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SAHEL WATER DATA & MANAGEMENT III

PROJECT PAPER

(625-0973)

AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

JUL 27 1987

ACTION MEMORANDUM FOR THE ACTING ASSISTANT ADMINISTRATOR FOR AFRICA

FROM: AFR/PD, Carol Peasley

SUBJECT: Sahel Water Data and Management III Project 625-0973

PROBLEM: Your approval is requested for a grant which totals $9,000,000 for the Sahel Water Data and Management III project (625-0973). Of this total $3,500,000 is from Section 121 of the FAA of 1961, as amended, the Sahel Development Program appropriation; $5,000,000 is from reobligated Sahel Development Program appropriation; $500,000 is from authorized, but unfunded Mission buy-ins. These Mission buy-ins are also Sahel Development Program appropriation. It is planned that a total of $3,050,000 will be obligated in FY 1987, which will include $1,500,000 of re-obligated monies.

DISCUSSION:

I. Background

A plan to assist the Sahel countries strengthen their agrometerorological and hydrological services was initiated by a 1973 resolution of the Permanent Interstate Committee for Drought Control in the Sahel (CILSS). In 1975, a multi-donor mission recommended a 15-year program, entitled AGRHYMET (Agriculture, Hydrology, Meteorology), divided into three phases of approximately five years each. Phase I (1975-81) created the AGRHYMET Regional Center in Niamey and strengthened the national agro-meteorological/hydrological services and linked them to a regional network. Phase II (1982-86) saw the installation of the national and regional computer systems, continued training and the initiation of operational data collection, analysis and diffusion. Phase III (1987-91) representing the current activity under consideration for A.I.D. support, proposes to complete an operational crop/rangeland monitoring system (including provision of NOAA AVHRR satellite imagery) and to begin provision of useful data to end-users (farmers, herders, national decision-makers) so as to have a positive impact on agricultural production and numerous other national development concerns. This phase will place increased attention on national-level operations (including the national

interdisciplinary working groups). It should also witness a progressive shift from expatriate to Sahelian technical assistance and a progressive shift from donor to Sahelian responsibility for the costs of the system. To date, A.I.D. has focused its $13 million contribution during Phases I and II essentially on the support of the computer system (hardware, training, technical assistance).

A special A.I.D. evaluation in late 1985 found the AGRHYMET Program globally on-track in relationship to its initial expectations and noted strong support for the continued A.I.D. involvement as represented by this Phase III authorization request.

The purpose of SWDMP III, as in previous phases is to support the development of a regional system, including national elements, which will record, process, interpret, transmit, disseminate and document timely, accurate and meaningful weather, climatic and hydrological information in the Sahel. The project will fund activities in data processing and remote sensing through a major technical assistance contract, selected equipment and training and, as an interim measure, a nine-month extension of the existing National Oceanic and Atmospheric Administration (NOAA) PASA agreement, in achieving these objectives.

Conceptually, SWDMP III support two focii of A.I.D.'s strategy in the Sahel region: a) data processing assistance to AGRHYMET will lead to improved data and analysis in support of agricultural production, a theme central to the RDSS; b) remote sensing assistance will lead to an advanced local system of crop monitoring, itself closely linked to RDSS food security objectives and A.I.D.'s priority requirement to generate early warning information on impending food shortages in the region.

There are numerous potential beneficiaries of the Sahel Water Data Network and Management III Project, through the key support it offers the AGRHYMET Program. Among the beneficiaries are the farmers who comprise 65% of the total population. Second, benefits accrue to scientists and technicians associated with the project through increased knowledge, competence and capabilities gained as a result of data generation and storage, training and research. Host countries and their citizenry benefit as a result of the rational, economic and productive use of water resources as well as an increased institutional capability to provide ancillary services to other sectors of the economy. The principal outputs of the project are: a) a reliable and cost-effective data processing system; b) usable

remote sensing products which are available at the national and regional levels; c) national and regional staff trained in hardware maintenance and remote sensing methods; d) selected improvements in national communication links.

II. Financial Summary

A.I.D.'s first year obligation is $3,050,000. Life-of-Project funding is $9,000,000, including a total of $500,000 of authorized, but unfunded Mission buy-in.

Estimated Budget ($000)

A.I.D.	FY 1987	LOP
-Technical Assistance	1,253	2,616
-Commodities	732	2,529
-Training	--	1,173
-Other	1,065	2,682
TOTAL	3,050	9,000

AGRHYMET Project Phase III costs are estimated at $42.0 million, of which A.I.D.'s contribution is $9.0 million. CILSS member countries will contribute some $5.0 million and an estimated $28.0 million will come from the United Nations Development Program (UNDP), Italy, The Netherlands, E.E.C., France and Belgium.

III. Project Analyses

The project has been reviewed and found to be feasible based on economic, technical, financial, institutional and social soundness analysis conducted in conjunction with Project Paper design.

This activity meets the criteria for Categorical Exclusion in accordance with Section 216.2 (c) (2) (iii). See Annex E of the PP.

IV. Implementation Plan, Conditions and Covenants

The Project Paper contains implementation and procurement planning which is realistic and workable. Arrangements have also been made for monitoring the execution of implementation planning and evaluating the attainment of project objectives, including longer-term sustainability.

In addition to the standard conditions precedent to disbursement, special covenants will be added to the Project Agreement which will require (a) that a special AGRHYMET Program management study will receive timely and substantive review by all donors; (b) that subsequent annual reviews of AGRHYMET performance will be made with reference to the program management objectives generated therein; (c) that Sahelian personnel will be provided under CILSS funding as agreed to by AGRHYMET and the donor coordinating committee (CAC).

The statutory checklists have been satisfactorily completed and are included in Annex F of the Project Paper. Pursuant to Section 121(d) of the Foreign Assistance Act, as amended, the Mission has certified that, since Sahel Development Program funds will not be made available to a foreign government, a negative determination is approved.

The project design team considered the advisability of involving Gray Amendment organizations. It concluded that the most appropriate contracting procedure would be full and open competition, with encouragement for participation of Gray Amendment entities as prime or subcontractors in accordance with Part 19 of the F.A.R.

No waivers are requested in this project.

Responsibility for A.I.D. project management of this regional project will remain in U.S.A.I.D./Niamey and be backstopped by AFR/SWA and AFR/PD/SWAP.

The ECPR, chaired by the Director, AFR/PD, met on May 21, 1987 recommended that the project be approved subject to the following changes in the Project Paper: a) A.I.D. concerns about AGRHYMET program objectives over time and the availability of resources to attain those objectives will be included in an upcoming management study and therefore will be annually reviewed as part of the monitoring/evaluation plan; b) an allowance of $600,000 will be included in the PP budget to fund one full-time project manager to be located in U.S.A.I.D./Niamey; and c) the Agency will monitor progress toward resolution of telecommunication problems and re-assess our formal position during the 1989 project evaluation.

V. Justification to Congress

A Congressional Notification was forwarded to the Congress on May 29, 1987 and the waiting period expired on June 13, 1987 without objection.

VI. Recommendations

That you sign the attached Project Authorization thereby approving life-of-project funding of $9,000,000 for the Sahel Water Data and Management III (SWDM III) Project.

Attachments

1. Project Authorization
2. Project Paper

Clearances:

AFR/SWA:PDichter _____ Date 7/14/87
AFR/PD/SWAP:NMcKay draft Date 6/16/87
AFR/DP:JPatterson _____ Date 7-14-87
GC/AFR:PJohnson _____ Date 14 July 87
AFR/CONT:RKing _____ Date 7-22-87
AFR/PD:AHarding _____ Date 7/16/87
SER/AAM/OS:SDean phone (w/) Date 7/16/87

AFR/PD/CCWAP:JChau/JHradsky:jbt:6/18/87:647-9067:3322K

ATTACHMENT 1: PROJECT AUTHORIZATION

AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

PROJECT AUTHORIZATION

Name of Country/Entity:	Sahel Regional
Name of Project:	Sahel Water Data and Management III
Number of Project:	625-0973

1. Pursuant to Section 121 of the Foreign Assistance Act of 1961, as amended (the "Act"), I hereby authorize the Sahel Regional Water Data and Management III project, involving planned obligations not to exceed Nine Million United States Dollars (US $9,000,000) in grant funds ("Grant") over a five year period from date of authorization, subject to the availability of funds in accordance with the A.I.D. OYB/allotment process, to help in financing foreign exchange and local currency costs for the project. The planned life of the project is five years from the date of initial obligation.

2. The project ("Project") consists of support for the development of a regional system, including national elements, which will record, process, interpret, transmit, disseminate and document timely, accurate and meaningful weather, climatic and hydrological information in the Sahel.

3. The Project Agreement(s) which may be negotiated and executed by the officer(s) to whom such authority is delegated in accordance with A.I.D. regulations and Delegations of Authority, shall be subject to the following terms, covenants and major conditions, together with such other terms and conditions as A.I.D. may deem appropriate.

a. Source and Origin of Commodities; Nationality of Services

(1) In accordance with the policy set forth in A.I.D. Handbook 1, Supplement B, Chapter 16, Section 16C3a(2)(b), the procurement and audit practices and policies of the World Meteorological Organization ("WMO") will apply to commodities and services procured by the WMO.

(2) Commodities procured by A.I.D. under the Grant shall have their source and origin in the United States or the Cooperating Countries, except as A.I.D. may otherwise agree in writing. Except for ocean shipping, the suppliers of commodities or services procured by A.I.D. shall have the United States or the Cooperating Countries as their place of nationality, except as A.I.D. may otherwise agree in writing. Ocean shipping financed by A.I.D. under the Grant shall be financed only on flag vessels of the United States or the Cooperating Countries, except as A.I.D. may otherwise agree in writing.

b. Condition Precedent to Disbursement

Prior to any disbursement, or to the issuance by A.I.D. of commitment documentation pursuant to which disbursement may be made, WMO shall submit to A.I.D., in form and substance satisfactory to A.I.D., evidence that the funding for country commitments from CILSS and other donors necessary to carry out this Project have been received.

c. Covenants

The Project Agreement(s) shall contain covenants substantially as follows:

(1) The results of the AGRHYMET Management Study agreed to at the May 15, 1987, meeting of the AGRHYMET Coordinating and Advisory Committee ("CAC") will be made available to all CAC members no later than January 1, 1988, and the final version of the AGRHYMET Management Plan will be formally submitted to A.I.D. upon completion of review and approval by the CAC.

(2) The CAC will annually review the status of AGRHYMET performance in relation to its avowed objectives, as expressed by its Management Plan and will conduct a comprehensive performance review in 1990, following completion of an in-depth A.I.D. evaluation currently scheduled for July, 1989.

(3) The Sahelian personnel to be provided with CILSS funding will be provided as agreed by AGRHYMET and the CAC.

Edward L. Saiers
Acting Assistant Administrator
Bureau for Africa

JUL 28 1987

Clearances:

AFR/SWA:P.Dichter (draft)	Date	7/14/87
AFR/PD/SWAP:B.Burnett (draft)	Date	7/23/87
AFR/DP:J.Patterson J.Govan for	Date	7/14/87
AFR/CONT:R.King C.Rattan for	Date	7/21/87
AFR/PD/CCWAP:J.Hradsky	Date	7/27/87
AFR/PD:C.Peasley J.Graham for	Date	7/23/87

2229H

GC/LAC,PGJohnson/tim:2July87:647-9218

ATTACHMENT 2: PROJECT PAPER

AGENCY FOR INTERNATIONAL DEVELOPMENT

PROJECT DATA SHEET

1. TRANSACTION CODE: A (A = Add, C = Change, D = Delete)

Amendment Number

DOCUMENT CODE: 3

2. COUNTRY/ENTITY: Sahel Regional

3. PROJECT NUMBER: 625-0973

4. BUREAU/OFFICE: AFR/SWA 06

5. PROJECT TITLE (maximum 40 characters): Sahel Water Data & Management III

6. PROJECT ASSISTANCE COMPLETION DATE (PACD): MM 01 DD 01 YY 93

7. ESTIMATED DATE OF OBLIGATION (Under 'B.' below, enter 1, 2, 3, or 4)

A. Initial FY 87 B. Quarter 3 C. Final FY 91

8. COSTS ($000 OR EQUIVALENT $1 =)

A. FUNDING SOURCE	FIRST FY 87 B. FX	C. L/C	D. Total	LIFE OF PROJECT E. FX	F. L/C	G. Total
AID Appropriated Total						
(Grant)	(3,050)	( )	(3,050)	(9,000)	( )	(9,000)
(Loan)	( )	( )	( )	( )	( )	( )
Other U.S. 1.						
Other U.S. 2.						
Host Country (Member-States)		1,000	1,000		5,000	5,000
Other Donor(s)	9,000		9,000	29,000		29,000
TOTALS	12,050	1,000	13,050	38,000	5,000	43,000

9. SCHEDULE OF AID FUNDING ($000)

A. APPROPRIATION	B. PRIMARY PURPOSE CODE	C. PRIMARY TECH. CODE 1. Grant	2. Loan	D. OBLIGATIONS TO DATE 1. Grant	2. Loan	E. AMOUNT APPROVED THIS ACTION 1. Grant	2. Loan	F. LIFE OF PROJECT 1. Grant	2. Loan
(1) SH	7505					9,000		9,000	
(2)									
(3)									
(4)									
TOTALS									

10. SECONDARY TECHNICAL CODES (maximum 6 codes of 3 positions each): 053 | 054 | 246 | 641

11. SECONDARY PURPOSE CODE: 660

12. SPECIAL CONCERNS CODES (maximum 7 codes of 4 positions each)

A. Code

B. Amount

13. PROJECT PURPOSE (maximum 480 characters)

To develop a regional system, including national elements, which will record, process, interpret, transmit, disseminate and document complete, timely, accurate and meaningful weather and climatic information in the Sahel.

14. SCHEDULED EVALUATIONS

Interim MM 07 YY 89 | MM YY | Final MM 01 YY 92

15. SOURCE/ORIGIN OF GOODS AND SERVICES

[x] 000 [x] 941 [ ] Local [ ] Other (Specify) _____

16. AMENDMENTS/NATURE OF CHANGE PROPOSED (This is page 1 of a _____ page PP Amendment.)

17. APPROVED BY

Signature: [signature]

Title: P. DICHTER, Director, AFR/SWA

Date Signed: MM 06 DD 19 YY 87

18. DATE DOCUMENT RECEIVED IN AID/W, OR FOR AID/W DOCUMENTS, DATE OF DISTRIBUTION

MM DD YY

AID 13304 (8-79)

ABBREVIATIONS AND ACRONYMS

AID, USAID	United States Agency for International Development
AISC	Assessment and Information Services Center of NOAA
ARC	AGRHYMET Regional Center in Niamey
CAC	Coordinating and Advisory Committee of AGRHYMET
DEC	Digital Equipment Corporation
FAO	United Nations Food and Agriculture Organization
GIS	Geographic Information Systems
IRR	Internal Rate of Return
MBO	Management By Objectives
MS DOS	MultiSoft Disk Operating System
MWG	Multidisciplinary Working Group
NAC	National AGRHYMET Center
NOAA	National Oceanic and Atmospheric Administration
NPV	Net Present Value
NVI	Normalized Vegetation Index
NWS	National Weather Service
PC	Personal Computer/Microcomputer
PID	Project Identification Document
PP	Project Paper
PTT	Postes, Telephones et Telegraphes
SWD&M III	Sahel Water Data and Management III Project
UNDP	United Nations Development Program
WMO	World Meteorological Organization

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I. PROJECT DESCRIPTION

A. Summary and Recommendations

1. Background

Since the early 1970s, the eight member states of CILSS (Comite Inter-Etat pour la Lutte Contre la Secheresse au Sahel) have faced severe recurrent drought, with adverse impacts on agriculture, livestock and economic growth. Populations throughout the region have suffered from deteriorating nutritional status, growing physical hardship in the effort to extract diminishing returns from the severely taxed Sahelian resource base, and from sometimes major social transitions caused by outmigration, persistent economic insecurity and the "marginalization" of many rural production systems. Those living in the most arid zones have been particularly hard hit, with the good years no longer sufficient to offset the long-term effects of the downswings.

Among the dislocations in the Sahel over the past one-and-a-half decades, food insecurity is one of the most costly, both in financial and human terms. The cost of food imports and emergency distribution far exceeds the cost of food production. In human terms, food shortage has caused enormous suffering, leaving especially deep and potentially long-lasting scars on children under five. In development terms, all long-term objectives are threatened when basic human needs go unmet.

