drought for much of the developing world for the purpose of mobilizing assistance. Over the past 15 years, the Sahel and Horn regions of Africa have been of particular interest. Beginning in 1977, USAID entered into an agreement with the National Oceanic and Atmospheric Administration (NOAA) to develop a Climate Impact Assessment Technology (CIAT) that used satellite and conventional meteorological data to identify areas experiencing drought. Initially, the program focused on the Caribbean Basin and, subsequently, projects were undertaken in other sensitive parts of the world, including Africa.

In 1984, the program was redirected to the Sahel and Horn regions of Africa. The primary purposes of the program were: (1) to identify problem areas; (2) to assess relative crop vigor; (3) to forecast crop yields for the region; and (4) to ultimately transfer the CIAT system to African centers.

USAID is considering the continuation of its agreement with NOAA. As part of its internal deliberations, USAID requested that the Board on Science and Technology for International Development (BOSTID) of the National Research Council evaluate the scientific soundness of NOAA's program. A panel was convened for this purpose, and this document constitutes its final report.

In its work, the panel formally met twice in Washington, D.C., and was briefed by, or met subsequently with, personnel from USAID/Washington, NOAA's Assessment and Information Services Center (NOAA/AISC), the U. S. Department of Agriculture (USDA), the U. S. Geological Survey (USGS), the National Aeronautics and Space Administration's Goddard Space Flight Center (NASA/GSFC), and the NOAA-University of Missouri Cooperative Institute for Applied Meteorology (CIAM). All meetings took place between October 27 and December 10, 1986.

The panel reviewed the NOAA program in light of program objectives. Overall, it was the panel's opinion that CIAT should be able to provide timely identification of problem areas within the region. Secondly, as for monitoring crop condition, the panel felt that information on crop vigor was of questionable validity. Thirdly, the panel found that quantitative yield forecasts were based on an

unsound methodology and suspect data. Finally, the panel could not evaluate technology transfer directly. However, in view of the preceding points, it was clear that only some parts of the technology should be considered for transfer. Moreover, it was not clear whether the CIAT offers host country governments any advantages over existing data sources.

Two problems pervaded most aspects of CIAT. One was a lack of adequate technique validation. Methods in both remote sensing and agroclimatology were developed and demonstrated first in the United States. These had not been validated sufficiently in the African context to assure acceptable performance. The second, related, problem was in calibration. Regression yield models were based on relationships between observable variables (for example, precipitation and normalized vegetation index [NVI]) and independent official yield data that were admittedly suspect. The model output was compared to suspect yield data to gauge its utility.

Without regard to cost or practicality, the panel made specific suggestions to improve the techniques used in NOAA's CIAT: (1) examine other sources of information on precipitation and soil moisture from other satellites; (2) develop statistical statements on the probability of specific climatic events; (3) replace agroclimatic regression models with process models; (4) make first-order corrections of Advanced Very High Resolution Radiometer (AVHRR) data to compensate for sensor and atmospheric variations; (5) systematically incorporate spatial information on agricultural variations to improve NVI interpretations; (6) better characterize the nature of the agricultural systems within the region to permit more reliable interpretations; (7) assign assessors to the field more often in order to improve their understanding of the countries involved; (8) consider incorporation of alternative information on food availability (for example, market prices); (9) work more closely with USAID to learn their needs and explain CIAT products to a wider audience; (10) establish regular information exchange with NOAA-USDA/Joint Agricultural Weather Facility and USDA/Foreign Crop Condition Assessment Division; (11) work with NASA/GSFC to develop a joint AVHRR data set; and (12) publish descriptions of CIAT component systems in peer-reviewed journals.

Because the work conducted by NOAA/AISC was done at the request of USAID, the panel also had recommendations for USAID. If the types of information provided by NOAA/AISC are useful to USAID operations and can be obtained most expeditiously and cost effectively from NOAA: (1) continue to rely on NOAA for climate information, but (2) clearly define the types, frequency and accuracy of information desired, (3) insist on closer collaboration between NOAA, USDA, and NASA, and (4) designate a single person or group for liaison between USAID and NOAA.

1

INTRODUCTION

The U. S. Agency for International Development (USAID) requires current information on the condition of crops in those parts of the developing world that are subject to serious climatic stresses. In particular, up-to-date information is needed for the areas of recurrent drought in sub-Saharan Africa. This information is used to assist in mounting and coordinating disaster relief and ensuring the food security of the region.

In 1977, USAID entered into an agreement with the National Oceanic and Atmospheric Administration (NOAA), Assessment and Information Services Center (AISC) to develop a Climate Impact Assessment Technology (CIAT). Initially, the program focused on the Caribbean Basin. Later, similar projects were undertaken in Africa, Latin America, South and Southeast Asia, the Middle East, and the Southwest Pacific Basin.

Building on this experience, a major effort was begun in 1984 to develop an operational CIAT system for monitoring crops in the ten countries of the Sahel and Horn regions of Africa.

The agreement under which the CIAT project was conducted is to expire March 31, 1987. USAID is considering whether the project should be continued and, if so, what improvements or alterations are needed. To assist in their evaluation of the project, USAID requested assistance from the National Research Council's Board on Science and Technology for International Development (NRC/BOSTID). In turn, BOSTID convened a panel for this purpose in October, 1986. This document constitutes the panel's report to USAID.

The panel was given the charge of providing answers to the following questions:

- Is the CIAT program scientifically sound and adequate to meet USAID's needs?
- Are there alternatives to the CIAT system and, if so, how do they compare with it?
- Can the CIAT program be adapted for and transferred to an African setting?

The panel was briefed by representatives of USAID, NOAA, the U. S. Department of Agriculture (USDA), and the U. S. Geological Survey

(USGS) in Washington, D.C., on October 27-28, 1986. A second working meeting of panel members only was held in Washington on December 4-5, 1986. Several members made follow-up visits to USAID, USDA, and the National Aeronautics and Space Administration's Goddard Space Flight Center (NASA/GSFC). A site visit was made by two panel members and an associated scientist, Linda Mearns of the National Center for Atmospheric Research, to NOAA/AISC operations associated with the Cooperative Institute for Applied Meteorology (CIAM) at the University of Missouri in Columbia on December 9 and 10, 1986.

2

U. S. AGENCY FOR INTERNATIONAL DEVELOPMENT (USAID) INFORMATION REQUIREMENTS

Prior to evaluating CIAT, we sought a better understanding of the demands that USAID places upon it. NOAA and USAID provided us with briefing documents. We also interviewed staff at USAID to define the objectives of the AISC project, the groups that were being served, the information they required, and their general impressions of the system and its products.

2.1 PROJECT OBJECTIVES

The purpose of CIAT was described to BOSTID in the following way (USAID 1986:1):

> The purpose of the project is to accelerate the rehabilitation and disaster recovery process associated with the African famine by providing operational assessments of the impact of weather on agricultural production, and to use these assessments as timely, reliable, and quantitative inputs into agricultural crop production forecasting, agricultural policy making, and rangeland management.

The CIAT system was designed in response to this broad directive, and to needs that evolved in USAID over the course of the project. As outlined by NOAA/AISC in their briefing, CIAT was to serve three primary functions:

- to identify problem areas;
- to assess relative crop vigor;
- to forecast crop yields.

In addition, once a satisfactory operational system had been developed, NOAA/AISC would:

- transfer the technology to appropriate centers in the Sahelian and Horn regions of Africa.

2.2 USERS

Current users of CIAT products represented at the initial briefing in Washington (October 27-28) were the Office of U. S. Foreign Disaster Assistance (OFDA) and the Bureau for Africa, including the Famine Early Warning System (FEWS) of the Office of Technical Resources, Office of Project Development, and Office of Sahel and West Africa Affairs.

There are a large number of users outside of Washington who were not represented at this meeting and who were not contacted formally. These include: USAID missions, U. S. embassies, host country governments, and regional centers (for example, Agro- et Hydro-Météorologie [AGRHYMET]). At various points in the briefing it was suggested that potential users might include extension workers and even farmers, but this idea was never fully explored.

2.3 REQUIREMENTS

NOAA/AISC data are put to a wide range of uses that reflect the diversity of the user group. According to our interviews, AISC products have been used by USAID in Washington to corroborate other information, target field assessments, issue early warnings, and identify locust problems.

We had hoped that we would find a well-defined set of information needs for various levels within USAID in terms of products, accuracy and timeliness. However, to our knowledge, USAID has not firmly defined its needs in terms of this project, and we were unable to establish these independently through our interviews. Nevertheless, timeliness was one of the most often stated general needs. Ideally, accurate, long-range weather predictions would permit USAID to plan assistance programs months in advance. Unfortunately, this skill does not yet exist in NOAA/AISC or any other organization. Thus, USAID must rely on reports of current conditions and probability-based projections of what they are likely to be in the near future. To be of any value, turnaround times for descriptions of crop condition must be less than one month during the growing season, and yield forecast must be available before harvest.

3

DESCRIPTION OF CLIMATE IMPACT ASSESSMENT TECHNOLOGY (CIAT)

As described above, CIAT was developed over the last ten years by NOAA/AISC to monitor drought, assess crop vigor/crop conditions and forecast crop yield early in the season. The system is based on three subsystems. Data from each subsystem are given for assessment to specialists who are knowledgeable about the area to which they are assigned. These persons make their assessments based on: (1) subsystem output; (2) other pertinent background information; and (3) their knowledge of the area.

For crop condition and yield, data are analyzed and reported within 50 x 100 km (1/2 x 1 degree) grid cells for the region.

A description of each system, the other materials used, and the products that are produced and disseminated follows (AISC and CIAM 1986).

3.1 HISTORICAL BACKGROUND

In 1974, NOAA established the Center for Climatic and Environmental Assessment (CCEA) in response to growing concerns about global food supply and the rapid rise in petroleum prices due to the OPEC embargoes. The Center was first headed by James McQuigg, a leading climatologist, and was located in Columbia, Missouri--primarily because of Dr. McQuigg's strong working relationship with the University of Missouri's Department of Atmospheric Sciences.

CCEA was also assigned a major role in the LACIE (Large Area Crop Inventory Experiment) that began in 1974. This project, which involved NASA, NOAA, and USDA, lasted for five years and was followed by the AgRISTARS project which lasted until the early 1980s. A primary goal of both the LACIE and AgRISTARS projects was to develop a crop monitoring technology based on conditions in the United States which could be extended to other areas with less reliable crop statistics. During the LACIE and AgRISTARS projects, CCEA staff developed considerable skill and expertise in the assessment of crop yields from a knowledge of antecedent and current weather conditions. The CIAT was derived largely from this experience.

The end of the AgRISTARS project prompted an internal reorganization in NOAA. CCEA and CEDDA (Center for Experimental Design and Data

Analysis) were merged to form the Center for Environmental Assessment Services (CEAS), which later was renamed the Assessment and Information Services Center (AISC). At present, that unit maintaines 13 professionals in Columbia, Missouri, and about 15 in Washington, D.C. All of the Columbia personnel are engaged in work sponsored by USAID, as are two professionals in the NOAA-University of Missouri CIAM. Six to seven professionals in the Washington contingent of AISC are also involved in USAID sponsored work (C. Sakamoto, personal communication).

3.2 AGROCLIMATIC INDEXES

Real-time meteorological data are obtained from the World Meteorological Organization's Global Telecommunications System (WMO/GTS) on a daily basis. They provide essentially synoptic information from the primary meteorological stations in each country. Nominally, up to 200 rainfall stations may be reporting on this network, but the spatial distribution is uneven. The precipitation record from 1961-1980 was selected as a reference point and average decadal values have been computed for this period. Precipitation data are reported for each station in absolute amounts, and as a percent of the average for the reference period. Station decades are then ranked and percentiles are produced. This is one of many indicators used to assess the temporal and spatial distribution of precipitation.

A water balance model is used to predict soil moisture using these precipitation assessments. This part of the methodology was developed by FAO (Frere and Popov 1979). The Doorenbos and Pruitt (1977) method of estimating evapotranspiration provides an overall water-deficit index. This method requires the development of crop coefficients to indicate water requirements of the crop at different stages of its development.

3.3 SATELLITE ASSESSMENT MODELS

Satellites provide a second source of information. Both the Meteorological Satellite (METEOSAT) and the NOAA Television Infrared Observation Satellite (TIROS-N) series are used to estimate rainfall from cloud-cover patterns. In addition, a normalized vegetation index (NVI) is derived from data produced by the NOAA Advanced Very High Resolution Radiometer (AVHRR). In developing the NVI, responses from the red and near-infrared parts of the spectrum are combined. The NVI generally corresponds well with biomass or photosynthetically active material (Tucker 1979). This technique of computing a vegetation index from AVHRR data for monitoring vegetation has been widely used (Hayes 1985). Color images are also made, using the Ambroziak scheme (AISC and CIAM 1986), and distributed as one of AISC's products.

3.4 CROP YIELD FORECAST MODELS

Three independent crop yield models are used by assessors to develop a consensus forecast. One model was developed based on the assumption that the final yield of a crop is proportional to the NVI at a specific crop stage. The NVI information is used to monitor relative crop vigor through the critical growth period. NVI values are calculated for daily images of the region, and a weekly composite is developed by discarding bright cloud-contaminated pixels, and by finding the greenest pixel for each point during the week. The greenest values are then averaged within the 50 x 100 km assessment grid-cell to produce a single NVI value. The average NVI values are then smoothed over time. Results are referred to NVI/yield relationships established in prior years to develop a yield forecast.

A second model uses traditional regression-based methods that relate yield with precipitation. Precipitation data come from reporting stations within the region. Yield data from which the model was developed come from agricultural statistics reported by national governmental entities.

The third model uses precipitation estimates made by Earth Satellite Corporation (EARTHSAT). These estimates are derived from METEOSAT data using a cloud-indexing scheme to identify precipitating clouds. Maximum crop yields have been determined and a maximum percent reduction in yield is projected by monitoring precipitation and temperature.

3.5 OTHER INFORMATION

The NOAA assessors have access to reference information for each of the areas they analyze. This is gathered from various sources such as atlases, the general literature, and in-country reports, and serves as background information for the assessors.