AGRHYMET* was established in 1975 by the Heads of State of the CILSS countries in response to this crisis. Its mandate was to support increased food production in the Sahel by providing national planners and researchers with timely weather and climatic data, and with "better knowledge as to cyclical events and their impact on water, soils, vegetation and crops." This was to be done by establishing a regional information system composed of interdisciplinary working groups in each CILSS country (drawn from meteorological, agricultural and hydrological services), with a regional information processing and training center in Niamey, Niger. The Executing Agency for the AGRHYMET Program is the World Meteorological Organization (WMO) in Geneva. The organizational structure of the program is shown in Figure I.1.

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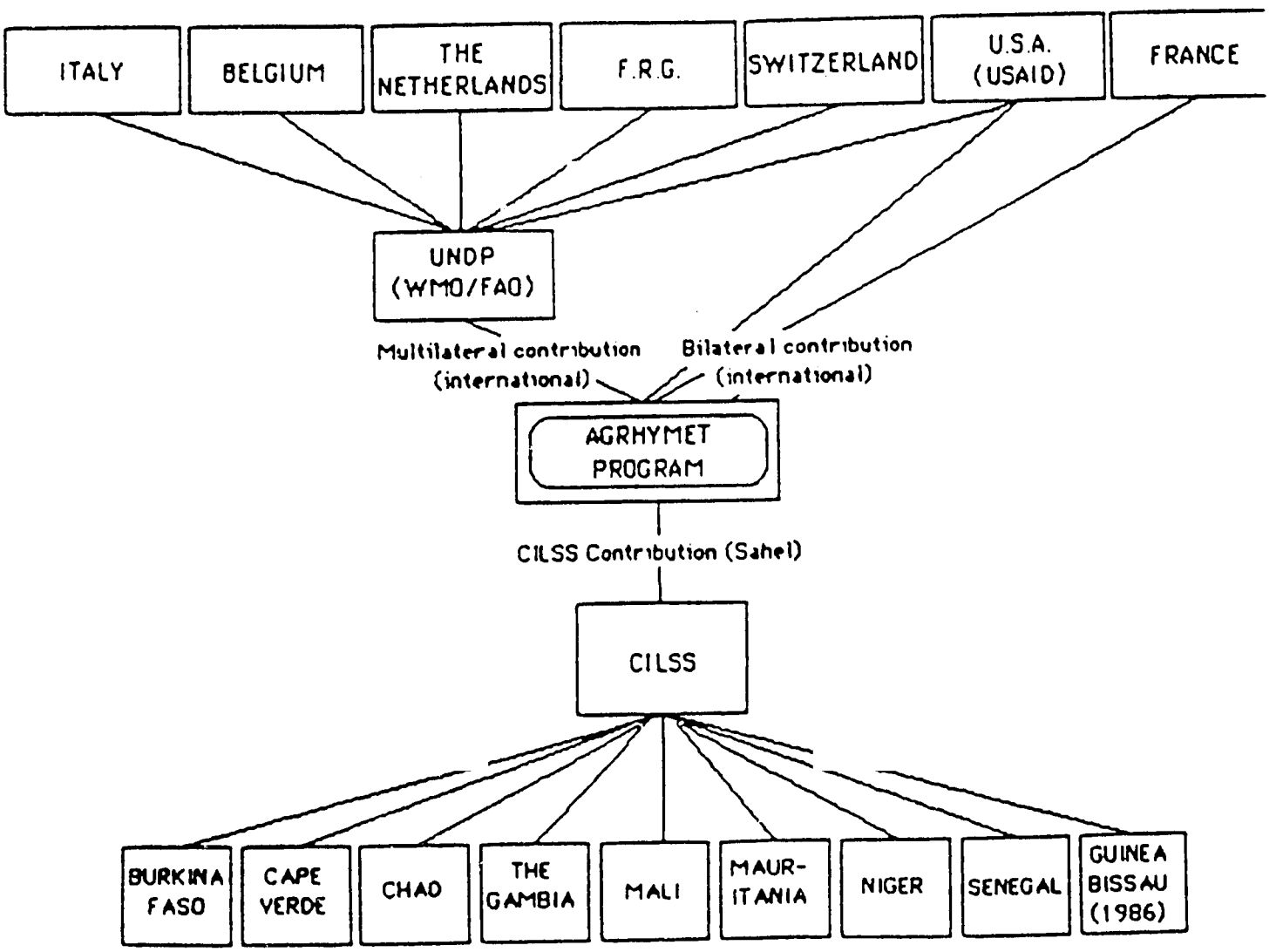
*The distinction is made throughout this document between the AGRHYMET Program, which refers to the overall multi-donor and multi-country AGRHYMET system, and the AGRHYMET Project (or Sahel Water Data and Management Project), which refers to that portion of the program funded by USAID.

THE DONORS AND THE CILSS IN THE AGRHYMET PROGRAM



AGRHYMET was to be completed in three five-year phases:

Phase I 1975-81:	Creation of the AGRHYMET Regional Center (ARC) in Niamey. Strengthening of national agrometeorological and hydrological services and networks; training of Sahel specialists both regionally and nationally.
Phase II 1982-86:	Implementation of operational activities to collect, classify and analyze data; publication of periodic bulletins; installation of national computer systems; on-going training.
Phase III 1987-91:	Provision of useful data to end-users; strengthening of national interdisciplinary working groups; on-going shift in technical responsibility from expatriate to Sahelian staff, and of financial responsibility from donor to CILSS governments.

AID has provided support to AGRHYMET through the Sahel Water Data and Management Project, begun in FY '77. Phase I U.S. funding amounted to $6,280,000, of a total $24 million in donor funding. Phase II AID funding was at $7 million, out of an estimated $45.3 million in donor contributions. Phase III will include a U.S. contribution of $9 million out of a total $38 million.

To date, AID's funding has been provided through a PASA agreement with the National Oceanic and Atmospheric Administration (NOAA), focusing on provision of computer hardware and software, technical assistance to operate and maintain this equipment, and technical training. AID has provided further technical assistance, not directly funded under the Sahel Water Data and Management Project, through the NESDIS division of NOAA. This assistance has been for the preparation of crop yield forecasts through the growing season, and for training in forecasting and data analysis.

Relative to the <u>outputs</u> expected of it in the first ten years, AGRHYMET appears to be on or near schedule. An additional major accomplishment of Phases I and II was to have been preparation for Phase III objectives of providing information to end-users and of beginning the transition to full Sahelian operation and control.

If successful, AGRHYMET appears to offer four potential contributions to Sahelian development:

Early Warning: A computerized information gathering and processing system for crop condition assessment, which in turn is an important component of an Early Warning System for localized food deficits in the region. Although the current state-of-the-art suggests that there are reasons for which it is not possible to do biophysical yield forecasting, it is possible to assess vegetation vitality, and to make important inferences about yield forecasting.

Crop/Livestock Improvement: An input for improved agricultural production and livestock system management, through collection, transmission, processing and analysis of consistent and reliable meteorological and hydrological data.

Statistics: A major source of agricultural and agrometeorological statistics in the Sahel. Recent developments in remote sensing technology also open the possibility that satellite monitoring may soon be capable of providing accurate, timely and geographically-specific rainfall estimation.

Improved Decision Making: A tool for other forms of private and governmental decision making in fisheries, transportation, forestry and other sectors.

2. Key Issues Underlying Project Design

AGRHYMET is a fifteen year program, involves at least ten major donors and international organizations, nine Sahelian countries and over twenty national agencies, and will yield benefits over several decades. In a program of this complexity, especially as it enters the final phase of major donor funding, it is essential to articulate the long-term objectives to be served by each donor contribution, and to assure that together they fit within a coherent regional development strategy. The two overriding principles applied in this project design are feasibility and sustainability. These are discussed in Section II.A. To be feasible, a proposed initiative must be technically viable given existing technologies and institutional structures, and all complementary inputs (including from other donors) must be available or committed. To be sustainable, initiatives must create recurrent cost streams (for both financial and human resources) which can be sustained with minimal donor assistance after 1991.

These concepts underlie all elements of project design, but are discussed in particular detail in Sections II.A, II.B and II.D. Their major implications for project design are summarized below:

> Hardware systems at all levels must move away from reliance on single, central machines and towards a modular approach which allows for greater flexibility in system maintenance, lower down times, reduced fixed and recurrent costs and greater capacity to benefit from rapid improvements in computer technology which are likely to increase both performance and reliability.
>
> At the NACs, both hardware and software must emphasize microcomputer technology which allows low cost, easy to install, maintain and replace equipment and a wide range of off-the-shelf software. Not only are such systems much cheaper to operate, they are compatible with computer configurations being used in other ministries in most Sahelian countries and are likely to increase effective automation of AGRHYMET national level tasks.
>
> The remote sensing component should stress Sahel-based operations, which will speed the production and delivery of crop yield forecasting information to the national centers, complement efforts underway by other donors and place greater emphasis on understanding, interpreting and presenting satellite data in a form which is most useful both to the NACs and to other downstream users, such as drought relief agencies and national and inter-donor planning organizations.

3. Summary of the Project

Goal and Purpose of the AID Project

The goal of the Sahel Water Data and Management III Project is to contribute to food self-sufficiency in the Sahel through:

- A steady production of agriculture-related research, recommendations, tested practices and improved production methods.

Adoption of improved practices developed through the use of AGRHYMET-generated data on weather, climate, hydrology and related issues.

The specific sub-goal of the project is to strengthen the capacity to perform agrometeorological and hydrological data collection and analysis in the Sahel.

The purpose of the project is to support the development of a regional system, including national elements, which will record, process, interpret, transmit, disseminate and document timely, accurate and meaningful weather, climatic and hydrological information on the Sahel.

The SWD&M III Project will have a recommended funding level of $9 million, which includes a $500,000 allowance for Mission "buy-ins" (see Section II.B). It will have two principal components:

Provision of hardware, software, technical assistance and training to improve the efficiency of the data processing system (including some telecommunications elements) and to allow its continued operation and maintenance through 1991.

Provision of software, technical assistance and training to establish and make operational a viable system for analyzing and interpreting remote sensing satellite data, for further developing methodologies in this area and for transferring remote sensing/crop yield forecasting skills to Sahelian staff at the ARC and NACs.

These components, currently provided by NOAA/NWS and NOAA/NESDIS under two separate PASA agreements, will be managed by a single technical assistance contractor during Phase III.

Table I.1 summarizes the proposed AID inputs for Phase III of the project. Detailed budgets are provided in Section II.B and in the Technical Annex (Annex B). A detailed implementation plan is shown in Section III.A.

In summary, the data processing component will provide 54 person-months of local hire technical assistance for logistics and inventory management, and 54 person-months of Sahelian (AID-funded) administrative/logistics staff. In addition, this component will train ARC and NAC personnel via short courses in computer maintenance, electronic maintenance and

Table I.1
SUMMARY OF PROJECT COSTS

REMOTE SENSING COMPONENT		
Long Term Technical Assistance	$458,023	
O/S Allowances, Educ, Housing, Etc	$398,988	
Travel and Per Diem	$264,138	
Training	$597,758	
Consultants	$164,947	
Other Direct Costs	$166,066	
Subtotal		$2,049,920
DATA PROCESSING SYSTEM COMPONENT		
Long Term Technical Assistance	$324,105	
O/S Allowances, Educ, Housing, Etc	$0	
Travel & Per Diem	$158,181	
Consultants	$620,000	
ARC Logistics	$250,000	
NAC Logistics	$390,000	
Telecommunications	$220,000	
Training	$575,000	
ARC New Equipment	$968,000	
NAC New Equipment	$701,000	
Subtotal		$4,206,286
U.S. PROJECT MANAGEMENT AND SUPPORT		
U.S. Management/Support Labor	$369,184	
U.S. Management/Support	$79,950	
Subtotal		$449,134
OTHER		
Contingency		$200,000
Mission Buy-Ins		$500,000
Special Studies (MBO, Remote Sensing)		$80,000
NOAA Phase II Extension		$900,000
USAID/Niamey Project Management		$600,000
Total		$8,985,340
ROUNDED TO:		$9,000,000

software development. Because several ARC personnel requiring degree programs for maintenance of VAX systems have already been trained, further training will primarily focus on the lower level skills needed to carry out maintenance of microcomputer technology and to develop application programs using preexisting database, spreadsheet, mapping and other off-the-shelf packages available for microcomputers. Refresher courses will be offered to ARC technicians for maintenance of the VAX 780 and minicomputers.

Finally, the data processing component will provide the following categories of equipment to the ARC and NACs: at the ARC, up to four minicomputers to back up and eventually replace the existing VAX 780, plus associated software, peripherals and spare parts, as well as several MS DOS-based 80286-based microcomputers (with software) and, finally, the interfaces necessary to link VAX and MS DOS systems; at the NACs, several 80286-based microcomputers, plus associated software, peripherals, spare parts and communications equipment. Also at the national level, the project provides for up to forty Single Side Band Radios (plus spare parts) to facilitate internal telecommunications for reporting field data.

The remote sensing component will provide 36 person-months of expatriate technical assistance for satellite data use methodology development and crop yield assessment, 42 person-months of expatriate technical assistance for satellite data analysis and interpretation programming and 31 person-months of short-term technical assistance in crop yield forecasting and related activities. In addition, this component will train 15 NAC and ARC staff per year for each of the five years (this training will require a further 21 months of short-term consultants/trainers), plus a limited amount of software for remote sensing analysis. All of the hardware and most of the software needed for this component are funded under the data processing component.

The home office management/support will provide for 18 person-months of a U.S. project manager, 16 person-months of U.S. support/procurement staff and 18 person-months of a U.S. administrative assistant. The home office management will support all field activities for both components.

Implementation of the SWD&M III project presupposes the availability of a certain number of CILSS-funded Sahelian staff members at the ARC. These individuals have been identified by the ARC as being available. Their availability is a necessary precondition for project execution. Requirements for CILSS-funded Sahelian staff are as follows:

> Three computer technicians trained by NOAA in U.S.-based training programs, to serve as the core of a regional maintenance and support

capability. From this group, one specialist will be selected to replace the expatriate data processing system manager in the course of Phase III.

At least two full-time specialists to work with the AID-supplied agrometeorologist and computer programmer and with French remote sensing experts to produce ten-day crop yield assessments using satellite data received and processed at the ARC.

Secretarial and administrative support to AID-supplied specialists working at the ARC.

Table I.2 summarizes all personnel requirements (in person-months), by year.

B. Design of the AID Project

1. Structure and Strategy

Two areas of AID support are recommended:

Continued support to the data processing system.

Provision of technical assistance to interpret AVHRR satellite data received at the ARC, and to refine and transfer satellite data analysis methodologies to the staff of both the regional center and the national centers.

The strategy underlying the project design is built upon two concepts: feasibility and sustainability.

Feasibility is interpreted to mean that first, each component of the AID project is technically proven and, second, that all complementary inputs required are identified, feasible and already funded.

Sustainability refers essentially to recurrent costs. The term "recurrent costs" itself encompasses several concepts. Proposed options must be cost-effective, in that they must provide more for the money than other alternatives. This involves an implicit prioritization of desired outcomes, because certain outcomes may have to be sacrificed if their incremental value does not justify the incremental cost. Skilled manpower requirements are also an essential underlying concept. Systems which require a high level of skilled manpower are likely to need costly recurrent inputs of expatriate

Table I.2

SUMMARY OF PERSONNEL REQUIREMENTS
(In Person Months)

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
A. Project Management (U.S. based)						
Project Manager	3.6	3.6	3.6	3.6	3.6	18
Logistics/Procurement	2.5	3.6	3.6	3.6	2.7	16
Admin Assistant	3.6	3.6	3.6	3.6	3.6	18
B. Data Processing (Field based)						
Logistics Mgr	6	12	12	12	12	54
Admin/Support	6	12	12	12	12	54
Short Term T.A.	10	20	18	17	10	75
C. Remote Sensing (Field based)						
Sat Data Programmer	6	12	12	12		42
Agrometeorologist		12	12	12		36
Short Term T.A.	4	10	9	6	2	31
Training T.A.		5.4	5.2	5.2	5.2	21
Sahelian CILSS Staff						
Data Processing	36	36	36	36	36	180
Remote Sensing	24	24	24	24	24	120

SUMMARY

Total Short Term & Mgmt	179
Total LT Field T.A.	186
CILSS LT Counterparts	300

personnel for much longer than systems which do not, even with high levels of training expenditure, because independent skills require both formal training and years of on-the-job experience. Finally, the recurrent costs to be minimized are not those which accrue during the life of the donor-supported project, but rather after the AID project comes to an end. While it is not asserted here that all components proposed for AID funding can be carried out after 1991 without any donor support, it is assumed that the prospects for obtaining on-going funding either from other donor sources or from within national government budgets will be maximized if the recurrent costs are low.

Adherence to the twin principles of feasibility and sustainability significantly alters final project design. It can be noted that:

> At the regional level, application of the criteria both reduces costs and increases system performance relative to the current system.
>
> At the national level, major reductions in recurrent cost can be achieved with very little loss of potential capacity. Moreover, effective utilization of the system can also be increased through reliance on simpler, more flexible and cost-effective systems.
>
> Finally, application of the system feasibility criterion leads to greater emphasis on the local level, relative to the current system.

2. Inputs and Outputs for Phase III

The inputs for Phase III are:

> Computer hardware, software and associated maintenance.
>
> Technical assistance, both in the form of long-term resident specialists and short-term assistance.
>
> Training (short- to medium-term).
>
> Management and operational support.

a. Hardware and Software

During Phase III, US support will continue to provide the major part of donor funding required to maintain the computer

system at the ARC and the NACs. In addition, AID will provide upgraded computer equipment and new software, with the intention of putting in place modern, cost-effective data processing systems with low recurrent costs by the end of Phase III.

At the ARC, hardware will consist primarily of four minicomputers phased in during the five year period to back up and eventually replace the existing VAX 780, 80286-based computers suitably configured (hard disk and high resolution color monitors) to use remote sensing interpretation software, two data storage disks, a serial line multiplexor, diskette drives and system interfaces.

Software at the ARC will consist of multi-user operating systems, compilers and program development tools, MS DOS support software, packaged spreadsheet, database and word processing software, and image processing and mapping programs.

Hardware at each NAC will consist of an 80286-based computer with expanded memory, hard disk, winchester disk, quad density diskette drives, high resolution matrix printer/plotter, communications channels and power supply equipment.

At each NAC, packaged MS DOS software plus mapping software will also be provided.

The hardware and software described above, for both the ARC and the NACs, will support the remote sensing component as well as the data processing component of the proposed AID project.

b. Technical Assistance

i) Data Processing Component

This component calls for one long-term resident technical expert at the ARC. Sahelian ARC staff will provide the core support to maintenance operations at the ARC and in each national center. However, as the transition to microcomputers progresses and the PDP 11/34s are phased out, reliance on regional maintenance personnel should decrease. This will relieve pressure on regional staff, which at present is stretched too thin to provide adequate and timely maintenance to national centers.

The resident technical expert at the ARC funded by this project will be a local hire inventory management supervisor (for 54 months). In addition, this component will fund a local hire administrative assistant for 54 months.

A significant body of short-term technical assistance will also be required for the data processing component. A total of 75 person-months of such assistance is budgeted. Experience over the past five years, and anticipated needs for the coming phase suggest that the range of technical expertise required is too broad to be adequately covered by a single resident technician. Therefore, the idea of a full time resident technical manager has been replaced with a pool of regular short term advisors. Short-term specialists, working under the direction of program management, will be used to provide state-of-the-art inputs in such areas as system design, equipment selection, software selection, networking and related fields.

It is also strongly recommended that some person-months of short-term technical expertise be set aside for periodic "outside" review of the data processing system strategy and implementation approach, in order to avoid the technical obsolescence which can easily occur in such rapidly changing fields. This is particularly relevant because the likely technical advances to be made over the next five years will be in the direction of providing more powerful and user friendly hardware and software at lower cost and with lower maintenance requirements. Anticipating technology change and keeping abreast of it will very likely reduce overall project costs, and will certainly allow transfer of a more appropriate and cost-effective system in 1991.

Short-term experts will also be required to carry out data processing training programs described in section (c) below.

ii) Remote Sensing Component

The remote sensing component will require 42 person-months of a resident Satellite Data Analysis Programmer and 36 person-months of a resident Satellite Data Use Specialist. Their functions are described in detail in Section II.A.

In addition, 31 person-months of short-term technical assistance will be provided by U.S.-based specialists in agrometeorology, statistics, satellite imagery and assessment methodology.

Finally, a further 21 person-months of short-term experts will be needed to prepare and carry out the training programs for remote sensing described below.

iii) Telecommunications Component

This component provides for modems, satellite equipment, transceivers, PTT interfaces, upgrade of switching systems and Single Side Band Radios to be supplied for local-level use in

transmitting meteorological data from field stations to national centers. The project will also create a "buy-in" mechanism which allows AID Missions to provide Mission funding, within the SWD&M III management structure, to purchase additional telecommunications equipment as specific country needs and Mission priorities dictate.

In addition, the project budget includes several months of short-term technical assistance to support, if necessary, the Italian-funded study of telecommunications options between countries. Speed and reliability of telecommunications between NACs and the ARC is a significant impediment to program efficiency and will prevent attainment of other program goals if unresolved. This study should be conducted in close collaboration with WMO and with other donors who may eventually fund additional intercountry telecommunications capacity for AGRHYMET.

c. Training

For the data processing system, the person-weeks of recommended technical training are shown in the table below.

Type of Training	Number of Trainees	Length of Training	Potential Location of Training
PC Maintenance	27	3 weeks	Niamey
Software Devt	36	3 weeks	Niamey
Minicomputers	6	3 months	Europe
LT Training*	3	1 year	Europe/US
Refresher Courses	10	1 month	Niamey/Europe
User Groups (Software)	80	2 weeks	NACs
Electronics, etc.	10	2 months	Niamey/Europe
GIS/Cartography	10	6 weeks	Niamey

*To be funded via NOAA PASA.

For the remote sensing component, one training program per year will be offered for each of the five years. Each training session will include a maximum of 15 participants from the NACs and ARC, and will be subject to strict selection criteria. Training in the first two years will be held in the United States (in French), and in each subsequent year in Niamey. Selected trainees from the first two sessions will

serve as instructors (working with expatriate training staff) in the last three annual sessions. At such time as a final decision is made regarding the location of training, a waiver for 935 training will be sought if appropriate.

The principal outputs of the projects are:

For the data processing system, an efficient, fully operational system of hardware, software, peripherals and communications links which is adequate for all system data processing requirements and is reliable and cost effective.

For the remote sensing component, processed Satellite images, statistical and graphical interpretation packages provided to NAC's, and regularly produced vegetation indices and other crop condition assessment indicators.

Trained staff in computer maintenance software development, electronics and other equipment maintenance; up to seventy five Sahelian NAC staff members trained in remote sensing methods and interpretation.

Improved national communication links via provision of SSB radios in each country.

3. Critical Assumptions

The belief that the proposed Phase III AID project can be successfully implemented is premised on several critical assumptions. These assumptions are organized below under the following headings: "Within the AGRHYMET Program" and "Outside the AGRHYMET Program."

Within the AGRHYMET Program:

That France will carry through on its commitment to construct the AVHRR receiving station in Niamey, and will provide the technical expertise necessary to receive the data and put it on diskette in a form which is compatible with the NOAA/AISC format.

That trained Sahelians as specified in Table I.2 are currently available to work with the proposed remote sensing agrometeorologist and software specialist in order to produce regular bulletins based on the AVHRR data, and with the data processing Technical Manager to support the AGRHYMET computer system.

That WMO and the AGRHYMET Program management will take the lead on redefining the program objectives to put the agricultural production objective in proper focus.

That UNDP funding at each national level program will be sufficient to maintain base operations of data acquisition, collection and analysis.

Given the April, 1987 CAC meeting in Rome, there would appear to be sufficient progress on each of the above points to allow AID funding to proceed as scheduled.

Outside the AGRHYMET Program

The critical outside assumption for the program to be economically viable is that the agricultural research community in the Sahel will, over the next fifty years, make important advances in research based on improved climatological data and information, and that agricultural extension communities will be able to reach 15-20% of Sahelian farmers with such improvements in the coming decades. As the economic analysis shows, the program will be economically viable even with a very slow initial adoption rate, which is thought to be conservative.

Having performed the analysis, however, it may be extremely difficult, even in hindsight, to determine if the percentage of the increased yields brought about in the Sahel attributable to agrometeorological and climatological information is sufficient to justify the program. Prospectively, it can certainly be judged that AGRHYMET generated data will increase the chances that agricultural productivity increases will be developed and implemented.

C. Major Program Design Issues and Their Resolution

1. AGRHYMET Program Objectives

The terminology used to define the mandate of the AGRHYMET Program is not as precise as the terminology used in USAID project designs. Specifically, AID makes the distinction between "Goal" and "Purpose," the former being the overall aim to be supported by the program and the latter being the operational objectives to be achieved. In the initial mandate defined by the Heads of State of CILSS member countries in 1974, the development goal to be supported was increased food security in the Sahel via long-term contributions to increased agricultural production in the region. The specific objectives were to collect, analyze and disseminate

agrometeorological and hydrological data which could be used to strengthen rural production systems in the region (including agriculture, herding and other current or potential productive activities) and to provide early warning of crop yields in a given year.

Over time and with the worsening food situation in the Sahel, the development aim of the project (increased food production and security) and its operational objectives have sometimes been given equal status as program "objectives." While most documents continue to make the appropriate distinction between "development objectives" and "immediate objectives," some do not, and many donor and national participants appear to have failed to realize the importance of the distinction. In every country visited by the Project Paper Design Team (with the exception of Niger), responsible members of UNDP, AID and National Government staffs expressed at least some disappointment that there were no agricultural production increases to which the AGRHYMET program could point after ten years of operation. In AID terms, the "goal" was treated as though it were the "purpose." In all cases observed by the Team, the more senior the commentator, the less sharply the distinction between goal and purpose was drawn.

Not surprisingly, this widespread interpretation of the program purpose has led to increased emphasis on agricultural production increases as an immediate objective. This appears to be having the following effects:

> Both donors and national participants are confused about what the program should attempt to do.
>
> There is a shift in funding flows, with a higher proportion of financial resources going towards production-related activities (the Department of Agrometeorological Applications, the pilot projects, efforts to transmit real time information to farmers, etc.).
>
> Human resources at the meteorological and hydrological services have been increasingly allocated towards directly agricultural efforts, and these services are under increasing pressure to cross institutional lines into agricultural production/extension. Despite sometimes excellent efforts, this task may be inappropriate in the long-run.
>
> The AGRHYMET system is being widely judged by the wrong criterion: direct impact on food production. The timeframe against which this criterion is applied is consequently far

shorter than is realistic, with little appreciation of how consistent agrometeorological and hydrological data can contribute to the long-term development of the region.

The AGRHYMET system itself has responded to the pressure for visible production impacts by justifying its existence in those terms. Therefore, by consensus between funders and recipients, the program is being judged too strongly against a criterion which, when applied, reasonably gives AGRHYMET lower priority than other projects which have a more direct and immediate production impact.

The "operational phase" of AGRHYMET -- as Phase III is intended to be -- is widely interpreted as being the phase during which the program directly reaches the farmer. The claim that the system can or should do so has in fact caused sufficient skepticism that funding has been in jeopardy for several national programs. In short, being judged a failure by an attractive criterion has been more harmful than it would have been to be judged successful by the correct criterion.

Finally, and most importantly, the consequence of emphasizing the production objective has been to fail to emphasize the strongest argument in support of the AGRHYMET program: that it will be impossible, in the long-run, to make significant advances in agricultural research and productivity without high quality meteorological and hydrological data. This argument, which is the most credible reason to support the program, is therefore not being factored into priority-setting and funding decisions. 1/

1/ As this document was being finalized, the Executive Committee of the AGRHYMET Program formally changed the Agricultural Production Objective in response to the recommendations made by USAID/Niamey and the Project Paper Design Team. Through this very positive and decisive action, the Executive Committee has reformulated the objective to clarify that AGRHYMET will not directly improve agricultural production, but will do so through the impact on agricultural research/extension of the long-term data the system produces.

This set of underlying issues is the backdrop for the initial (as of January, 1987) unevenness in UNDP support of national programs:

> In Burkina Faso, the UNDP contribution to Phase II was $700,000. The planned Phase III contribution had been reduced by 20%.
>
> The initially planned Phase III UNDP contribution in Mali was one-third of the Phase II contribution.
>
> The UNDP contribution in Senegal was similarly set at one-third of the Phase II level.

Only in Niger, where the Multi-Disciplinary Working Group has been less active than in any of the other three countries, had the contribution been increased, from $720,000 in Phase II to $1.1 million for the coming phase.

As the funding situation existed in January 1987, the AGRHYMET system was a chair with legs of very different lengths, reflecting divergent understandings of what the program is about. In each UNDP office visited (except Niger), the desire to see tangible agricultural benefits was cited as one of the reasons for being unwilling to continue to support operating budgets of the meteorological and hydrological services (other major reasons included overall funding constraints and national government priorities within those constraints). Yet there is strong evidence that UNDP contributions to national programs are essential to the base line operations of these services. The meteorological service in Mali has been able to attract a sizable government contribution to its operating budget (due largely to a very active and successful involvement in monitoring and prediction activities during the growing season), but this is not the case in other countries.

In Senegal, the government contribution to the non-ASECNA operating budget (as distinct from the equipment and salaries budgets) is 2 million CFA francs per year -- approximately $6,000. However, the government also makes a counterpart contribution to the UNDP funding in the amount of 13 million CFA francs ($40,000) per year. Reduction of UNDP budgets therefore reduces both the donor and counterpart contributions. There is little evidence that the government is either willing or in a position to increase its non-counterpart contributions to meteorological and hydrological services. These contributions have, if anything, been under downward pressure for overall budgetary reasons. It is difficult to determine if this reflects a lack of government commitment to this area or the simple inability to fund investments in

future security in the face of overwhelming short-term difficulties. Certainly, even if the former were not an obstacle, the latter would be.

If the purpose (immediate objective) of the program is to collect, analyze and disseminate data and to strengthen the national services, then donor contributions may have to be used to strengthen operating capacities of the national services, for it is the base line operations and not the pilot projects which directly support the program purpose. The Economic Analysis Appendix (Appendix D), and the Socioeconomic Analysis Section of this Project Paper (Section II.D.) explain in detail why base line meteorological and hydrological information is the key to AGRHYMET's long-term contribution to Sahelian development. Yet operational support of the national services does not appear to be as enticing to donors as direct funding of the perceived "payoff" activities. It is the unanimous opinion of the Design Team that unless operational support to national services continues through Phase III, and probably for some time and at some level beyond Phase III, most national services will cease to play a useful role in AGRHYMET. It is to be noted that without a functional national level operation, the AGRHYMET Regional Center would be completely undercut.

Fortunately, the UNDP itself has responded to concerns about possible reductions and uneveness in Phase III funding by reevaluating each national contribution in light of overall program objectives. The final funding levels, as of April 1987, appear to provide a satisfactory resolution to the problem of national program funding. These funding levels have been established as follows:

Mali	$ 800,000
Burkina Faso	558,000
Chad	1,355,000
Mauritania	936,000
Niger	1,100,000
Cape Verde	473,000
Senegal	747,000
Gambia	583,000

2. Program Design vs. Donor Funding Commitments

During the Geneva CAC meeting of September 1986, several donors pointed out that the WMO Phase III design document, while excellent in technical content and coverage, did not represent an adequate basis for planning Phase III, for three reasons:

- Its agricultural production objectives seemed overly optimistic.

It did not state what the program would cost.

It contained insufficient guidance as to which elements should receive priority in the event that funding was insufficient to implement the whole design.

The strategy for using this document, as explained in recent meetings with a WMO representative, is to have various donors fund portions of the design, with a view to obtaining total funding in increments. Two issues required donor attention in this context:

Who should have lead responsibility to ascertain which portions of the designed program have or have not been funded and to solicit donor contributions for the outstanding elements? WMO is the obvious candidate for this task, but must explicitly accept this responsibility.

If, as now seems likely, the entire designed program cannot be funded, at what point should it be redesigned to reflect priority allocation of available resources?

In order to assure that the AGRHYMET program focuses on what funding/design gaps may still remain, AID requested that WMO update the status of funding from each principal donor. As of the April 1987 CAC meeting in Rome, WMO was able to establish the funding levels shown below:

PLANNED DONOR CONTRIBUTIONS TO AGRHYMET PHASE III
(In Millions of U.S. Dollars)

Donor	Contribution	Est. Pct. of Total
United States	$ 9.000	24%
France	7.400	19%
Italy	10.000	26%
UNDP	6.552	17%
Belgium (Est.)	0.800	2%
Holland (Est.)	1.000	3%
EEC (Est.)	2.500	7%
Other	.800	2%

Dutch, Belgian and EEC contributions are not yet firmly known, and have been shown for indicative planning. WMO gave formal assurance at the CAC meeting that a final Financial Plan which includes all donor contributions will be distributed as soon as outstanding donor commitments are known.