In addition, ancillary data are gathered for each area describing weather and non-weather events that might impact crop production. These data are used as a supplemental secondary source of information against which assessors can check their assessments.

3.6 INFORMATION DISSEMINATION

Assessment bulletins are sent to appropriate USAID offices in Washington, and also USAID missions, U. S. embassies, host country governments, and to the AGRHYMET Regional Center in Niamey, Niger. Reporting is done by means of three principal products. First are monthly executive summaries which highlight major regional weather impacts. The second group of products consists of more detailed regional and country analyses. Finally, cables are issued every ten

days to update the monthly bulletins.

There also are special satellite products with a more limited distribution. These include smoothed NVI values and NVI anniversary differences for the 50 x 100 km assessment grid-cells. In addition, satellite images are distributed as are quantitative crop-yield forecasts. These special products are sent principally to the AGRHYMET Regional Center in Niamey, Niger, FEWS in Washington, Sahel host countries, USAID Missions and U. S. embassies in the region.

4

REVIEW OF THE CIAT SYSTEM

The following review is based on information gathered and analyzed during the panel's six weeks of meetings, visits, and study of documents provided by USAID and NOAA/AISC. Despite this degree of effort, our knowledge of CIAT and competing systems may still be incomplete. Perhaps more importantly, our evaluation is based only on the scientific merits of the systems studied. We did not consider budgetary limitations or other constraints, such as time limits, difficulty in assembling requested information, and other impediments to the functioning of an operational system.

4.1 METHODS

In the sections that follow, we present an assessment of the various methods incorporated in CIAT that are used to achieve its primary project objectives (see 2.1). These assessments represent both our own critical evaluation of CIAT procedures and the responses of USAID personnel to questions asked of them.

4.1.1 Climate Monitoring

Precipitation. USAID personnel indicated that rainfall data are their greatest need. We are not convinced that CIAT is using all relevant rainfall information that is accessible through WMO and NOAA channels.

NOAA/AISC is well-positioned to provide rainfall data in near-real time and to interpret their significance. Yet, NOAA/AISC rely on several sources of data (USAID missions and AGRHYMET) that may not be delivered to them until two or more weeks after the end of the reporting (decadal) period (AISC and CIAM 1986). Interpretations of other satellite data (for example, thermal or microwave) beyond those purchased from EARTHSAT might be made to independently assess cloud-top temperatures and to estimate soil moisture. In addition, it was not clear whether all direct precipitation-monitoring stations and river gauges are interrogated and their data incorporated into AISC assessments.

Moreover, it is clear that a better forecasting capability would be of great potential benefit. Precipitation records for a number of stations in West Africa may be long enough to permit calculation of precipitation probabilities and also contingent probability statements of various temperature and precipitation combinations that could improve precipitation forecasting (at least in the probability sense). This type of information might better meet USAID needs because it makes statements about future conditions.

4.1.2 Remote Sensing

The remote sensing system utilized in CIAT is built around the AVHRR multispectral scanner. The advantages of the AVHRR system are that it provides multispectral information for a large area at very low cost on a daily basis. Its principal disadvantage is its very low ground resolution. Results could no doubt be improved by using a higher resolution system such as the Landsat Multispectral Scanner (MSS) or Thematic Mapper (TM), or the French Système Probatoire d'Observation de la Terre (SPOT) satellite. However, an increase in resolution would result in a geometric increase in data and processing costs. A summary of the major land remote sensing satellite systems is found in Appendix 2.

In the evaluation of the remote sensing methods, several issues emerged because of the nature of CIAT and the peculiar conditions of the Sahel. These involved questions concerning: (1) technique validation; (2) AVHRR calibration; (3) AVHRR geometric registration; (4) regional heterogeneity; (5) NVI reliability; and (6) data presentation.

Validation. Most of the techniques employed have been developed for use in other regions. We do not feel that they have been sufficiently validated in the African setting.

Techniques that incorporate NVI time-series information derived from AVHRR in the grain belt of the United States have been developed that show a strong correlation with historic yields. However, they have not been used operationally to monitor crops and forecast yields or production (Boatwright et al. 1986). Generally, the remote sensing techniques currently employed by CIAT parallel this model and they have been used previously in varying forms. However, the environments in which they were used elsewhere differ considerably from those of the Sahel.

In the case of Boatwright et al. (1986), test areas were located in North Dakota, Nebraska, and Kansas. This agricultural region is extremely large and well organized, fields are large and homogeneous, the bulk of the region is devoted to a few crop types, and cropping practices are comparatively uniform. Admittedly, the basic approach is sound. However, there are virtually no parallels that can be drawn

between the agricultural systems of these states and those of Sahelian Africa.

Given the profound diversity of crops and cropping practices, the peculiarities of local economies, and the paucity of reliable ground data, it is unreasonable to expect the methodology to function well in the Sahel without significant modification.

Calibration. More work is needed to improve and demonstrate the quality of the AVHRR data set.

A large part of the CIAT system is based on NVI values derived from AVHRR data. The range of NVI values used to develop a single-season time series describing crop condition is very small. Because the optical properties of the atmosphere vary daily, there can be significant differences in the spectral signature of an area between successive days. In addition, large variations in spectral response occur as the atmospheric depth and the pixel size increase toward the ends of the scan line. Because the AVHRR has a wide range of look angles (from 0 to 54 degrees on either side of nadir), the range of response is larger than with other satellite systems (Holben and Fraser 1984). CIAT has considered this problem and feels that the "greenest" pixel rule in compositing weekly scenes, the averaging of responses within the reporting grid, and the smoothing of weekly responses reduce this inherent variability to acceptable levels.

Several different NOAA satellites have been used to develop the historical relationships between NVI and crop response upon which the system is built. However, there has been no critical evaluation of differences in sensor characteristics among instruments, nor of changes in performance through time for a single instrument. Without such knowledge, the technique lacks credibility. Moreover, others working in the field have reported differences in NVI within an annual data set caused by the atmosphere or by the sensor itself that are equal to half the annual amplitude associated with vegetation response (C. J. Tucker, personal communication). NOAA/AISC feels that its technique of selecting the greenest pixel, and subsequently averaging and smoothing these values, adequately compensates for random variations. No fully satisfactory rationale for this approach was presented by NOAA/AISC. It appears that the problem has not yet been fully analyzed.

Spatial Heterogeneity. The effects of heterogeneity in regional land use and cropping practices are not dealt with systematically.

Small field sizes and widely varying intercropping practices are common to the Sahel region. Thus, unlike the U. S. Midwest, individual fields are not discernible and the area devoted to a single crop is difficult to estimate. Moreover, substantial irrigated areas are contained within the study region, and because the system is concerned exclusively with rainfed crop and rangelands, responses from irrigated agriculture contribute to the "noise". Although such areas are comparatively small in extent, their contribution to pixel response can

be significant given the contrast between them and surrounding dryland agriculture in crop type, plant density, and vigor. The degree of contamination this introduces to the NVI value has not been assessed.

The NVI is an integration of all signatures within a pixel, and thus a single value represents a spatially complex mixture. In the CIAT, it has been assumed that all vegetation, including crops and other vegetation types, is responding in concert to climate patterns. While this may true in the broadest sense, given the size of the reporting grid and the differences in crop phenology and spectral characteristics, this is a risky assumption. Attempting to link the NVI value to a particular crop without additional information on land capability, land use, or estimates of individual crop areas within the assessment grid cell is unjustified.

While it appears that general land use and cropping characteristics are considered qualitatively by CIAT assessors when they develop forecasts, there is no systematic procedure for reducing the heterogeneity that becomes incorporated in the NVI calculation.

Geometric Registration. Registration of images is based on reference data internal to the AVHRR system, these reference data are not always reliable. No attempt is made to register all images to a common base.

Because NVI data are averaged over a 50-by-100 km grid cell, errors introduced by registration to crop vigor and yield assessments are likely to be minimal. However, when temporal comparisons are made at full resolution, problems should be anticipated.

NVI Reliability. The reliability of a simple NVI value over different soil backgrounds and small amounts of vegetative cover has not been demonstrated (Huete et al. 1985).

Extracting accurate information about vegetation is exceedingly difficult in low cover situations because soil is the dominant factor. Moreover, the complex spectral interactions of vegetation with varying soil backgrounds significantly compound the problem.

The value of the NVI for crop condition monitoring and quantitative yield forecasting is uncertain in view of the wide range of soil colors and vegetation cover in the region, combined with the factors outlined above that can cause significant error, particularly in marginal dryland agriculture. Other related spectral indexes, such as "brightness" have shown promise in estimating vegetation cover where values are less than 30 percent (Musik 1983).

Data Presentation. Presentation of spectral information using the Ambroziak Color Coordinate Scheme (ACCS) was judged to be neither better nor worse than other approaches. Comparable systems (for example, false-color systems) are more widely used and thus are perhaps less confusing. Given the variations that might be expected in red and infrared responses that result from factors discussed above, the

quasi-quantitative impressions conveyed by hue in the ACCS, or any other discrete color coding scheme, are misleading. For example, the abrupt boundaries in hue that are found on an ACCS image may or may not correspond with actual boundaries on the ground.

4.1.3 Agroclimatic Interpretation

Validation. Many of the agroclimatic methods were developed for use in North America but they have not been proven in the African environment.

As in the remote sensing activities, many of the techniques used in CIAT were developed elsewhere and have been used successfully in other environments. However, the African setting is substantially different from North America and, while the techniques may be sound, their applicability to African conditions has not been adequately demonstrated. For example, relationships that are assumed to exist between biomass production and yield were developed in regions where good data were available. Unfortunately, as in the case of the harvest index, even where good data are available these do not always prove accurate (Gallagher and Biscoe 1978). How these same techniques might work in Africa is not known, and there has been insufficient effort made to assess their performance.

Calibration. The calibration procedure used in the yield models is circular and based on data that are admittedly suspect.

Yield forecasts are based on the historical relationship between various measures of rainfall or apparent vegetation response and official yield statistics. Forecasts are later compared with the official yield statistics. This circular approach cannot, in itself, be used to validate the procedure. Moreover, the official yield data are unreliable and the forecasts can be no better than the data from which they are developed.

4.1.4 Other Information

Assessor Experience. While the most suitable interpretation approach has been adopted, the CIAT assessor team has not had sufficient regional experience to employ it effectively.

The CIAT has adopted the "convergence of information" approach to developing its interpretations. In this approach, the assessor considers all the information available, and makes a judgement that is most consistent with that information. Understandably, and most appropriately, judgements are heavily influenced by other information about the quality of data received and their significance in describing the condition of unique local agricultural systems. For example, as noted in the briefings, official yield figures in certain countries

have varied little over a number of years, despite well-documented precipitation variation. As a result, assessors discount or ignore official yield data in their assessments for those countries.

To use this approach effectively requires that the assessors should be intimately familiar with the countries to which they are assigned. The majority of the assessor teams have little on-site experience in the countries they assess.

4.2 PRODUCT ACCEPTANCE

Although we could not make a comprehensive evaluation of products, we were able to identify some perceived strengths and weaknesses through interviews with various users in USAID. This survey does not reflect consensus, but rather the range of reactions to CIAT products. As a result, there are a number of contradictions between the perceived values of products and the problem associated with them.

4.2.1 Perceived Value

Rainfall Data and NVI Products. Rainfall data, and to some degree NVI products, are the critical pieces of early-warning information produced by the CIAT system. For the most part, these were made available in a timely manner for use in Washington.

Images. Images were judged to be useful, particularly for briefing purposes. In addition, images portrayed gross continuous spatial variations within the data set that were obscured by the assessment grid system, and were also more effective in presenting subtle variations between years. This permitted users to develop their own shadings of interpretation from the results.

Technology Transfer. Transfer of some parts of the technology was felt to be imperative. The AGRHYMET Regional Center was considered by USAID personnel as the best place to begin "Africanization."

4.2.2 Problems

Yield Forecasts. Yield forecasts were judged to have little or no credibility. This stemmed from a mistrust of the techniques that were used and the presumed superiority of competing systems. In addition, it was sometimes felt that findings parallelled what was already known through other sources and were thus redundant.

Timeliness. Timeliness was an issue. Some users found that bulletins came too late to be of use in-country.

Scale. Scale of the 50-by-100 km reporting areas was a problem to some because the boundaries of these units did not correspond to generally-used administrative or crop reporting areas.

Technology Transfer. Transfer of the technology to African centers was questioned by some because they felt it could not be sustained locally without continuing USAID leadership and support. In addition, some felt it might prove politically difficult for regional centers to reconcile results from the NOAA/AISC system with forecasts from local or international agencies.

4.3 INSTITUTIONAL CONSIDERATIONS

Other groups within the United States, and elsewhere, are performing work that is similar to CIAT. The USDA/NOAA Joint Agricultural Weather Facility (JAWF) develops crop yield potential forecasts for the world's major agricultural areas based primarily on conventional meteorological data, supplemented by satellite data (GOES, METEOSAT, and GMS). It produces critical information on world-wide crop conditions for crop-commodity specialists within the USDA (Motha and Heddinghaus 1986).

In addition to yield-potential forecasts made by JAWF, agricultural production forecasts are made for strategically important countries by the Foreign Crop Condition Assessment Division (FCCAD) of the Foreign Agriculture Service (FAS) in USDA. FCCAD uses AVHRR images to monitor crop condition in much the same way as AISC. However, in contrast to the CIAT, FCCAD combines this information with higher resolution satellite data (for example, Landsat) to develop estimates of crop areas, and with ancillary map data to help in identifying crop types and forecasting potential yields. Data generated by JAWF are also incorporated by FCCAD in its projections. The FCCAD addresses relatively small areas, and uses comparatively detailed information. Overall, the combined JAWF and FCCAD efforts parallel CIAT in methodology and objectives. CIAT differs primarily in the users it seeks to serve and its focus on Africa.