The following points regarding donor funding are noteworthy: a) The French contribution is clearly defined and directly complements AID efforts, b) UNDP contributions to each national project are substantially higher than originally anticipated -- partially in response to concern expressed by AID and other donors, c) The Italian contribution is both in need of further definition and of better integration into overall program objectives. Italy has, however, agreed to fund the very important study of telecommunications options required for upgrading regional communications networks; and d) the EEC has expressed strong initial interest in funding implementation of a telecommunications system based on the meteosat satellite.

The above information provides an adequate basis to believe that critical program components are covered, and to proceed with AID Phase III support.

As a further indication of the CACs commitment to establishing a coherent planning/budgeting framework for Phase III, the April 1987 CAC meeting mandated that the Program Management Study, which is to take place in late 1987, review all aspects of planned management structures in light of these funding commitments.

3. The Telecommunications Problem

Like an electric motor which, no matter how well designed and executed, cannot function without electricity, the AGRHYMET Program cannot function without the telecommunications links necessary to transmit data and other information. Existing telecommunications links in the Sahel are insufficient to support program operations. The problem exists at two levels: first, data must be transmitted rapidly from field observation stations to the NACs; second, integrated national data must be sent from NACs to the ARC and processed national and regional data and information must be sent back from the ARC to the NACs. This information must move quickly and reliably, at a cost which the system can sustain.

In the near term, there is little prospect that Sahelian telecommunications infrastructure will improve to the point of making this possible. Yet many (if not all) of the options for upgrading regional telecommunications via AGRHYMET funding are much larger undertakings than the program can economically justify.

Telecommunications bottlenecks could become an increasingly serious handicap as the program enters its operational phase. Crop yield assessments, for example, are of little value if received a month late.

With respect to transmission of data from field stations to NACs, Single Side Band Radios provide a limited solution which can work in several countries. Other potential options include using police or military communications facilities, as is being done in Burkina Faso.

Transmissions between the ARC and NACs currently use the ASECNA (aviation) lines, but this has proven slow (AGRHYMET data gets low priority on available lines), often unreliable and does not permit computer-to-computer links. Commercial telex lines have also been used, but are very costly, unreliable and have a number of other technical disadvantages. One recent proposal appears promising, and is currently being investigated by AGRHYMET: there may be an available channel on the new Meteosat Satellite, which, if rented by AGRHYMET, would permit transmission and reception of information via relatively inexpensive transmitters and reception disks which could be placed in each country. This would permit direct transmission from one computer to another, and would occur instantaneously. If this option proves feasible, it would probably cost from $1 to $2 million to make operational.

At the Rome CAC meeting, the following new information was made available to participants:

> After extensive technical discussions, it is now believed that the proposed meteosat solution is a viable/cost effective option.
>
> Several additional technologies are worth testing for even lower cost one way data transmission links for in-country needs.
>
> Italy has agreed to finance the full feasibility study necessary prior to implementation of the proposed telecommunication option.
>
> EEC has expressed willingness -- subject to final authorization after the Italian study -- to finance implementation of the upgraded telecommunication system.

4. Definition of Program Products and Beneficiaries

It is generally agreed that the direct beneficiaries of the AGRHYMET program are the national meteorological and

hydrological services and MWGs directly funded; the farmers on the pilot projects who receive additional extension support and increased crop yields; the Niamey ARC; and, finally those national government and research organizations which will have access to improved agrometeorological and hydrological data. It is also generally agreed that rural populations will indirectly benefit from improved crop yield forecasting, insofar as it helps governments and planning agencies better anticipate and coordinate food aid needs in times of shortage.

At issue is whether and how farmers and herders will benefit in terms of increased production. To answer these questions, it is necessary to examine what products the program can reasonably provide. It should be recognized that any attempted answer may be controversial, as there are competing schools of thought. The discussion below is supported by more detailed analysis in the Agricultural Technical Annex (Annex B, Part III).

The distinction is made for this discussion between "agrometeorology" -- relating to day-to-day weather occurrences -- and "agroclimatology" -- relating to overall climatic conditions. After review of the existing pilot projects and discussions with both national service (meteorology, hydrology and agriculture) and expatriate personnel, the Design Team believes that the primary impact of AGRHYMET on agricultural production, especially in the short- to medium-term, will occur through agroclimatological rather than agrometeorological impacts. This derives from two subpoints:

> Better meteorological and hydrological data can substantially improve the capacity of the agricultural community to manage crop production given climatic conditions in the Sahel. Such potential improvements are substantial and are not necessarily obvious to agricultural planning or extension personnel or even to researchers. The very sizable yield increases achieved in the Mali pilot project can be attributed both to better agronomic practices and greater extension support and to improved agroclimatological management.
>
> AGRHYMET does not now have, nor is it likely to have in the <u>near</u> future, a cost-effective means of generating locally-specific agrometeorological information which can be transmitted to farmers in real time. Specifically, localized predictive information (such as rainfall forecasts) is not yet available and there is no <u>replicable</u> means of transmitting such information to farmers with sufficient speed for it to be of use. The current pilot projects suggest

that the provision of real time agrometeorological data is not critical to achieving yield increases. Therefore, the difficulty associated with timely transmission of such data may not be as great an obstacle as was originally believed.

These observations do not imply that day-to-day predictive information is of no value. Indeed, if it were available and if it could be rapidly transmitted it would be extremely useful, as it is in many industrialized countries. However, it makes little sense for AGRHYMET to base its entire strategy on providing such information given infrastructure realities in the Sahel and given that agroclimatological information, which need not be transmitted in real time, is still not being fully exploited.

This understanding of the impact of improved data on agricultural production systems is consistent with the view that the principal product of the AGRHYMET system is sound, detailed and timely information and analysis, compiled in a manner which is accessible to researchers and production agents. This data must be geographically specific and be available for long time periods. It is noted that in the United States, Australia and other developed agricultural systems, it would have been impossible to make the advances in farming systems research which have resulted in the most spectacular yield increases in the absence of sound data of exactly the type which AGRHYMET can and does generate.

Every staff member of agricultural production projects (national and expatriate) interviewed by the Team stressed that good meteorological and hydrological information was of vital importance to their programs. This set of individuals includes the Director of Operation Haute Vallee in Mali, the Director of Agriculture in Senegal and the principal personnel of the River Basin Development Office at USAID/Dakar, among others.

Early warning of crop yields is a subset of better information flows. It differs from other information gathered and analyzed by the AGRHYMET system in that the role of the ARC is relatively more important in primary data acquisition and processing, and the role of the national centers relatively greater in data interpretation, which is a reversal of the relative roles in other data produced by the AGRHYMET system.

However, for crop yield forecasting, as for the other data produced by the system, the Sahelian farmer is not a direct recipient of data, nor is he a direct beneficiary. In the long-run, however, rural populations will benefit because of the improved decision making at the policy level which better data allows.

In sum, both for activities in support of agricultural production and in support of crop yield forecasting, information does not have to flow to farmers in real time for the program to make a valuable economic contribution.

5. Regional vs. National Roles in the AGRHYMET Program

It is a misconception to think in terms of national vs. regional levels of AGRHYMET. In fact, the system is a pyramid consisting of a large base of local data acquisition points, each of which feeds into an appropriate national data collection and synthesis level. The eight (soon to be nine) national level entities are further linked at the regional level via the AGRHYMET Regional Center in Niamey.

In principle, each level in this pyramid can play a function in information collection, synthesis, analysis and transmission and each level can also potentially play a role in policy formulation and implementation. How data flows within the pyramid -- upward, downward and laterally -- and the role of each level in specific types of data flows, is a function of the relative capacities at each level and of the objectives of the data flow.

a. Local Level

Primary level for collection of meteorological and hydrological data. Transmits data to national center. Data transmission now severely hampered by lack of telecommunications. Development of local data collection points highly uneven.

b. National Level

Receives and synthesizes local data. Performs some data analysis. Interprets data in relation to other national parameters (such as within geographic information systems, etc.).

Transmits national level data to ARC and to other national level users (planning agencies, extension services). Telecommunications infrastructure now an obstacle to this task.

Receives regional meteorological and hydrological data from ARC (covering all countries). Receives data analysis, methodologies and support from ARC.

Receives AVHRR satellite data from ARC. Interprets data using ARC-supplied software and methodologies. Transmits data and analysis to other national institutions.

c. AGRHYMET Regional Center

Receives national data. Compiles, synthesizes and analyzes data from all national centers. Develops methodologies and maintains data bank. Coordinates agrometeorological research by working with existing agricultural research organizations and analyzing the implications of AGRHYMET data for rural production systems in the Sahel.

Transmits regional data and analyses to national centers and to other users within and outside the region.

Collects satellite data. Transmits satellite data, analyses and analytical support to national centers and to other users. Telecommunications infrastructure obstacle to this and above task.

The Management Study to be conducted before the next CAC Meeting will make an important contribution to clarifying roles and responsibilities at each level of the program, particularly in light of recent clarifications of Objective 3.

The logic of these roles and of the program objectives discussed in Section I.B.1. above suggest that the primary focus at the national level should be on receiving and organizing information obtained from the local level. This can be accomplished with relatively simple hardware, particularly given the evolution of computer technology. Given the extremely scarce financial resources which will be available at national centers in the absence of donor support, these centers should avoid both expensive hardware and development of an independent programming and software development capacity, neither of which will be sustainable in the long-run.

The Regional Center possesses the financial economies of scale and the intellectual critical mass necessary to develop a regional data bank (involving more sophisticated computer systems), to receive and process satellite data and to develop analytical methodologies needed to support national level operations. Moreover, it is through the Regional Center that the primary link can be maintained between the agricultural research community and the set of data and analyses developed by the AGRHYMET system.

6. Relationship of AGRHYMET to Early Warning Systems

The crop condition assessment efforts of the AGRHYMET Program constitute extremely valuable inputs into the national efforts to provide early warning of potential food deficits in the region. The remote sensing imagery and vegetation indices supplied by AGRHYMET are being used in several countries visited by the Project Paper Team, both by the MWGs and by other agencies involved in food planning and relief.

Wider regional Early Warning System (EWS) efforts will also rely heavily on the kinds of information AGRHYMET can provide. However, as pointed out in a recent memorandum on the subject (Hradsky, 1985) the EWS effort requires greater coordination, focus and integration with operating entities. An expansion of AGRHYMET's role in this project is currently hampered by several factors:

> Effective coordination with other institutions involved in EWS remains weak, although it is improving.
>
> The number and range of crop condition assessment products emanating from the program creates overlap with efforts being undertaken elsewhere and dilutes the quality and value of each product.
>
> The products which consume the greatest human and financial resources to produce (such as the ten day bulletins on rainfall) are not necessarily the most useful. There has been little systematic effort to establish priorities and focus on a limited number of products which can be effectively produced and which are useful to major clients.
>
> Some controversy persists within the scientific community as to the most appropriate methodologies and measures to use in crop condition assessment.

Over the past twelve months, it has become increasingly obvious that the ARC provides the infrastructure, analytical capacity and repository of data necessary to support several other major initiatives in the region. Perhaps the most important advantage AGRHYMET affords, however, is the working institutional arrangements between NACs and the ARC.

This overall capability has already been identified in the current AID-sponsored Famine Early Warning System (FEWS) project design effort as being able to rapidly supply remote sensing data, imagery and vegetation indices to each Sahelian FEWS country. The computer facilities and data bases developed at the ARC are also an efficient means of developing the in-depth resource analysis and monitoring effort on which FEWS seasonal warnings must draw from baseline information. While in the earliest stages of project design at the time of this Project Paper, it is currently anticipated that the yet to be defined FEWS project will play an active role in the remote

sensing component of the AGRHYMET project (selection of special TA, coordination of early projects, development of geographic information system, and use of AGRHYMET data within the U.S. Government).

Similarly, the ARC provides an excellent venue for the monitoring of agricultural, rainfall and other parameters which can give early warning of potential pest infestations -- including grasshoppers. Because the multimillion dollar AID effort currently underway for grasshopper control must rely on timely identification and treatment, AID funds spent in this area will be usefully leveraged by drawing on the ARC's continuous monitoring capability.

Finally, WMO, FAO and World Bank are currently planning projects for which the ARC can serve as a regional coordination/analysis center.

In all of the above efforts, it is important that protocols be developed which allow the Center to serve as a resource without itself being taken over by the objectives of each new project. Specifically, such projects, if properly managed, can become "clients" who help defray the recurrent costs of AGRHYMET's base activities, rather than causing an explosion of in-house staff which cannot be sustained after 1991. The planned Management Study should pay particular attention to articulating a strategy through which AGRHYMET can expand its support to larger regional efforts in EWS without losing focus on its primary objectives or creating unwieldy and unsustainable institutional structures.

D. Relationship to RDSS and Development Priorities

The relationship of the AID-funded project to the RDSS and to regional development priorities can best be judged for each component of the project.

1. Data Processing System Support

This project component will provide hardware, software and analytical support to the computer operations of the ARC and the national centers. While computer operations per se bear no direct relationship to either the RDSS or development objectives, the justification of this component is found in the program objectives which it helps further. The computer system at AGRHYMET is essential to compiling, organizing and analyzing meteorological and hydrological data, and to establishing methodologies to link this data to research on improved agricultural production in the region. The goal of improved data and analysis in support of agricultural production is central to the entire philosophy of the RDSS.

2. Remote Sensing Systems Support

This component will provide technical assistance, software and training in support of crop monitoring and yield forecasting efforts, which in turn feed into regional food deficit early warning systems. This effort ties directly to the food security objective of the RDSS and to the widely shared priority (both within Sahelian governments and among donors) for having timely information on the intensity and distribution of impending food shortages in the region. The Secretary General of CILSS has stated publicly that AGRHYMET is the highest priority project in the CILSS portfolio, and the early warning objective in particular has received the strong endorsement of all member Heads of State. AID and other donors have recently initiated a number of related projects, many of which link to AGRHYMET, to improve the speed and accuracy of efforts to forecast food needs and potentially available supplies.

II. FEASIBILITY ANALYSES

A. Technical Analysis

1. Data Processing System

In concise form, Phase III objectives of AGRHYMET data processing have been identified as follows:

a. To minimize recurrent costs during Phase III.

b. To provide a reliable system at all sites.

c. To build a sustainable system beyond Phase III.

d. To meet or exceed processing requirements, leaving room for growth.

e. To design an upgrade schedule which anticipates advances in technology.

f. To choose technology appropriate for the region.

Program Versus Project Sustainability

At the ARC, continued donor support may be needed beyond Phase III in order to sustain the data processing system. Such support need not come from the United States, however. Irrespective of whether post-Phase III support comes exclusively from CILSS or from a combination of regional and external sources, the ARC data processing system cannot be sustained past 1991 unless configurations currently in place are progressively changed during the next five years. The central change to be made is to shift from reliance on a single, relatively old and expensive to maintain technology (VAX 780) to a more flexible and lower recurrent cost system.

Similarly, the national services can function without donor input after 1991 only if data processing systems in place are simple, flexible and require extremely low recurrent costs.

Major Project Funding Options

Four major options were considered for the data processing system:

1) Total withdrawal of AID support at the end of Phase II.

2) Minimum funding to complete the Phase II objectives.

3) Continuation of current funding levels based on existing Phase III implementation proposals.

4) Shift to more flexible, lower recurrent cost design.

These options are discussed in detail in the Technical Annex to this Project Paper. Option 4 is recommended for the design of Phase III, for the following reasons:

Total withdrawal of AID support would cripple the data processing system for from several months to several years. During this period, early warning activities, methodology development and data compilation and analysis would be seriously hampered. Financial and human resources already committed by Sahelian countries, by CILSS and by other donors would be wastefully underutilized.

Minimum funding to complete Phase II objectives would be a viable, if not desirable, option if the system currently in place were fully functional and cost effective. However, in an optimistic scenario, the current system can only be made fully operational with considerable further expenditures on training of maintenance personnel. In a less optimistic case, the current system may never be fully functional because it is too complex and relies too heavily on old technology. In either scenario, the system transferred to the Sahel would be one which is largely outmoded, not compatible with a broad range of useful software (national level systems) and very expensive to maintain (at all levels).

Continuation of current funding levels based on existing Phase III proposals suffers from most of the same drawbacks which apply to Option 2 above and is considerably more expensive than the system proposed here. The system as currently conceived is not sustainable and may not be feasible. Technology advances have made newer, cheaper, more compatible and easier to maintain systems available which are better suited to the Sahelian environment and to program objectives.

The recommended option, design of a more flexible and lower recurrent cost data processing system, is discussed below.

Recommended Design

The largest recurrent cost in the current data processing system is maintenance. Single, large systems have astronomical repair costs if up-time is to be kept near 100%, especially in West Africa.