The National Aeronautics and Space Administration's Goddard Space Flight Center (NASA/GSFC) has developed a system for monitoring vegetation on a continental scale using AVHRR through its Global Inventory Monitoring and Modelling Studies (GIMMS) group. This is done to support basic research initiatives in global monitoring and modelling (Justice 1986).

The similarity in approach used by the NASA/GSFC, the complementary nature of the combined JAWF/FCCAD approach, and the partial overlap of their objectives in monitoring vegetation and crop variations as a function of climate seems obvious. Yet, there appears to be little or no coordination of these groups with NOAA/AISC.

Largely because of its research mission, NASA/GSFC has more depth

and experience in processing and interpreting AVHRR data, and has developed an extensive and consistent AVHRR data base for the world. Unfortunately, opportunities to share data and processing costs between NOAA/AISC and NASA/GSFC have been bypassed. In part, this may be due to differences of mission. CIAT is an operational program focused on products that must be delivered weekly; NASA/GSFC/GIMMS is a research program aimed at developing a better understanding of AVHRR and how it might be used, without much regard to timeliness.

Similarly, USDA/JAWF develops data that are complementary to, or at least independent of, the meteorological analyses of CIAT. Moreover, USDA/JAWF has access to an array of USDA experts on countries and crops whose expertise cannot be duplicated. Both JAWF and FCCAD process satellite data in an almost real-time mode and present their findings during open, weekly, government-wide briefings. Although FCCAD findings may not always be relevant to CIAT objectives, JAWF work most certainly is. The opportunity to share and mutually evaluate findings has been largely ignored.

4.4 OVERALL PROGRAM ASSESSMENT

Ultimately, the CIAT program must be judged on a single criterion--achievement of the objectives that were established for it. As outlined in the briefing, there were four objectives (see 2.1).

4.4.1 Problem Area Identification

Notwithstanding the spatial constraints imposed by the sensor system and the assessment grid, and the limitations of meteorological data, we feel that the CIAT system should be able to identify areas experiencing problems due to climate variations in ways that are timely and reasonably accurate.

4.4.2 Crop Condition Assessment

The information on crop vigor produced by CIAT is of questionable validity. As discussed in section 4.1.2, it is not possible to link NVI to any particular crop or land use within a pixel with confidence, let alone within an assessment grid cell. When NVI information is combined with appropriate meteorological data, however, it is possible to make general qualitative statements about the favorableness of the growing season, as it is manifest through general vegetation growth. From that, it is possible to make inferences about crop condition. Whether this represents an improvement over what can be done with meteorological data alone is unclear.

4.4.3 Yield Forecasts

CIAT yield forecasts are not based on a sound methodology. As discussed above (4.1.2, 4.1.3) most of the techniques employed in CIAT were developed for other environments and they have not been validated for Africa to a degree that assures confidence in their results.

It was forcefully argued that the results that were derived, and their correlation with reported yields were sufficient validation. However, the circularity of model calibrations combined with the admittedly poor yield data undermines this argument.

It is obvious that the AISC-CIAM group involved in CIAT is highly capable and doing the best it can, given the limitations of the technology, the data available to it, and the constraints of running an operational system. The panel feels, however, that making reliable quantitative yield forecasts for the Sahel and Horn regions is beyond the capabilities of the technology and data employed.

4.4.4 Technology Transfer

Because we did not visit with CIAT trainees from host countries or the AGRHYMET Regional Center, we cannot assess the effectiveness of this part of the program. However, our analysis of the larger program raised several issues about the technology transfer program and what its ultimate utility might be.

First, not all components of the CIAT are valid. Techniques for identifying problem areas would be appropriate to transfer. However, some modification to the reporting scale would be desirable to better meet national or sub-regional needs. Similarly, techniques for qualitative assessment of national crop condition might be useful if the scale were modified and if other data were incorporated (see 5.2.2).

Second, it is unclear whether there is a "market" for CIAT information. In anecdotal terms, it was explained that in many cases there is no other source of information, regardless of reliability. While this may be true in some situations, we saw no comprehensive comparison of CIAT products and what might be available from other sources.

Finally, it seemed obvious that the impetus for CIAT transfer came almost exclusively from USAID. Without their leadership and support, CIAT would probably not be sustainable.

5

SUGGESTIONS FOR CHANGES IN THE CIAT APPROACH

There are several possibilities for improvement in the CIAT program. The suggestions that follow are, perhaps, idealistic: they do not take into account the very real limitations of staff, budget, or time. However, one must begin with idealized approaches and then adjust or adapt as reality dictates.

In addition to suggested improvements of the current system, alternative methods are described briefly. As already mentioned, the panel feels that other techniques that might complement or even replace current methods may not have been examined adequately. The inclusion of alternative methods in this report is intended to promote both discussion of the products that are ultimately desired and a careful consideration of how they might best be acquired.

5.1 MISSION

The mission of CIAT has changed during the past seven years. This change appears to be a product of the change in clientele that CIAT has been asked to serve (see 6.1). Just as USAID must redefine its needs, so too must NOAA/AISC reconsider what it can realistically deliver. Particularly during the past two years, as NOAA/AISC attempted to develop its capability to make quantitative estimates of yield for the region, it appeared that the program became focused more on the technology than on the product.

Because of its strategic position in the nation's "weather" agency, NOAA/AISC is a logical entity to serve both the meteorological and climatological needs of USAID in Africa and in other regions in which it is interested. NOAA/AISC can serve as an intermediary to provide meteorological data of all sorts. It should also be able to function for USAID as an agency for collection, collation, and interpretation of ground-based and satellite-provided weather data, for computation of climatological probability statements, and for review of assessments generated in all other U. S. government programs that evaluate weather impacts on food production in the subject regions.

5.2 METHODS

Overall, our review of the methods employed suggests that there has not been sufficient effort made to validate those individual elements of the overall assessment procedure which have not been derived under African conditions, or to validate those elements which have.

Opportunities to improve the quality of assessments through collaboration, or at least consultation, with other agencies working in the same area appear to have been foregone. It may be both advantageous and necessary to develop independent assessments of crop conditions in Africa. However, unless the methods and results of different approaches are debated often and openly, the truth of the situation will be obscured.

5.2.1 Climate Monitoring

As noted above, it does not seem that enough is being done with the data available to NOAA/AISC. Measures of precipitation, temperature and soil moisture could be made independently by NOAA/AISC. This might improve the timeliness of products, and would add a significant degree of confidence to assessments.

5.2.2 Remote Sensing

As indicated below, most of the problems outlined in 4.1.2 have alternatives that may, or may not, be more suitable than those currently used.

Calibration. Simple methods to achieve first-order corrections for sensor and atmospheric variations exist and have been used for satellite data. These require dark and bright targets that are assumed to be constant (for example, deep space or water and bare sand), against which sensor values can be adjusted (Schowengerdt 1983). The technique has been used successfully to normalize AVHRR data for the region (C. J. Tucker, personal communication.)

Spatial Heterogeneity. If accurate projections are to be made of crop vigor and yield using AVHRR data, it is necessary to incorporate some estimate of the area within the study region devoted to any single crop, even in areas of relative homogeneity (Boatwright et al., 1986). Because a composite NVI value is used to represent an entire 50 x 100 km area, the relative amount of that area devoted to different crops must be known so that the NVI can be interpreted accurately.