In a new design, total redundancy is not cost effective, as either the standby system is a waste of resources 95% of the time, or the demand for computing resources requires regular use of the standby system and redundancy is lost. A better design calls for the use of modular systems, with a single module specified as large enough to accommodate the largest processing task and enough modules specified to accommodate a normal demand for processing capacity. A single modular failure will no longer cripple the entire system, and the urgency of repair is significantly lowered. Repair costs can be kept within budget and up-time (of enough modules to perform all critical functions) can approach 100%.

For the NACs, simple, reliable and inexpensive data processing solutions are essential. Personal computer "modules" are serviceable and supportable locally in many capitals, reducing the need for expensive maintenance staff training and/or regional staff travel to backstop local personnel. Even where local repair is not available, parts are inexpensive and easily replaced. Microcomputers are so much cheaper than existing computers in NACs that even if large components or entire machines are replaced it is less expensive than maintenance training and maintenance travel by ARC specialists. In addition to the cost and maintenance advantages discussed above, modern microcomputers provide at least as much or more power and capacity than the older machines now in use (PDP 11/34s).

Regional Center Data Processing System

Data processing implementation can be divided into three stages for purposes of discussion. The first is the current capability at the ARC. The second is the additional capability provided when the VAX 780 becomes operational. The third includes how the center evolves until the end of Phase III to satisfy the major criteria of reliable, adequate data processing capacity with a minimum recurrent cost.

The older technology Digital Equipment VAX 780 (non VLSI) does not meet any of the major criteria of this design as it is currently configured. One of the major rationales for its

purchase was a future capability to cluster a group of 780s to permit versatile sharing of main memory, disk and input/output between elements of the cluster. Until recently, the 780 was the only processor that was compatible with current software and storage devices at the center and could be clustered. Current minicomputers can provide a clustering capability with new technology that is 90% of the capacity of a 780 for as little as 20% of the cost of a 780.

The cluster concept provides reliable, cost effective central processing capability with the ability to add additional elements as processing requirements dictate. An Ethernet local area network can be used to interconnect the minicomputers, terminal clusters and personal computers throughout the center complex at Niamey. Major mass storage can be either distributed among "cluster elements" or concentrated on one "file server" processor.

An important criterion in equipment selection should be compatible hardware and software networking between multi-user systems and the MS DOS-based personal computer that provides most of the communications, mass-storage sharing and file transmission capability that is required at the regional center.

National Centers Data Processing System

The Digital Equipment PDP 11/34 multi-user system installed in six of the eight countries has proven to be an unsupportable and inappropriate technology for the national centers and cannot support most of the software applications that are required.

A small number of personal computers, some with multi-terminal capability to support data entry, stationed in each of the active MWG ministries will better serve the users. Each of the systems will be tailored with software, mass-storage, and special peripherals (plotters, digitizing tablets, and color displays) to match the needs of the specific ministry. The 80286-based or PC-compatible personal computers can be serviced locally in a number of the capital cities, and the distributed nature of the configuration eliminates any critical single point of failure, an absolute necessity to contain recurrent repair costs.

Programmers at the ARC are already developing applications that run on personal computer spreadsheets and have studied the feasibility of transporting the "SUIVI" water data bank software to MS DOS. Data Base Management software is commercially available which will run on ARC computers and NAC personal computers.

Data communications costs within the national capitals remain a serious reliability and cost problem. However, short and periodic data transmissions between personal computers can be made much more reliably and cost effectively than that required by terminals located in divergent ministry buildings connected to a central timesharing PDP 11/34. One or more of the personal computers will be designated the data collection and regional communications processor and will have to be connected to the telephone, telex, GTS, or satellite system.

System Configurations

Regional Center

The building block of a redesigned ARC processing system is the cluster element, or minicomputer. Two or more cluster elements would form the network that would support a growing demand for computing and data communications between staff at the center.

An increasing role for MS DOS-based 80286-based personal computers is expected, and such systems are already being provided increasingly by the donor countries of the various experts at the center. The cluster network must be available to these systems to increase the ability to share data and ideas among staff. This would be accommodated by Ethernet interfaces on each PC, integrating them into the cluster network and making available extensive MS DOS support tools in cluster elements.

It is envisioned that up to four cluster elements (i.e., minicomputers) will have to be phased in to satisfy computing demand over Phase III. It is also expected that the cost of each cluster element will decrease over time. At current prices, a cluster element is estimated to cost $125,000, including software and spare parts.

The Phase III budget includes sufficient allowance for these cluster elements plus other required equipment specified in the Technical Annex, including a digitizer and plotter for mapping and geographic information systems.

National Centers

System Configuration #1 (Hydrology application: water budget and report generator)

One of the most important modules that must be installed as soon as possible. Software can be adapted and operational very early through the use of simple but advanced applications development tools, such as the spreadsheet.

System Configuration #2 (Meteorology application: Image Processing)

The second most important module, requested by the national services to display and manipulate remote sensing satellite data currently available from the US and eventually available from French furnished facilities at the ARC.

System Configuration #3 (Hydro and Meteo application: Data Base Management)

The system which will take the most development work and may have to be deferred to later in Phase III for this reason. While it can be built upon a number of existing software packages, including database management, spreadsheet, statistical and word processing programs, system configuration and methodology will be specific to the needs of the NACs, and must also be compatible with systems developed for other NACs and the ARC.

System Configuration #4 (Meteorology application: Models)

This is the one module which need not be developed quickly because applications software (the SUIVI Chain) is now available which can run on the PDP 11/34. However, before the PDP 11/34s are phased out, a new PC-Compatible module -- which is likely to be an adaptation of the existing SUIVI software -- must be put in place. Because some countries do not now have PDP 11/34s, early adaptation to PCs of the SUIVI chain may be called for if national needs warrant it.

The total estimated per country costs for implementing the full set of configurations outlined here is approximately $66,000, inclusive of all software, hardware, connections and related supplies. Detailed breakdowns of equipment needs are provided in the Technical Annex.

The recommended implementation schedule for installation of the cluster elements and MS-DOS-based systems at the regional level and for installation of the five configur tions at each NAC is summarized in Section III.A of this document (Table III.1).

The total cost of the recommended data processing system, inclusive of hardware, software, supplies, maintenance, long- and short-term technical assistance and support and management, are integrated in Table II.1 which also summarizes the

cost of recommended support by USAID to the crop monitoring/ remote sensing component of the project.

Technical Assistance Needs

Technical assistance needs for the data processing system are summarized in Section I.B.2. and in Table I.2, and costing is included in Table II.1.

Training Needs

A major difference between the recommended design and current project operations is the reduction in long-term training costs. To date, long-term training has been anticipated for two hardware specialists and one software specialist in each country, plus several additional trainees who are to work at the ARC. A typical current training program involves one year of English language training and two years of technical training in the United States. Average training costs (from start to finish, including some on-the-job training) are estimated at $125,000 to $150,000 per person. The retention rate has been a little over 50%, implying an effective cost of $250,000 to $300,000 for each specialist trained and retained. Experience with returned trainees suggests that many need continued support and one or more years of work experience before they have an independent capability.

Built into this system is the need for continued training in future years, as skilled individuals are promoted, transferred or hired away by the private sector. Even for those original trainees who remain in place, rapidly changing computer technology will require further specialized short courses from time to time.

Therefore, two hardware specialists placed per country will require that four be trained (50% average retention rate), at a total cost of $150,000 x 4 = $600,000, plus periodic renewal and refresher courses.

This level of maintenance skill is only necessary to maintain mainframe systems (the VAX 780) or equipment such as the PDP 11/34s or similar machines. The PDP 11/34s have proven too complex to use or maintain in the Sahel, and more modern microcomputers have equal or greater capacity, cheaper and better preexisting software and much lower purchase and maintenance costs. While manpower training and skills transfer have merit in their own right, it seems excessive to spend $600,000 and to lock into high recurrent costs in order to maintain equipment which could be efficiently replaced with machines costing $10,000 or less. Scarce training resources may be better devoted to more urgent skills, either within AGRHYMET or in other priority sectors such as agriculture, health, economics, etc.

The proposed design, by substituting microcomputers for existing machines, and substituting preexisting spreadsheet, database, statistical and word processing microcomputer software for tools which would have to be specially developed for the PDP 11/34s, reduces both hardware maintenance and software training from multi-year formal courses to a series of tiered training activities, ranging from six week formal off-site courses to one week, on-site orientation sessions and user support groups. This approach is both more cost-effective and has proven itself to be efficient in similar applications in the United States and other industrialized countries. The specific training requirements are summarized in Section I.B.2 and are further discussed in the Annex B of this Project Paper.

2. Remote Sensing Component

This component will provide the basic technical assistance and training required for the AGRHYMET system to interpret AVHRR satellite data, to calculate and use normalized vegetation indices and other measures of vegetation status, to refine interpretation methods, to develop simple user friendly software packages which permit broader application of the NVIs and other results of the remote sensing information and to transfer the skills necessary to the use and interpretation of satellite data to ARC and NAC staffs.

The AID financing for this component will complement two on-going activities financed outside the AID system. France has financed and begun construction on placement of an AVHRR receiving station in Niamey which will permit the ARC to receive daily satellite data from the NOAA (U.S.) satellite in real time. France has further committed to provide ARC with the technical assistance necessary to put this data on diskette in a format consistent with the current NOAA AISC system requirements (using the U.S.-supplied ARC computer facilities). The French effort is scheduled to be fully operational by March 1988. While France has committed to this effort and has begun implementation, the utility of the contribution is linked to the assumption that some other donor (presumably the United States) will provide the forward linkages proposed under this funding component.

Simultaneously, the ARC is using staff trained by NOAA/AISC, with the assistance of a resident expatriate advisor, to perform crop condition assessments based on the AVHRR data, NVIs and satellite imagery now being provided by the United States. ARC expects this cadre of trained Sahelian specialists to bear the main burden for ten-day assessments and crop yield forecasting using satellite data. Again, this expectation is premised on the assumption that the United States will provide the hardware, technical assistance and training required to make the overall system operational.

In late 1986, AID commissioned an expert panel assembled by the National Academy of Sciences to evaluate the scientific validity of remote sensing methods used by NOAA/AISC in crop condition assessment in the Sahel. The panel identified several areas in which the NOAA methodology would benefit from refinement or revision. It also suggested that, within the limitations of statistical and ground truthing information available in Africa, crop monitoring via satellite may be of more limited value than in other parts of the world.

Because of the importance of the remote sensing component to AGRHYMET's early warning efforts, the program should have access to the best available methodologies. Therefore, the project design provides funding for a comparative evaluation of available remote sensing techniques to be carried out, ideally in the summer of 1987. This evaluation, to be conducted by a group of specialists in the field, will help establish the consensus around which future AGRHYMET remote sensing activities funded by USAID will be organized. Because of the urgent need to initiate this study before the Phase III contract begins, funds for this study will be held outside the Phase III contract.

Technical Assistance

This proposed component of the SWD&M III Project calls for provision of two long-term resident technical advisors:

> A Satellite Data Analysis Programmer for 42 months, commencing in month 1. This advisor must be a qualified programming specialist familiar with microcomputer technology and with available software packages for database management, spreadsheet, mapping programs and lower level programming languages (basic, Pascal, etc). He/she need not have a degree in computer programming, but should have a technical graduate degree (Masters or above) with at least five years experience in programming and computer program design and development, preferably in a natural resources-related field. Developing country experience is highly desirable but not essential. Good French language reading and speaking is required (FS 3), especially for counterpart training and training of NAC staffs in software applications.
>
> A senior Satellite Data Use Specialist for 36 months, commencing in month 12 and ending in month 48. This individual should have an advanced degree in agrometeorology or some closely related discipline, with specific expertise in working with satellite data on

agriculture, natural resources and meteorology. She/he must be fully conversant with satellite and computer technology uses for agrometeorology, and should have proven experience in biomass/vegetation assessment methodologies and program development. Long-term developing country experience is highly desirable but not essential. FS 3 French speaking and reading skills are required.

A total of 26 person-months of short-term specialists will be required to provide focused technical support to the assessment and skills transfer activities being conducted in the field. This technical assistance will be largely in statistics, crop yield monitoring, photointerpretation and other specialized assessment techniques.

Training

Annual training courses are recommended for each of the five years of the project. The purpose of the training is to thoroughly familiarize participants with the methodology, uses and techniques of the satellite data-based crop condition assessment process, and the create a corps of specialists in each country and at the ARC capable of implementing an operational assessment program. The annual training program will consist of a six week course similar in scope and contents to the course offered by NOAA/AISC and CIAM at the University of Missouri, Columbia.

Up to fifteen Sahelian participants from the NACs and the ARC will be financed each year. The training program will take place in the United States in years 1 and 2, and at the ARC in each of the next three years. It is essential to the success and the cost-effectiveness of the training program that there be strict selection criteria for limiting the number of participants to those with appropriate background and aptitude for taking the lead in future implementation. The recommended training program is also built on the expectation that up to two of the trainees from the first two annual courses can become sufficiently proficient to serve as instructors in subsequent courses in Niamey. Use of some Sahelian instructors and of ARC facilities will reduce training courses substantially in years 3-5.

Equipment

All hardware and most of the software required to offer this component of the project will be purchased under the Data Processing component. Hardware will consist of 80286-based

microcomputers with hard disk at the ARC and each NAC, plus high resolution color monitors and some plotting equipment. Software will consist primarily of off-the-shelf packages for which applications templates (modules) will be developed by resident expert staff. Additional budget is included for consumables and miscellaneous items.

B. Financial Analysis

1. Budget Summaries

Table II.1 contains the Summary Budget for the recommended Phase III project design. The total cost of the program is $9 million. This includes:

- A $500,000 allowance for Mission "buy-ins".
- $900,000 for the nine-month NOAA Phase II extension for project transition and Phase II closeout.
- $80,000 for pre-Phase II contract studies -- specifically 4 person-months for the MBO study and 4 person-months for the remote sensing expert team.
- $600,000 for USAID/Niamey Mission management of the project.
- Approximately $7 million for equipment, logistics, training and long- and short-term technical assistance.

A higher budget option, allowing for increased telecommunications, monitoring of the agricultural pilot projects and further funding of equipment and logistics was also considered but not recommended given AID budget limitations.

The Technical Annex discusses one lower cost budget option, consisting of a lower level of technical assistance and equipment support for the data processing component. This option is not presented here because it is felt that:

1. The lower planned support level could in fact lead to higher actual expenditures because the uncertainty of maintenance costs (and hence their expected value) rises the greater the reliance on the existing "single system" concept with no redundancy.

2. Lowering AID funding over the next five years by reducing the rate of installation of new and lower recurrent cost computer equipment will directly result in transferring a much higher and unsustainable recurrent cost system to the Sahelian countries after 1991, even if actual costs conform to expected costs during this phase. In choosing between short-term cost reduction to AID and long-term reduction of recurrent costs to the Sahel (sustainability), the latter was thought to be the higher priority.

The budget shown in Table II.1 includes a limited number of single side band radios for each country. These radios serve as the principal communications links between field reporting stations and meteorological agencies in the capital cities. For some countries, a larger number of SSB radios will be required if the reporting systems are to functions efficiently. The need for further equipment varies by country, depending on the size and population of the country, the number of reporting stations, the level of access to other communications infrastructure, the state of repair of existing SSB radios and the willingness of other donors and/or ability of national governments to financial such telecommunications devices. In general, the USAID Mission in each country is best placed to determine what national needs for SSB radios are, and if such needs merit priority support by the AID system.

In the same way, a number of specific national needs were identified in the course of the FP design which cannot be satisfied under the principal components of the region-wide project. Such needs may include logistical support, further computer equipment and special studies.

In order to allow the flexibility for each USAID Mission to selectively increase its support in areas it considers critical, without unduly increasing the management requirements on the Mission, the project design includes a "buy-in" mechanism whereby the Missions can place Mission funds in the Project Contract for implementation by the Project Contractor of specific activities designated by the Mission. The budget presented allows $500,000 for eventual Mission buy-ins.

2. Recurrent Costs of the Project

Will the Sahelian states cover at least a portion of the total costs required to keep AGRHYMET in service, or at least enough to sustain a minimum benefit flow? The problem in this section is to determine for the purposes of the economic evaluation (1) factors which will influence the level of

SUMMARY OF COSTS FOR RECOMMENDED PROJECT DESIGN

Remote Sensing Component	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Long Term Technical Assistance	$14,469	$125,880	$154,963	$162,711	$0	$458,023
O/S Allowances, Educ, Housing, Etc	$46,302	$92,810	$110,233	$149,643	[illegible]	$398,988
Travel and Per Diem	$20,935	$76,896	$74,044	$92,263	$0	$264,138
Training	$0	$224,761	$133,129	$119,934	$119,934	$597,758
Consultants	$0	$65,979	$32,989	$32,989	$32,989	$164,947
Other Direct Costs	$41,340	$28,938	$30,385	$31,904	$33,499	$166,066
Subtotal	$123,046	$615,265	$535,744	$589,444	$186,422	$2,049,920

Data Processing System Component	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Long Term Technical Assistance	$32,245	$67,715	$71,101	$74,656	$78,388	$324,105
O/S Allowances, Educ, Housing, Etc	$0	$0	$0	$0	$0	$0
Travel & Per Diem (Long Term)	$20,661	$30,222	$31,733	$40,578	$34,986	$158,181
Consultants	$80,000	$170,000	$150,000	$140,000	$80,000	$620,000
ARC Logistics	$30,000	$80,000	$60,000	$45,000	$35,000	$250,000
NAC Logistics	$40,000	$120,000	$100,000	$80,000	$50,000	$390,000
Telecommunications	$45,000	$50,000	$50,000	$45,000	$30,000	$220,000
Training	$0	$250,000	$200,000	$75,000	$50,000	$575,000
ARC New Equipment	$343,000	$145,000	$50,000	$200,000	$230,000	$968,000
NAC New Equipment	$274,000	$30,000	$30,000	$337,000	$30,000	$701,000
Subtotal	$864,907	$942,937	$742,834	$1,037,234	$618,374	$4,206,286

Table II.1
(Continued)

U.S. Support	Year 1	Year 2	Year 3	Year 4	Year 5	Total
U.S. Support Labor	$19,326	$81,171	$85,230	$89,491	$93,966	$369,184
U.S. Support Travel	$14,469	$15,192	$15,952	$16,750	$17,587	$79,950
Subtotal	$33,795	$96,364	$101,182	$106,241	$111,553	$449,134

Other	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Contingency	$20,000	$50,000	$50,000	$40,000	$40,000	$200,000
Mission Buy-Ins	$0	$200,000	$150,000	$100,000	$50,000	$500,000
Special Studies (MBO, Rem Sensing)	$80,000					$80,000
NOAA Phase II Extension	$900,000					$900,000
USAID/Niamey Project Management		$150,000	$150,000	$150,000	$150,000	$600,000
Total	$2,021,748	$2,054,565	$1,729,759	$2,022,918	$1,156,349	$8,985,340

ROUNDED TO: $9,000,000

recurrent cost support for the project five years after the end of donor support and (2) the impact of various levels of budgetary support upon the operation of capacities installed under the project.

AGRHYMET has included a substantial rebuilding and upgrading of Sahelian weather services and services which make use of weather and hydrological data. The system is also dependent upon crop monitoring capacity. This leaves a legacy of larger staffs needy of more extensive operational support than local budgets may be able to manage. What is the post-project support record on the part of Sahelian countries? The ambitious CILSS study of 1980 (Recurrent Costs of Development Programs in the Countries of the Sahel, CILSS, Ouagadougou, 1980) into recurrent costs found that whereas all projects sustained cuts, some fared much better than others and that a pattern could be found indicating consistent criteria had been applied across all of the Sahelian countries. The findings further indicated that level of outlay, although important was not necessarily the factor which determined survival or not.

Heller 1/ has calculated typical recurrent cost coefficients 'r' for projects in seven sectors using numbers from projects worldwide 2/. Projects having high concentrations of skills are associated with highest 'r', up to .7 (or 70% of the initial investment annually). The CILSS study examined 29 projects in 8 sectors in 7 countries and found that the post-project burden on these countries in terms of skilled staff, claims on scarce resources, and continuing demand for imported goods to be substantial. The average annual post-project cost of operation for agricultural projects was found to be 15% of the value of the initial investment. The highest equivalent figure produced by the CILSS study is .40, -- a rural development project.

An 'r' can be calculated for AGRHYMET at two levels; regional and national. The regional coefficient is the dividend of the installed cost of new equipment, $970,000, which will be all that is operational at the ARC by the end of Phase III and the annual cost of operation of the equipment, post-project, $250,000. This produces an 'r' of .26, which places it firmly in the mid-range of the CILSS study-group. This support level would permit the system to operate at 100%

1/ Heller, P.; "The Underfinancing of Recurrent Development Costs," Finance and Development, 16, #1, 1979, pp. 38-42.

2/ A measure, 'r', is used by financial planners to rank projects with respect to their likely cost in post-project time 'n'. The coefficient is notably sensitive to large use of consumables and need for high quality skills; both of which are characteristics of AGRHYMET.

of installed capacity, but also reflects a level well beyond what it is reasonable for national budgets to assume. A roughly linear relationship is believed to exist between level of support and operable capacity; such that were support to fall by a half, capacity would fall proportionately. Were support of ARC to be divided equally among CILSS members each would have to contribute $31,000 annually, not a large sum in absolute terms, but enormous in the context of the Sahels fiscal problems. Fortunately France is committed to support the technical staff indefinitely, but what of the equipment?

At the national level a somewhat more hopeful long-term outlook can be said to exist. The 'r' for a typical Sahelian country is about .14. This represents the dividend of $100,000 in annual support post-project divided by $700,000 in new equipment provided during Phase III. This 'r' level would support the system at 100% of installed capacity. In this instance the relationship between installed capacity and level of support is not linear but is a five step function reflecting the cumulative impact upon output as each of five computers fails.

The CILSS countries, therefore, will have to provide or find $131,000 annually to keep the entire AGRHYMET system functioning at 100% capacity each year after EOP. It is worthwhile noting that Senegal has found it difficult to manage anything above salaries in recent years (only allocating $8,000 on consumables last year) in the support of its meteorological department. In the case of AGRHYMET the past may not be a fully reliable guide to future public support.

The CILSS study showed a rather poor correlation to exist between post-project support and a project's 'r'; cost alone is not the operative criteria! By order of priority CILSS concerns appear to be technical (as reflected in the quality of the basic design), economic (contribution to economic growth) and financial 3/. Given the essential poverty of these countries this seems surprising, but is explained in terms of fungibility, which is to say money even when very scarce is still allocated subject to some criteria. These criteria appear to include -- perceived technical complexity, implementation problems during the life of the project, import content, importance to the growth process, relationship to proclaimed national objective(s) and identity of beneficiary. Briefly, how does AGRHYMET stand with respect to beneficiaries? With respect to implementation government budgetary planners are likely to focus upon the national dimensions of AGRHYMET, likely the local meteorological service and its ability to produce data. There have been persistent and often computer related implementation problems. Major systems (such

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3/ Unspoken in the report is the always important role of politics, surely a vital and continuing arbiter among choices.

as that in Bamako) may often be down. The very high import content (both in terms of skills and parts) is a serious source of concern. There has been concern that left to their own devices only the exceptional government would be able to carry on even a fraction of the work. Set against all this is the growing attention given meteorological data by the national leaders, the recognition of the advantages which early warning (taken alone) can bring, the provision of military communications to supplement civil, and there is ample precedent for staff retention. All of this argues not for a bump at the end of AGRHYMET but a gradual decline to some level which can be supported in the long term topped up now and again with some external financing.

Given this the analysis will assume that sufficient recurrent costs are made available to sustain (15%) of installed capacity which is enough to at least keep agronomic research supplied with weather related data.

C. Institutional Analysis

Institutionally, the AGRHYMET program is extremely complex, involving international, regional, national and local levels of participation, most in both policy and technical roles. Inputs must be coordinated from at least twelve different technical assistance sources, covering three main objectives and several subobjectives, and involving several dozen major discrete project or subproject activities, each of which may have to be separately managed.

Moreover, because the working definition of the program's objectives has shifted over time, some of the institutional roles in the program have lost their clarity, leading to increased burdens for coordination and supervision being placed on the already taxed management structure of the program.

As the program enters the implementation phase, which is also the last phase of major donor involvement, it is essential that institutional roles and objectives be put on a sustainable footing.

In the same way, the AID-funded portion of the program -- the SWD&M Project -- must also be placed in an institutional context which is consistent with the long-term program management structures.

The background and issues surrounding institutional development of the program are discussed in detail in the Institutional Annex. Critical institutional issues to be addressed in the coming phase are discussed below under the headings of "program issues" and "project issues."

Critical Program Institutional Issues

First, and most important, the Executive Committee of AGRHYMET must implement the redefinition of Objective 3 of the program. As noted in Section I.B.1 of this Project Paper, the November 1986 meeting of the Executive Committee resulted in a formal redefinition of Objective 3, to stress that the program will indirectly contribute to agricultural production increases through provision of better data, rather than through direct involvement with farmers in the near term. This change is extremely positive. It will, however, require the continued leadership of the Executive Committee to assure that this redefinition is reflected in the plans and funding commitments of the various levels of actors within the system. The redefinition of Objective 3 will reduce unrealistic expectations of what the program can achieve, but the diversion of real resources towards short-term agricultural gains must also be addressed, and is essential to sustainable program operations in the coming phase.

Complementary to this Executive Committee initiative is the need for a strong WMO role in assuring that the program objectives are properly understood by all participants, and that donor funding is coordinated in such a way as to assure that the highest priority objectives are funded first. There is an immediate need to inform all donors of what donor funding commitments are, where gaps continue to exist, and where and in what amounts further resources must be channeled to assure a coherent program starting in 1987.

Finally, the long-discussed "management-by-objectives" study is of even greater importance in light of the Objective 3 redefinition than it was previously. Steps should be taken immediately to assure that ARC management is given the resources necessary to undertake such a study in sufficient depth and detail to serve as the basis for the future evolution of institutional roles, both regionally and nationally.

Critical Project Institutional Issues

To date, the Data Processing Component of the SWD&M project has been carried out through a PASA with NOAA/NWS, and the Crop Monitoring Component (for the years that it has existed), through a separate PASA with NOAA/NESDIS. While the same two components are proposed for Phase III, each will increase in complexity and will require greater integration with other program elements. The Niger Mission has made it extremely clear that it does not have the management resources necessary to oversee two separate contractors for these components. It is therefore essential that a single contractor be responsible for the overall management of all technical assistance for the SWD&M III Project. Moreover, this contractor must be capable of bringing in short-term technical expertise in a variety of disciplines as needed (via subcontract or in-house personnel), to select technical resources (hardware,

software, methodologies and expertise) from whatever sources are most appropriate to Sahelian needs, to assure French-language instruction and logistical support and to be responsible for the cost-effectiveness and developmental soundness of project design and implementation, particularly as they relate to the issues of recurrent cost and RDSS objectives. The design does, however, call for all procurement to be done via an independent procurement services agent (PSA), who could presumably continue to support the program after AID support ends.

The second critical institutional issue for the project is its relationship to overall program management. To date, the AID-funded project has been management directly by NOAA and AID. The resident technical advisor does not report to program direction and has full control over the project budget. In the opinion of the design team, the current system does not provide a sustainable model for future Sahelianization, is inconsistent with the pressure placed on the ARC to implement management-by-objectives, undercuts the effort to encourage coordinated donor support under WMO management and increases the day-to-day management burden on the Niger AID Mission. It is strongly recommended that USAID-funded long-term technical advisors under both components of the project be integrated with program management structure, as are French and other donor experts. While budgetary responsibility should remain with the AID contractor under direct supervision and control by AID, the resources available through AID should be managed within the program, rather than separately.

D. Socioeconomic Analysis

The economic analysis attempts to determine, through a reference case and sensitivity analyses, the likelihood that investments in the AGRHYMET Program will yield a positive return for the economies of the Sahel.

The underlying assumptions of the economic analysis must be consistent with realistic expectations on both the level and timeframe of impacts. This has not always been the case for previous economic justifications of the program, leading either to overestimation of the benefits, or, equally seriously, to estimated benefits which are not credible when judged by objective observers.

How Will the Benefits be Realized?

Two categories of benefit can be identified: (i) time, money and lives saved through early warning of potential food shortfalls and (ii) the value of additional rural production which results from the improved agricultural decision making through consistent and reliable agrometeorological and hydrological data.

The first category of benefit is extremely difficult to quantify. Any quantifications would be sufficiently suspect that they could not easily serve as the sole economic justification of the project without recourse to the simple value judgement that the potential benefits are worth the cost. Therefore, the approach taken here is to begin with a quantification of the potential production benefits. If those benefits are seen to be sufficient, over a broad range of assumptions, to justify project expenditures then the non-quantifiable benefits will only strengthen the overall economic attractiveness. If the production benefits are insufficient to make the program economically viable, then we can calculate what the value of the non-quantifiable benefits would have to be in order for the program to break even. While such an approach does not make early warning benefits easier to quantify, it does better correspond to the judgemental process necessary to finalize the analysis.

The Timeframe of Production Benefits

In conformity with the argument put forth in Section I of the Project Paper, it is assumed that benefits to rural production systems will occur indirectly, through existing research and extension communities, and over long periods rather than in the short-run. Furthermore, it can reasonably be supposed that benefits will, in early years, be extremely small, will increase very slowly for a number of years, and will continue to be negligible -- relative to total production -- for over a generation. Thereafter, as a consequence of improvements in infrastructure and communications and advances in scientific research, benefits can be expected to grow somewhat faster, with noticeable overall results realized somewhere between years 30 and 50 from today (that is, between 2017 and 2037).

Therefore, while the investments are heavily front-loaded relative to the 50-year period of analysis (some $60 million to date and another $30 million over the coming five years), the benefits are almost entirely in the out years. In economic terms, the discounted present value of benefits far in the future is very low relative to the nominal future values. That is, a dollar promised in fifty years is worth much less than a dollar promised today. This, then is the economic test which must be passed: can we reasonably expect that benefits realized far in the future will be sufficient to offset investments made today?

The "diffusion-of-innovation curve" used is a characteristic "S-shaped" curve embodying a very low initial impact, increasing slowly, and a higher rate of increase in the middle years, tapering off to a stable longer-run level in later years, as shown in Figure II.1. The point at which the rate of increase begins to taper off is known as the "saddle point", as identified in Figure II.1. The vertical axis (Y-Axis) measures the percentage of farmers in the Sahel

affected, while the horizontal axis (X-Axis) is time (0-50 years).

The reference case uses a diffusion curve with a saddle point at year 35, as shown in Figure II.2. This curve assumes that by 1991, less than one-tenth of one percent of farmers will be affected by agricultural improvements which derive from AGRHYMET produced data, and that the percentage of farmers affected thereafter will be as shown in Table II.3.

Table II.3

RATE OF DIFFUSION OF INNOVATION IN THE SAHEL: REFERENCE CASE

Year	Percent of Farmers
1991	0.098%
1996	0.28%
2001	0.64%
2006	1.31%
2011	2.58%
2016	4.99%
2021	9.56%
2026	14.76%
2031	17.51%
2036	18.95%

The practical implication of the assumption underlying Table II.3 is that it will not be until the first decade of the twenty-first century that one percent of Sahelian farmers will even indirectly benefit from yield increases induced as a consequence of the AGRHYMET Program.

Two other diffusion curves are tested as well: one with a saddle point at year 30, and the other with a saddle point at year 40. The three curves (including the Reference Case) are compared in Figure II.3.