Even without crop area estimates, the reliability of crop condition and yield assessments could be improved by spatially stratifying the region according to any number of criteria (for example, irrigated and

non-irrigated areas, agroclimatic regions, or agricultural systems).

The further improvement of yield forecast would likely involve an additional level of sampling as used by the USDA/FCCAD. For selected areas that are either especially important (for example, the Groundnut Basin in Senegal) or representative of larger areas, more intensive sampling might be done using Landsat MSS or TM. This would provide better estimates of crop mixes and area planted.

5.2.3 Agroclimatic Interpretations

The current interpretations could be improved by incorporating the above suggestions. Beyond this, the credibility of reports could be realized by backing away from the implied precision of forecasts.

If their limitations were to be more fully explained to the user, qualitative forecasts would be more acceptable. Simple descriptions of current conditions relative to preceding years would be preferable. The addition of error bars, regardless of how broad, would also relay the levels of uncertainty that exist in these projections. Currently, the use of a single number in a report or telex implies a level of confidence that does not exist.

5.3 ALTERNATIVE METHODS

Process Models. NOAA/AISC should consider other approaches to developing yield forecasts. Models of plant growth offer an attractive alternative to current algorithms. There are, for example, models of sorghum growth and yield which use daily increments of weather information to provide estimates of both developmental stage and final yield as the season progresses.

In essence, the current condition of a crop and its potential yield can be predicted on the basis of soil moisture conditions prior to planting, and on the weather subsequent to planting up to the most recent date for which weather information is available. Projections of yield beyond that point can be made on the basis of various weather scenarios (for example, normal rainfall, 50 percent above or below normal, etc.), and distributed in any number of ways. By using these scenarios, it is possible to project the potential that might be achieved under a range of management systems for the area. Submodels can be run where limiting factors, such as insufficient nutrients, replanting, or loss of leaf area due to insect damage or disease, can be considered and the effects predicted in terms of ultimate yield.

By following such an approach, NOAA/AISC can present USAID and other users with a matrix of potential yields based on various levels of input, management, and preexisting and conceivable weather conditions. This approach is more sensitive to local conditions and avoids unreliable blanket forecasts. In the current operational

environment, the use of process models may not be a reasonable immediate expectation: the difficulty of gathering reliable or sufficiently detailed data to cover the region may not be possible. However, continued research aimed at the development of appropriate process models as an ultimate CIAT component is necessary.

Non-Meteo ological Data. Other sources of information exist which are highly sensitive to food availability but do not rely on meteorological observations. Market prices of cereal crops and meat reflect, in part, the availability of food. Factors other than climate, such as hoarding, food assistance, speculation, and state price controls, make market prices somewhat unreliable. However, these factors are in some ways more indicative of the total situation because they reflect the amount of grain in storage or otherwise available that cannot be revealed in an analysis of weather data.

Market data are easily gathered, and various international agencies have on-going programs (for example, the Centre de Coopération Internationale en Recherche Agronomique pour le Développement [CIRAD], International Crops Research Institute for the Semi-Arid Tropics [ICRISAT], International Livestock Centre for Africa [ILCA], Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières [IRAT], Institut Français de Recherche Scientifique pour le Développement en Coopération [ORSTOM]). These and private voluntary organizations (for example, Cooperative for American Relief Everywhere [CARE], Catholic Relief Services, and Lutheran World Relief) could easily be entrained to provide comparable data for the region. Such organizations can constitute an independent source of information that could be used in conjunction with official government statistics.

Unfortunately, these data are derived largely from non-U. S. sources and thus are vulnerable to interruption. In addition, it is not always possible for international agencies and voluntary organizations to provide information on a regular or timely basis. Hence, a timely and accurate system cannot be built on these data alone, but they would be highly desirable as secondary sources for verifying other reports.

5.4 USER RELATIONSHIPS

If the CIAT program is to succeed, a major effort will be required to deal constructively and frequently with users within USAID. The CIAT team should spend more time with USAID to understand their needs and explain their products.

As already noted, the scope of the project has changed over time as the range of users within USAID expanded. As this group grew, there was no commensurate effort made by CIAT to assess USAID's new needs and make sure that they were satisfied. In addition, the techniques being used for assessments were not adequately explained to users, some of

whom came to view the technology as a "black box," and therefore felt that they could not rely on its products. Finally, our interviews revealed that many potential users within key offices of USAID were not familiar with CIAT products, did not use them, and had no opinion about the overall project.

5.5 PUBLICATION

The CIAT program has suffered in the eyes of users when compared to other systems (for example, NASA/GSFC/GIMMS or USDA/FCCAD). Much of the problem is derived from the fact that descriptions of the complete CIAT system do not appear in peer-reviewed publications.

For CIAT, peer-reviewed publication would serve two purposes. First, it would describe the technology to users in a comprehensive manner and subject it to scientific criticism. Second, and perhaps more importantly, the appearance of system descriptions in a peer-reviewed journal would be viewed by USAID personnel and others as independent and non-biased certification of the techniques described.

The AISC-CIAM team has done an excellent job in the past in publishing its agroclimatic research and has earned a reputation for high quality work, particularly with LACIE and AgRISTARS. However, the bulk of CIAT, including application of previously used techniques to Africa, and virtually all of the remote sensing technology developed by AISC-CIAM, has not had the same type of "certification" and thus has not earned the same confidence.

5.6 INSTITUTIONAL ARRANGEMENTS

The apparent overlap with programs in other agencies is obvious, but equally difficult to resolve. Differences of mission are likely to preclude consolidation, but there appear to be opportunities for enhanced cooperation.

USDA. The World Agricultural Outlook Board (WAOB) performs work that is similar to CIAT, but on a world-wide scale. As noted, the techniques used by JAWF in support of WAOB are independent of, if not complementary to, the meteorological work done by CIAT. At a minimum, participation in weekly WAOB briefings, or particularly the monthly Africa briefing, by CIAT personnel should be mandatory. This would facilitate the exchange of information and provide an opportunity to compare information and interpretations that could lead to more reliable results.

NASA. The GSFC/GIMMS mission is different from that of CIAT. However, the GIMMS AVHRR data set is global and includes Africa. From preliminary examination, it appears that the global GIMMS historical

data base is superior to CIAT's because it has undergone a first-order correction for atmospheric and sensor differences and it has been geometrically registered to a common base. Given the differences in mission, it is unlikely that GIMMS would be able to, or be interested in, providing data to CIAT within the time frame in which they must operate. However, perhaps some agreement could be established whereby common processing costs could be shared.

6

SUGGESTIONS FOR USAID

Over the course of the NOAA/AISC project, USAID's needs have changed. Unfortunately, the changes in users and their needs have not been adequately enunciated by the agency. CIAT has been asked to provide information on drought, crop conditions, and yields that can be used by various USAID offices in Washington, regional centers, USAID missions, U. S. embassies, and host country ministries. It has even been suggested that ultimate users might include extension agents and farmers. Clearly, of these groups, no two have the same needs in terms of information content, frequency, scale, or cost. Therefore, it is unfair to expect one system to satisfy all of these users.