Underlying Assumptions

The current (1986) population of the Sahel is put at 35 million. The population is estimated to be 85% rural, with 75% of rural dwellers being sedentary farmers. Average rural household size is 9, yielding approximately 2.5 million farm households. Estimated holdings under cultivation are 5 hectares per household, 25% of which are taken to be under cash crops, the remainder being used for subsistence agriculture. Irrigated hectares are assumed to be extremely low (2% of aaaaa

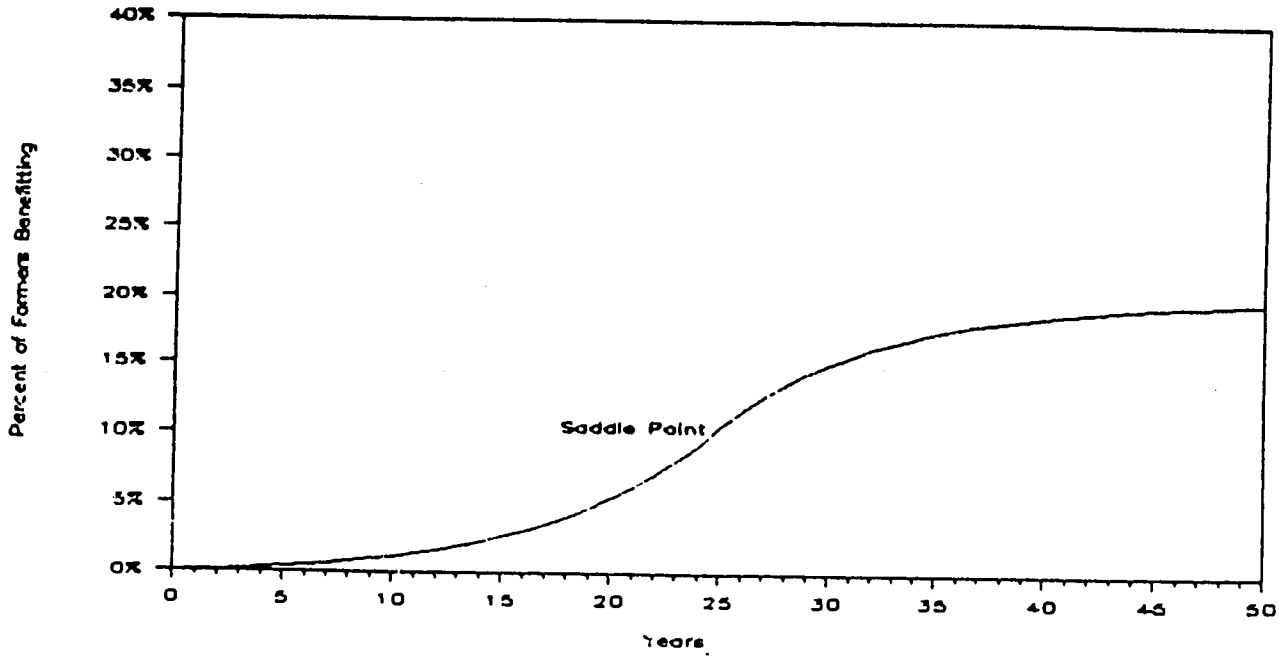

Figure II.1

SAMPLE TECHNOLOGY DIFFUSION CURVE

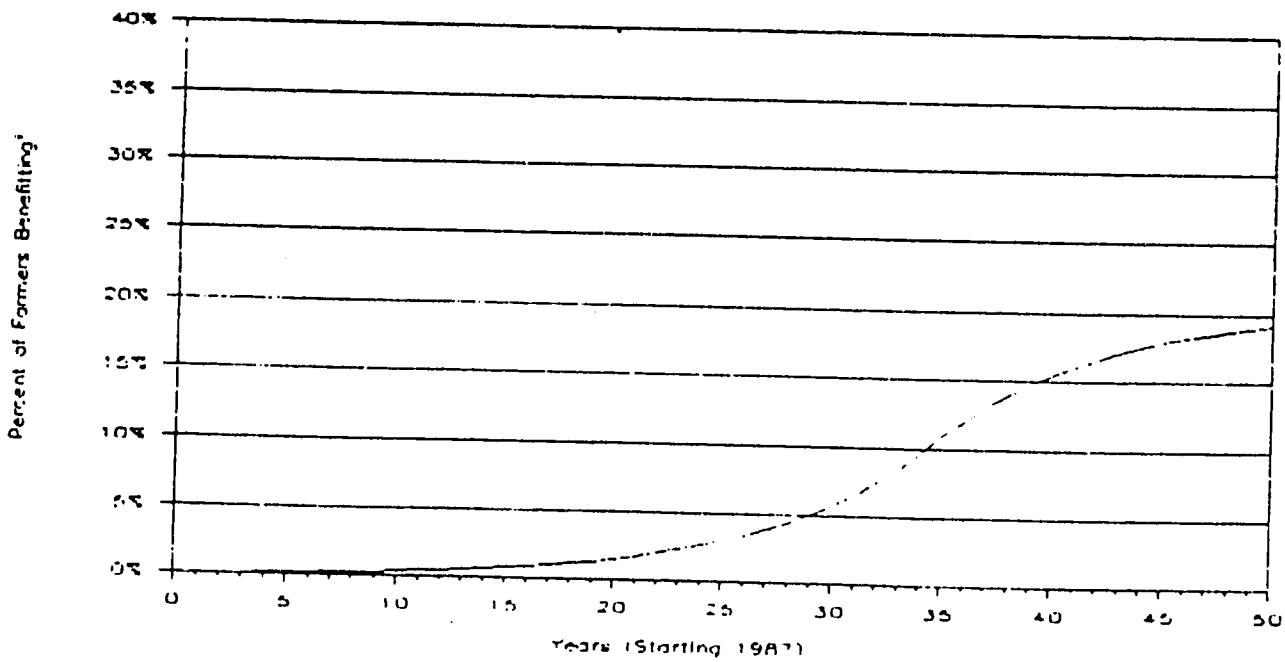

Figure II.2

REFERENCE CASE TECHNOLOGY DIFFUSION

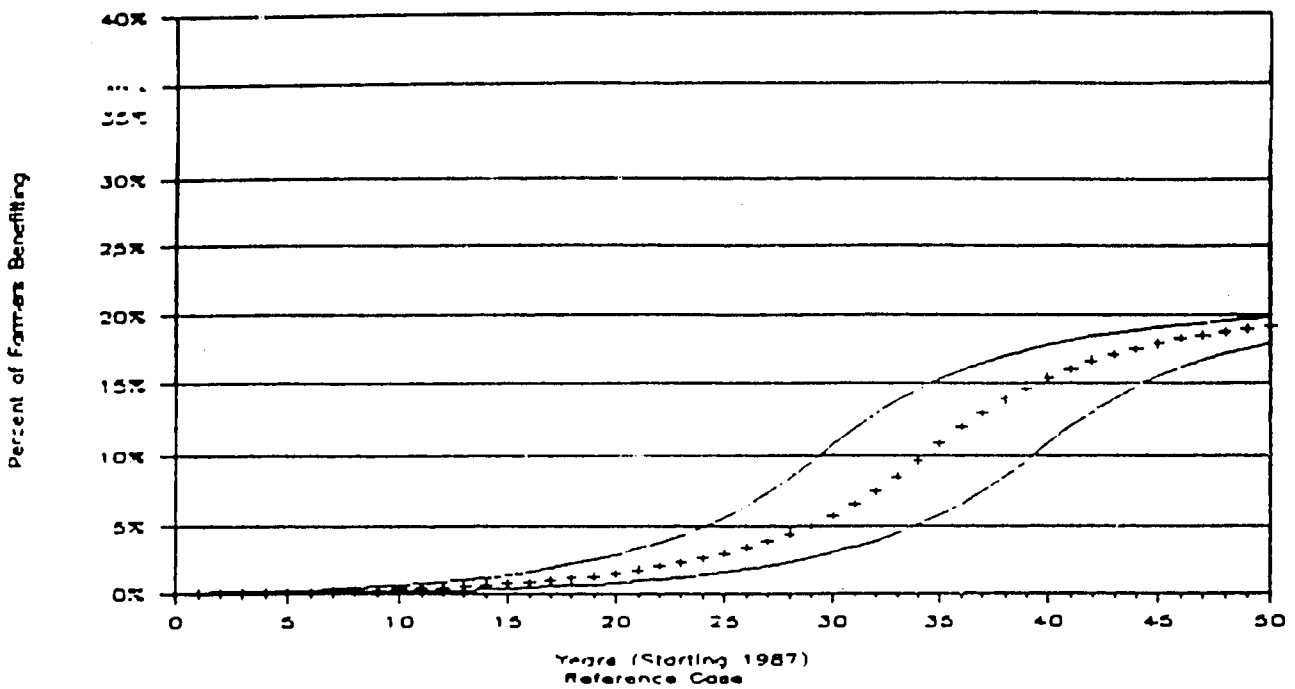

Figure II.3

ALTERNATIVE TECHNOLOGY DIFFUSION RATES

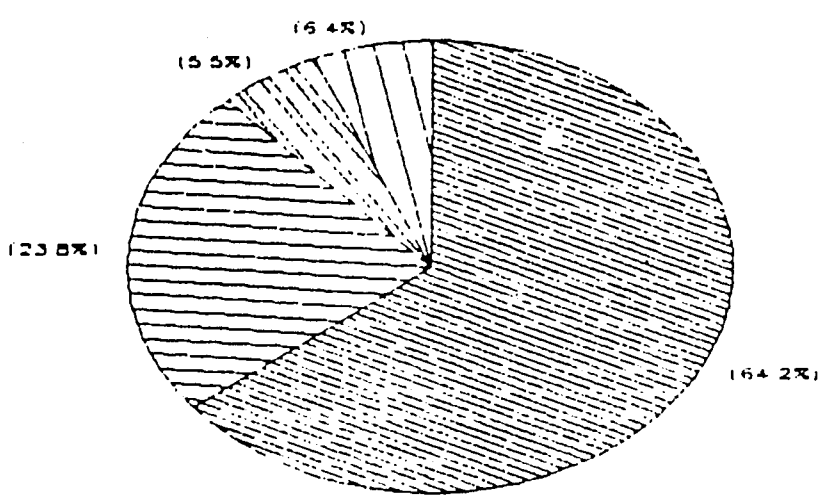

Figure II.4

PERCENT OF FOOD, CASH CROP, IRRIGATION, AND RANGE

total holdings). On average, subsistence yields are put at 600 kilograms per hectare, cash crop yields at 1000 kg/ha and irrigated yields at 1,600 kg/ha. Because the Sahel is now in food deficit, and because deficits are expected to grow, the opportunity cost for food production is measured by the cost of food imports. At the margin, imported grain is valued at 150 CFA francs per kilogram. Cash crops, while typically higher in market value, are given a lower economic value (100 CFA/kg) because they do not necessarily require imports to fill a shortfall relative to anticipated levels.

Population growth is put at 2.8% per annum, but agricultural production increases are held to 1% per annum, which corresponds to average performance over the last two decades. In part, this reflects outmigration from rural areas to urban centers, and in part it reflects the per capita deterioration of agricultural production. A higher rate of growth than the 1% rate used here would increase the projected benefits from AGRHYMET, but the lower rate is used to be conservative.

The Reference Case analysis takes into consideration all previous costs incurred for the program, starting in 1975. 1987 is taken as the base year, with past investments valued upwards to convert them to 1987 dollars, and future investments and benefits discounted to present values. Investments in the program are estimated at $60 million for the first ten years, $30 million from 1986-1991, and $2 million per year (real) for each year from 1992-2037. This latter figure represents the assumed recurrent cost of the program, whether from donor or national government sources.

The Technical Annex on agricultural production suggests that, over the long-run, sizable percentage increases in yield could accrue from better management of climatological phenomena. In bad years, the percent increase relative to a "no action" case should be even higher than in good years. The current pilot projects suggest that a series of practices to better manage climate can increase yields by over 50% (even after removing the effects of better agronomic and extension management in the pilot projects). We assume here that the maximum yield increase obtained by farmers who do benefit from the program (see table above for percentage of benefitting farmers) is 30%. Finally, it is assumed that farmers producing cash crops and irrigated crops will also benefit from AGRHYMET data (irrigated crops more from hydrological than from meteorological information), and that, over time, better range management will also be a benefit of the program. The same diffusion rate is assumed for all rural producers, with the proportion of overall benefits obtained from each type of production activity being a function of its relative importance in the rural economy, as summarized in Figure II.4.

It should be noted that the assumed costs of the program ($60 million + $30 million) include all costs, including setup costs, past mistakes and the costs which presumably can be attributed to the early warning effort.

Results and Conclusions

The discount rate used for the analysis is 10%. For convenience, both the net present value (NPV) and the internal rate of return (IRR) are presented. A positive NPV or an IRR above 10% implies that the program is economically viable on the basis of production impacts alone.

Reference Case. The reference case gives an IRR of 11.5%, or an NPV of $60.5 million. If this case proved correct, the implication is that the AGRHYMET Program will prove economically attractive for the Sahel even when all sunk costs of the past ten years are included on the cost side and when no non-production benefits are considered.

Sensitivity Cases. The results of the full set of sensitivity analyses are summarized in Table II.4.

Table II.4

SUMMARY OF SENSITIVITY ANALYSIS RESULTS
(NPVs in Millions of U.S. Dollars)

	Sensitivity	NPV	IRR
Case 1:	Saddle point at year 30	$155.0	13.4%
Case 2:	Saddle point at year 40	-$ 7.2	9.8%
Case 3:	Sunk costs of past 10 years excluded	$147.5	18.7%
Case 4:	Annual recurrent cost of	$ 55.4	11.4%
Case 5:	Food production valued at 100F/kg	$ 17.8	10.5%
Case 6:	Food production in Sahel grows at 1.5% p.a.	$ 91.7	12.1%

Cases 1 and 2 show the results to be quite sensitive to the rate at which improved techniques reach rural producers, with a highly positive NPV if the saddle point occurs at year 30, and a slightly negative NPV if it occurs at year 40. Case 3 presents the economic analysis in a slightly different perspective. In effect, it assumes that all investments to date are sunk costs and that the decision faced by both Sahelian Governments and donors today is whether further investments in AGRHYMET will yield benefits which justify the investments yet to be made. This is, of course, a rational economic point of view, since even the decision to suspend the program will do nothing to eliminate past costs, nor is their any appreciable salvage value to existing program assets. In

Case 3, further investments are seen to be highly profitable for the Sahel. Case 5 tests the impact of a lower assumed price of food (100 CFA vs. 150 CFA per kilogram). Returns fall sharply in this scenario, but the NPV remains positive, with an IRR just over 10%. Finally, Case 6 assumes that agricultural production in the Sahel grows slightly faster than it has over the past twenty years (at 1.5% per year vs. 1% as assumed in the reference case), thereby increasing the base to which production benefits are applied. This case yields a sharply increased NPV of $91.7 million and an IRR of 12.1%.

The finding that the AGRHYMET program is economically viable appears to be robust under a broad range of downside assumptions, based solely on the production benefits. Only if technology diffusion occurs more slowly than the conservative reference case is there an apparent risk of non-viability. To test the importance of this potential risk, a further case was run (Case 7), which is a combination of Cases 2 and 3. That is, for an investment made today (without consideration of sunk costs) would the program be profitable if diffusion occurred at the slower rate assumed in Case 2? Case 7 yields a highly positive NPV of $79.7 million and an IRR of 15.4%. Finally, using Case 3 as the base case, the NPV remains positive even if only less than a 2.5% penetration rate is achieved by year 40 (2026) corresponding to a saddle point at year 50.

Because the above results are exclusive of the impact of any benefits from the early warning component, the overall program can be judged economically viable for all cases run, including Case 2. In this respect, it should be noted that, unlike the production gains, the benefits of the early warning component occur evenly throughout the period of analysis, rather than being concentrated in the out years. Therefore, even a relatively low valuation will weigh heavily in the present value of benefit streams, and consequently in the Net Present Value of the program. Even Case 2 (the worst case) comes within $7.2 million of breaking even at a 10% discount rate, without taking account of the non-quantified benefits from the food, money and lives saved by all AGRHYMET efforts to improve food security planning over the next fifty years. If the program has even minimal success, it seems safe to conclude that the cumulative value of such non-quantified benefits will be at least sufficient to make up this $7.2 million shortfall.

E. Environmental Analysis

Sahel Water Data and Management Phase III, as with the previous two phases, has been determined by AID Washington to be eligible for a categorical exclusion of standard environmental regulations. A copy of the IEE is contained in Annex E.

III. IMPLEMENTATION

A. Implementation Plan

Table III.1 shows the detailed implementation plan by component, breaking out technical assistance, equipment procurement, training and evaluation separately.

Technical assistance is to be provided by a single technical assistance contractor, with equipment purchases handled through a separate procurement services agent. Mission management will be provided by USAID/Niamey under the supervision of an AID direct hire employee, assisted by a personal services contractor who will be financed under this project.

B. Procurement Plan

USAID inputs to the Phase II program are now being carried out under two separate PASA agreements: one with the National Weather Service of NOAA, for the data processing component, and the other with the NESDIS division of NOAA, for the remote sensing component. For several reasons, these arrangements cannot continue unchanged during Phase III:

> USAID/Niamey does not have the staff time or in-house expertise to manage two different contractors for the SWD&M project. The Mission requires, as is consistent with Africa Bureau policy, that all project components be managed by a single contractor, in order to reduce Mission management burdens.
>
> It is not cost-effective to maintain two separate contractor home office management structures.
>
> The ARC, like the Mission, is better served if it is able to coordinate with a single point of focus for all USAID inputs, as it already bears the burden of having to coordinate a large number of international, regional and national actors in the program.
>
> The AISC branch of NOAA/NESDIS, which has been carrying out the remote sensing component for the past three years, has been formally disbanded as of January of 1987.