This dilemma has not gone unnoticed in USAID. It has been pointed out that many areas of contention in the discussion of early warning are not so much technical as they are conceptual. Any early warning system that is developed will (1) have multiple objectives, and (2) serve different actors from different fields at different levels (Hradsky 1986). USAID has asked AISC to provide information to these varying groups without clearly defining who they are and what exactly they need.

6.1 USER IDENTIFICATION

A fundamental question that USAID has largely neglected regards the ultimate CIAT users and, hence, the mission of the program. While it may be expedient to claim that CIAT will serve everyone from the desk officer in Washington to the Senegalese farmer in his field, their needs are substantially different and profoundly affect the structure and objectives of the program.

There are now at least three levels of users of CIAT data. They should be better characterized and their needs better defined.

<u>AID/Washington</u>, through OFDA and FEWS and SWAP, is and should be the primary consumer of data. Although the needs vary somewhat among these units, all can be grouped under the rubric of early warning. Collectively, USAID/Washington appears to make the most use of the CIAT's products.

USAID Missions and U. S. Embassies constitute another group of users. Evidence that the data are effectively used by this group and that the group perceives the data to be of significant value is not convincing. It would seem that this is a potentially important group whose interest in its products should be cultivated by NOAA/AISC.

Host Countries have access to the data but do not appear to make much use of it. In view of the range of competing information at national levels, CIAT products may not be of great value or interest. This situation should be examined further.

Extension Workers and Farmers are not and cannot be viewed realistically as potential users. It is virtually impossible to imagine a regional system providing them, on a timely basis, with better information than they currently have from conventional experience and sources.

6.2 INFORMATION REQUIREMENTS

Assuming that technology is not the limiting factor, USAID will have to specify its information requirements in terms of four criteria:

Type. Within the panel, there was some question about the types of information required by USAID. It seemed obvious that estimates of precipitation, identification of problem areas, and general indicators of crop condition are desired. There may be other indicators, though, that would be as useful, such as soil moisture. In addition, the value of yield predictions without accompanying estimates of land area devoted to production is not great. Some set of information types should be developed with a corresponding set of priorities.

Scale. The CIAT system was originally designed to serve the needs of USAID/Washington, and perhaps regional centers. The resolution of the remote sensing instrument and the size of the assessment grid are designed to provide information for a subcontinental region. The system is less well-suited to provide information that is important for planners and managers at the national or provincial level. If it is decided that the system should provide information at this level, it will require modification and be significantly more expensive.

Precision and/or Accuracy. It is understandable that USAID would like quantitative measures of impact wherever possible. This may not always be possible, however, given the

constraints of the technology and budget. This is particularly true in the case of yield forecasting. Better estimates can be made with existing technology, but at significantly higher cost.

Timeliness. The time constraints on the life of useful data should be better defined. Delivery of information to Washington is made within one week, and deliveries to the hands of mission personnel range from two weeks to one month. It is unlikely that the one-week time period can be improved upon. However, if more types of information are required, or the precision and/or accuracy demanded of the information is increased, delivery time will also be increased.

7

CONCLUSIONS AND RECOMMENDATIONS

This final section is divided into two parts. The first part outlines our general understanding of the nature and status of USAID's needs and how well CIAT has been able to meet them. The second part summarizes our recommendations to both USAID and NOAA/AISC.

7.1 CONCLUSIONS

7.1.1 USAID Needs

The NOAA/AISC CIAT program must be assessed in light of what USAID expected of it, how USAID has used and valued the data, and what the alternatives to CIAT might be. This is difficult to do for several reasons:

1. There is no clear statement by USAID describing and explaining the climate information it needs to fulfill its various responsibilities.

2. The use of CIAT products within USAID and host countries is limited.

3. The question of whether comparable information can be gathered from other sources in a similar timeframe and at lower cost has not been fully explored.

7.1.2 NOAA/AISC Performance

NOAA/AISC received direction from several different offices within USAID during the course of the project. Despite confusion that seemed to stem from this arrangement, NOAA/AISC has attempted to build an effective program to develop and implement an operational climate impact monitoring system. The CIAT program had four objectives that were met, in our view, with varying degrees of success.

1. Problem area identification. The CIAT system should be able to provide timely information on problem areas over large regions.

2. Crop condition assessment. Crop conditions cannot be assessed with confidence. While useful for describing general agricultural conditions in a qualitative way, findings cannot be linked reliably to any single crop without additional information on crop areas and distribution.

3. Yield forecast. Yield forecasts are not based on a sound methodology. Models are built on unreliable data.

4. Technology transfer. The panel could not evaluate this activity. Only parts of the technology should be considered for transfer, and only after the host country's need for this information is demonstrated.

7.2 RECOMMENDATIONS

7.2.1 USAID

There are two fundamental issues USAID should resolve before determining whether to continue its involvement in the CIAT program. First, is the type of information produced by the system useful to the agency in fulfilling its mission? If so, it is necessary to characterize this need by answering the following questions:

1. Who are the primary users of the CIAT products?
2. What types of information do they need?
3. How often, how accurate, at what frequency, and at what scale (in terms of the size of the minimum area reported upon) must they be?

Secondly, assuming that these points are resolved and a comprehensive user survey is done to characterize information needs, USAID must determine if these needs can be satisfied more efficiently and cost effectively by other organizations, such as WMO/GTS.

If user needs are adequately defined, and those needs cannot be better met by other agencies, then USAID should continue the CIAT program. Because of its strategic placement, NOAA is in a unique position to provide information on climate and its impact on agriculture in Africa. Moreover, NOAA/AISC has assembled a skilled team to produce such information.

The panel makes the following recommendations to USAID if the CIAT program is continued:

1. Based on the user requirements described above, clearly define the scope of the program in terms of the products to be delivered and their users.

2. Insist on greater coordination of NOAA/AISC and (a) NOAA-USDA/JAWF on assessment, (b) NASA/GSFC/GIMMS on data acquisition and data rectification, and (c) USDA/FCCAD on techniques and interpretation.

3. Designate a single person or group within USAID to serve as liaison with NOAA/AISC to ensure better communication between the two organizations.

7.2.2 NOAA/AISC

The CIAT program has incorporated proven techniques developed in other environments and attempted to apply them to Africa. Overall, however, these methods have not been sufficiently validated for use in the African context. In addition, data quality has not been critically evaluated and the techniques used for reducing data variability are, in themselves, subject to question.

The panel makes the following recommendations to NOAA/AISC to improve the CIAT:

Agroclimatic Methods

1. Examine additional sources for providing information on precipitation (for example, independent analysis of METEOSAT) and soil moisture (for example, thermal inertia analysis of METEOSAT and microwave response from NIMBUS).

2. Work toward developing statistical statements on the probability of specific climatic events or conditions using historical weather data from the region.

3. Replace regression models with process models for forecasting yields where possible.

Remote Sensing Methods

1. Make first-order corrections of AVHRR data to compensate for sensor and atmospheric variations.

2. Systematically incorporate spatial information on regional agricultural variations to improve NVI interpretations (i.e., stratify).

3. Use multistage sampling techniques that include large-scale aerial photographs of selected transects, together with direct on-site inspection of sub-sample areas to better identify crop types and crop vigor.

Interpretations

1. Better characterize the environmental and agricultural systems within the region as an aid to assessors in making their interpretations.

2. Place assessors in the field more frequently to improve their understanding of all relevant sectors in the countries with which they work.

3. Consider the incorporation of additional forms of information on food availability (for example, market prices).

Cooperation

1. Work more closely with USAID to learn its needs and explain CIAT products to a wider audience.

2. Establish regular information exchange with NOAA-USDA/JAWF and USDA/FCCAD.

3. Work with NASA/GSFC to develop a joint AVHRR data set.

General

1. Publish descriptions of CIAT methods in peer-reviewed journals.

8

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APPENDIX 1

GLOSSARY OF ACRONYMS

ACCS	Ambroziak Color Coordinate Scheme
AGRHYMET	Agro- et Hydro-Météorologie
AgRISTARS	Agriculture and Resources Inventory Surveys through Aerospace Remote Sensing
AISC	Assessment and Information Services Center
AVHRR	Advanced Very High Resolution Radiometer
BOSTID	Board on Science and Technology for International Development
CARE	Cooperative for American Relief Everywhere
CCEA	Center for Climatic and Environmental Assessment
CEAS	Center for Environmental Assessment Services
CEDDA	Center for Experimental Design and Data Analysis
CIAM	Cooperative Institute for Applied Meteorology
CIAT	Climate Impact Assessment Technology
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement
EARTHSAT	Earth Satellite Corporation
FAO	Food and Agriculture Organization of the United Nations
FAS	Foreign Agriculture Service
FCCAD	Foreign Crop Condition Assessment Division

FEWS	Famine Early Warning System
GIMMS	Global Inventory Monitoring and Modelling Studies
GMS	Geophysical Monitoring Satellite
GOES	Geostationary Operational (or Orbit) Environmental Satellite
GSFC	Goddard Space Flight Center
GTS	Global Telecommuications System
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ILCA	International Livestock Centre for Africa
IRAT	Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières
JAWF	Joint Agricultural Weather Facility
LACIE	Large Area Crop Inventory Experiment
LANDSAT	Land Remote Sensing Satellite
METEOSAT	Meteorological Satellite
MSS	Multispectral Scanner
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NVI	Normalized Vegetation Index
OFDA	Office of U. S. Foreign Disaster Assistance
ORSTOM	Institut Français de Recherche Scientifique pour le Développement en Coopération
SPOT	Système Probatoire d'Observation de la Terre
SWAP	Sahelian and West African Program

TIROS-N	Television Infrared Observation Satellite
TM	Thematic Mapper
USAID	U. S. Agency for International Development
USDA	U. S. Department of Agriculture
USGS	U. S. Geological Survey
WAOB	World Agriculture Outlook Board
WMO	World Meteorological Organization

APPENDIX 2

COMPARISON OF SATELLITE REMOTE SENSING SYSTEMS

TABLE 1 Comparison of Satellite Remote Sensing Systems

SPOT	Advanced Landsat Thematic Mapper (TM)	Landsat Multispectral Scanner(MSS)	Very High Resolution Radiometer (AVHRR)	Meteosat
Spectral bands (micrometers)				
0.51-0.73	0.45-0.52			
0.50-0.59	0.52-0.60	0.5-0.6	0.58-0.68	0.50-1.0
0.61-0.68	0.63-0.74	0.6-0.7		
	0.76-0.90	0.7-0.8	0.72-1.10	
0.79-0.89		0.8-1.1		
	1.55-1.75			
	2.08-2.35			
			3.55-3.93	
				5.7-7.1
	10.04-12.50	10.30-11.30	10.50-12.50	
Instantaneous field of view/resolution (meters)				
10 (pan) 20 (HRV)	30	80	1100	2500(vis) 5000(TIR)
Repeat cycle				
5/20 days	16 days	16 days	12 hours	2 hours?
Turnaround (time between acquisition and delivery)				
4 weeks	4 weeks	1 week	2 weeks	
Area per image (square kilometers)				
3600	34000	34000	5018000(LAC) 17640000(GAC)	
Data cost per square kilometer (dollars)				
0.41	0.10	0.02	0.00003(LAC) 0.000007(GAC)	

SOURCE: Compiled by Charles F. Hutchinson, 1986.

APPENDIX 3

PROGRAM DESCRIPTION

A. GENERAL OBJECTIVE

To undertake a scientific evaluation of the National Oceanic and Atmospheric Administration's (NOAA) Climate impact assessment technology used in Africa.

B. BACKGROUND

By September 1986, the National Oceanic and Atmospheric Administration Assessment Information Services Center (NOAA/AISC) will complete a project to develop a climate impact assessment technology (CIAT). This technology has been geared for use in the Sahelian and Horn regions of Africa. The purpose of the project is to accelerate the rehabilitation and disaster recovery process associated with the African famine by providing operational assessment of the impact of weather on agricultural production, and to use these assessments as timely, reliable, and quantitative inputs into agricultural crop production forecasting, agricultural policy making, and rangeland management. AID now needs to determine if it should continue to fund the CIAT program; and if so, what improvements or revisions are needed to meet our goals. To understand this analysis, AID should have the CIAT evaluated in terms of its scientific credibility, efficiency and efficacy, and how it might be properly integrated into AGRHYMET and other related AID initiatives in Africa (e.g. FEWS).

Of priority to AID in this context is its current analysis of the Sahel Water Data and Management Project III (625-0973) for which PID and PP design should be completed prior to November, 1986. That project envisages the funding of a post-OFDA NOAA CIAT system for Africa which would be housed in the AGRHYMET Regional Center in Naimey, Niger.

C. DESCRIPTION OF SERVICES

The evaluation of the CIAT will include an examination of a range of complicated and interrelated issues. The evaluation therefore

should be undertaken in phases. This TOR encompasses the first phase of that process, which simultaneously will be critical to the final design of the AGRHYMET project.

The CIAT initially should be evaluated in terms of its scientific soundness or credibility. This makes an appropriate beginning for several reasons. It must be based on a sound scientific basis; and its operational methodology must gain the confidence of the decision makers it is meant to serve. In addition, the strengths and weaknesses of each of its components will be assessed. Such an inventory will be needed to effectively design subsequent phases.

The assessment of the credibility of the CIAT should specifically address the following issues:

- recognizing the exigencies of an operational system, do the methodologies and modeling techniques utilized in the CIAT conform to normally accepted scientific standards?

- does the CIAT produce reliable analyses that reflect field realities?

  is the current spatial level of detail of the CIAT analyses commensurate with the scale of the phenomena being analyzed?

- is the CIAT analysis conducted in the most efficient manner?

  compare the strengths and weaknesses of the CIAT methodologies and/or technologies with other systems in use (e.g. FAO, NASA/Goddard, ESA, UNEP, USDA);

  any additional salient issues that might arise during the assessment process.

The assessment should also include any recommendations of the evaluation panel for improving the CIAT concerning the methodology, technology or the operational aspects of CIAT and research that may be needed to improve the process.