Table III.1

EQUIPMENT AND OPERATIONS: IMPLEMENTATION SCHEDULE

		YEAR 1				YEAR 2				YEAR 3				YEAR 4				YEAR 5			
		I	II	III	IV	I	II	III	IV	I	II	III	IV	I	I'	III	IV	I	II	III	I
Gambia																					
	PDP 11/34																				
	80286-based Micros:																				
	Config #1																				
	Config #2																				
	Config #3																				
	Config #4																				
Cape Verde																					
	PDP 11/34																				
	80286-based Micros:																				
	Config #1																				
	Config #2																				
	Config #3																				
	Config #4																				
Niger																					
	PDP 11/34																				
	80286-based Micros:																				
	Config #1																				
	Config #2																				
	Config #3																				
	Config #4																				
Mauritania																					
	PDP 11/34	N.A.																			
	80286-based Micros:																				
	Config #1																				
	Config #2																				
	Config #3																				
	Config #4																				
Chad																					
	PDP 11/34	N.A.																			
	80286-based Micros:																				
	Config #1																				
	Config #2																				
	Config #3																				
	Config #4																				

Table III.1

EQUIPMENT AND OPERATIONS: IMPLEMENTATION SCHEDULE

(Continued)

	YEAR 1				YEAR 2				YEAR 3				YEAR 4				YEAR 5			
	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
A. ARC																				
PDP 11/60 #1	———	———	———	———																
PDP 11/60 #2	———	———	———	———	———	———	———	———												
Old Unibus I/O	———	———	———	———																
VAX 780	———	———	———	———	———	———	———	———	———	———	———									
Mincomputer #1					———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———
Mincomputer #2									———	———	———	———	———	———	———	———	———	———	———	———
Mincomputer #3														———	———	———	———	———	———	———
(Mincomputer #4)																		———	———	———
Ethernet					———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———
80286-based Micros																				
(National Configurations)																				
Configuration #1	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Configuration #2						- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Configuration #3											- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Configuration #4	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
B. NACs																				
Burkina Faso																				
PDP 11/34	———	———	———	———	———	———	———	———	———	———	———									
80286-based Micros:																				
Config #1	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———
Config #2	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———
Config #3	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———
Config #4											———	———	———	———	———	———	———	———	———	———
Mali																				
PDP 11/34	———	———	———	———	———	———	———	———	———	———	———									
80286-based Micros:																				
Config #1	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———
Config #2	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———
Config #3	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———
Config #4											———	———	———	———	———	———	———	———	———	———
Senegal																				
PDP 11/34	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———				
80286-based Micros:																				
Config #1	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———
Config #2	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———
Config #3	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———
Config #4																				

NOAA/NWS does not possess the in-house capacity to take over the functions which have been offered by NOAA/NESDIS, and it is not clear if, as a government agency, it has the mandate to compete with the private sector in recruiting appropriate individuals or subcontractors.

For the data processing system, the skills required are widely available through the private sector, which routinely provides similar data processing services to AID throughout the world. The quality of the services provided to the project will depend on an overall knowledge of computer technology and information system design and management, as well as on the quality and French language ability of the specific field staff selected, the experience with USAID procurement and developing country equipment specification requirements and the capacity of managing field projects in a development context.

The services required for the remote sensing component will be more difficult to meet from any single source. Even if NOAA/NESDIS/AISC were still in existence, the recent National Academy of Sciences evaluation suggests that this component should draw on a broad range of skills rather than relying on a single methodology. In anticipation of the possible disbanding of AISC, and for reasons of project efficiency, Phase III design relies on the skills of the two individuals to be placed in Niamey, rather than on a single U.S.-based institution. Of these two individuals, the computer programmer need not, at the outset, have strong experience in crop yield assessment, and the job description allows for use of the kind of computer skills which are widely available. The resident Agrometeorologist, however, should be familiar with satellite data, crop yield assessment and perferably, with the NOAA assessment methodology. Short-term experts can be drawn from former staff of AISC, from NASSA, USDA and/or universities and the private sector.

The most difficult to replace service, in the absence of AISC, will be the training portion of the remote sensing component. A collection of individuals with some past experience in the field will not be sufficient to create a coherent training program which teaches an established, implementable methodology and which builds upon past training offered through AISC. It is recommended that, after an initial review of remote sensing component options to be performed early in Phase III, a suitable contractor be selected for this training. The ARC and all past trainees at the NACs interviewed by the Project Paper team expressed satisfaction of the training program carried out in Columbia, although with the caveat that it would benefit from greater French language support.

Detailed consideration of these issues by each of the Project Paper team members has yielded the following list of criteria for determining an appropriate contracting mechanism:

- Ability to manage all project components.
- Experience and track record in managing complex field projects.
- Knowledge of development, including economics, recurrent costs, institutional development and Sahel-specific issues.
- Range of technical skills, including experience with large-scale as well as PC-based systems, information system management and software development and support.
- Ability to subcontract and use consultants in order to draw from a broad range of technical and scientific expertise.
- French language capacity of staff and consultants.
- Training experience, especially in Africa-based French language training.
- Familiarity with AID reporting and financial requirements in order to reduce Mission management burdens.
- For the remote sensing component, ability to establish technical credibility with the scientific community.

No specific weights have been attached to these criteria, and they are not presented in order of importance. Implementation of the project must be guided by a vision of what the AGRHYMET program, and the SWD&M project, can contribute to Sahelian development, of what sustainable objectives should be now and in the post-project period and of how to bring technical resources to bear to accomplish these objectives, given institutional circumstances in the Sahel, budget constraints and time limitations.

Given the disbanding of NOAA/AISC, sole source contracting with NOAA would not meet AID regulations (Handbook 12, Chapter 2) requiring that the entity is "not competitive with private enterprise." As a number of private sector organizations offer data processing services of the kind required for

this project. NOAA would clearly compete with the private sector. Therefore, is recommended that contractor selection be made through competitive bids. This option is believed to afford the best chance satisfying the range of criteria necessary to successful implementation of the Phase III project and of long-term program objectives.

When contracts are awarded under full and open competition procedures, AID will encourage the participation to the maximum extent possible of small business concerns, small disadvantaged business concerns, and women-owned small business concerns in this activity as prime contractors or subcontractors in accordance with Part 19 of the Federal Acquisition Regulation. A.I.D. will make every reasonable effort to identify and make maximum practicable use of such concerns. All selection evaluation criteria being found equal, the participation of such concerns may become a determining factor for selection.

C. Transition from Phase II to Phase III Contractor

1. Information Systems Component

In order to assure that the transition to the new contractor selected to implement the project occurs without disruption of program activities, the current PASA agreements with NOAA will be initially extended for a period not to exceed 9 months.

The total cost of the nine-month extension of the NOAA/NWS PASA is currently estimated at approximately $900,000. The PASA should be written to allow enough flexibility to extend NOAA services for from one to three months if the situation warrants.

The PASA extension will allow for field technical services, home office support, maintenance costs, U.S. training, and a limited amount of equipment.

The extension of field technical personnel and home office support will allow current personnel to remain in place for at least three months after the new contractor has placed field staff in Niamey (expected by January 1988). The maintenance budget provided under the PASA extension will allow normal maintenance operations for nine months.

The U.S. training costs budget will permit trainees already in the U.S. to complete their long-term programs. NOAA will also place two additional long-term trainees in September 1987. Their training will continue until September of 1990. The justification for placement of two additional trainees, despite the emphasis in the design of Phase III on

short-term training, is that the two individuals to be placed in September 1987 are both candidates for ARC maintenance positions, which require greater expertise than is required for the NACs.

A limited amount of equipment will be needed during the transition to meet needs which cannot easily be deferred until the new contractor is in place. New equipment purchases by NOAA should be kept to a minimum, however, to avoid duplication with future project purchases and incompatibility of equipment and/or system design philosophies.

The new contractor will take over support to long-term trainees already in the U.S. This will be provided from the contractor's home office and will obviate the need for low level administrative and technical support from NOAA until 1990. While NOAA has past experience and success at providing trainee support, it will be much more cost-effective to handle this intermittent function through contractor home office staff than to maintain separate NOAA staff for the purpose.

Table III.2 shows the implementation schedule for the transition period, and includes the timeline for solicitation of proposals, contractor selection, contract negotiation, and placement of field staff.

2. Remote Sensing Component

Under a separate PASA agreement with NOAA/NESDIS and the Cooperative Institute for Applied Meteorology (NOAA and the University of Missouri), AID will also extend the services of CIAM for one year. This extension, which will be financed through non-project sources, will permit provision of remote sensing data, images, software, and training through the 1987 crop season. It will also allow further development work and training in the period from March 1987 - March 1988. The new SWD&M III contractor will have sufficient overlap with this effort to allow an orderly transition and the establishment of operational systems in time for the 1988 crop season.

3. Specific Phase III Contracting Mechanisms

Under the Phase III project, AID will obtain the following contractor services:

- A technical assistance contractor who will provide all long-term technical assistance, project management, short-term specialists and through whom routine supplies will be procured.

Table III.2

TRANSITION PLAN

TRANSITION ACTIVITY	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR
Contracting											
PP Approved	o										
RFP Preparation		----------									
RFP Issued - CBD Announcement			o								
Proposals Prepared & Received				-------o							
Evaluation of Proposals & Award					----------o						
Contract Signature								o			
Phase III TA Contractor in Field									o		
NOAA Phase II Closeout											
Project Technical Manager (PTM) Provide NOAA Logistics Technical Description to AID		------o									
NOAA Provide Logistics Plan to AID		------o									
AGRHYMET Assumes Maintenance Responsibility			----------	----------	----------	----------	----------	----------	----------	----------	----------
NOAA in Back-Up Mode for Maintenance			----------	----------	----------	----------	----------	----------	----------	----------	----------
NOAA Provide Only Phase II Closeout Procurement & Installation			----------	----------	----------	----------	----------	----------	----------	----------	----------
NOAA Conducts Washington Orientation for Bidders			---								
NOAA PTM Orient Phase III Contractor									------		
Phase III Contractor Assumes Logistics Responsibility										----------	----------
Phase III Contractor Assumes Training Responsibility											------
NOAA PASA Ends - PTM Returns											

Table III.2

TRANSITION PLAN

(Continued)

TRANSITION ACTIVITY	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR
Special Studies											
Management Study											
Initial Visits					------		----------	----------	----------		
Draft Management Plan									o		
CAC Meeting										o	
Remote Sensing Expert Team			----------	----------							

NOTE: For details on the Management Study, see Section - II.C. For details on the Remote Sensing Expert Team Study, see Section - II.A.2.

A procurement services agent (PSA) through whom AGRHYMET will procure equipment and spare parts funded by AID. The use of such a PSA will facilitate procurement during Phase III by relying on an experienced procurement agent such as those utilized in current AID IQC arrangements.

D. Monitoring/Evaluation Plan

1. Monitoring

a. The Integrated Program

The WMO is the Implementing Agency, and has responsibility for monitoring the overall program. In this capacity, it reports to the AGRHYMET Executive Committee, composed of representatives of each member state and of CILSS. The Executive Committee is assisted by the Coordinating and Advisory Committee (CAC), to whose Chairman WMO also reports. All major international agencies and donors who contribute to AGRHYMET are represented on the CAC.

The Chairman of the CAC has primary responsibility for assuring that donors are kept informed of program status. The CAC Chairman participates in Executive Committee Meetings as an observer, and both the Executive Secretary of CILSS and the Chairman of the Executive Committee participate in CAC meetings. Finally, the Director General of the AGRHYMET Program attends both the Executive Committee and CAC meetings, assuring coordination between these bodies.

Two specific steps are recommended to improve monitoring and coordination during Phase III:

> A detailed report by the WMO, through the CAC Chairman, at the next CAC meeting, on the size and nature of donor contributions to Phase III, comparison of these contributions to priority funding requirements and identification of outstanding areas for which funding either does not yet exist or is still insufficient.
>
> A joint meeting of the CAC and of either the Executive Committee or other designated country representatives, in order to assure that programs being implemented during Phase III are consistent with post-project transition, and to identify further transition issues to be resolved during Phase III. The Management Study will be a primary source of information for this aspect of program monitoring.

b. The Sahel Water Data and Management III Project

Direct monitoring of the project will be carried out by the project Contractor, who will be responsible for implementation of all project components. All project field and short-term personnel will report to the Contractor's Project Manager, who in turn will be directly accountable to USAID/Niamey. The AFR/SWA will collaborate with PD/SWAP and other AID/W offices to support USAID/Niamey in project oversight and financial control.

The project Contractor will have specific responsibility to assure that USAID Missions in each participating country receive adequate and timely information on project activities in their countries, and that they are regularly updated on overall project status. Anticipated national activities will be reported to each Mission by Cable System from USAID Niamey, and through regular visits by field personnel to each Mission. Updates on project status will be provided by the Contractor's home office management in the form of substantive Quarterly Progress Reports and an Annual Report distributed to all relevant AID offices. These reports will also contain, where appropriate, information about other program activities (outside the AID project) which may be useful to AID and which facilitate donor coordination within each country. It is recommended that at least the Annual Reports also be made available to the Executive Committee and the CAC.

2. Evaluation Plan

The AID SWD&M Project, as well as the AGRHYMET Program, have been in existence for ten years. Both proposed components of the Phase III AID project are already operational. Phase III is intended to be the implementation phase of the program, and may be the last phase which relies primarily on donor support. For these reasons, both a detailed mid-term evaluation and a thorough end-of-project evaluation are recommended.

The objective of the mid-term evaluation should be to determine if the Phase III design and its implementation meet the twin criteria of feasibility and sustainability. The objective of this evaluation should not simply be to determine how successful the project has been (an implicit purpose of any evaluation), but much more to assure that measures to improve project performance be undertaken in time to affect the course of Phase III implementation. Specifically, factors to be examined should be those which affect achievement of

Phase III objectives and which will increase the cost-efficiency and sustainability of post-Phase III Sahelianization. Such factors include:

A review of progress towards implementation of the recommendations of the Management Study.

Rate at which regional and national maintenance responsibility is being successfully transferred to Sahelian personnel.

Level of up-time of sufficient system capacity (ARC and NAC computers) to perform all critical functions.

Recurrent cost of data processing system maintenance.

Level of development of satellite data interpretation methods and ancillary tools, such as packaged mapping and database programs.

Success at transferring satellite data interpretation methodology to Sahelian personnel.

Efficiency of training programs.

Coordination of remote sensing/crop monitoring component with other food deficit early warning systems/actors.

Degree to which technological advances in computer hardware and software and/or in satellite data processing technology render existing or planned project activities obsolete.

Extent to which solutions to the telecommunications bottlenecks have proven viable and progress towards their implementation.

Finally, relative success or failure of the project in establishing clear, simple and appropriate systems and tools to carry on project operations with a minimum reliance upon costly expatriate inputs, particularly in the post-1991 period and beyond.

The end-of project evaluation will consider largely the same set of issues. The focus will be more on performance evaluation and less on mid-course correction, although strengthening the quality and appropriateness of systems left in place for the post-1991 phase will also be a major objective of this evaluation.

The mid-term evaluation should take place at the end of year 2 of the project. To the extent possible, it should be carried out by individuals with some knowledge of the project and whose mix of skills maximize the likelihood that they will be able to make positive contributions to refining the project course over the remaining three years of its existence. The end-of-project evaluation should take place six months before the end of Phase III.

IV. CONDITIONS, COVENANTS AND NEGOTIATING STATUS

Because of the previous two phases of AGRHYMET implementation and the frequent, intensive reviews and analyses undertaken on Phase III to date, the status of Phase III implementation planning is already very well advanced. The A.I.D./W approval of the final Project Paper included a requirement that special attention be drawn to the upcoming WMO/AGRHYMET management study which is expected to more clearly define AGRHYMET program objectives, the roles of various actors in the AGRHYMET network, and key products which can be generated by the program. This led to the inclusion of the special covenant language on the management study noted below.

Conditions Precedent and covenants to be placed in the Grant Agreement are noted below:

Condition Precedent

1. Standard specimen signature
2. Evidence of availability of funds from other donors and the CILSS regional organization.

Covenants

1. The results of the AGRHYMET Management Study agreed to at the 5/15/87 meeting of the CAC will be made available to all CAC members by 1/1/88 and the final version of the AGRHYMET Management Plan will be formally submitted to A.I.D. once reviewed and approved by the CAC.

2. The CAC will annually review the status of AGRHYMET performance in relation to its avowed objectives, as expressed by its management plan, and, further, will conduct a comprehensive performance review in 1990, following completion of an in-depth A.I.D. evaluation currently scheduled for 7/89.

3. The Sahelian personnel provided under CILSS funding will be provided as agreed by AGRHYMET and the CAC.

Sahel Water Data and Management III (625-0973)

Methods of Implementation and Financing
($000)

Method of Implementation	Method of Fiancing	LOP Estimated Amount
Grant to World Meteorological Org.	Letter of Credit	$ 9,000

1) The World Meteorological Organization is audited annually.

Annex I

SAHEL WATER DATA AND MANAGEMENT III

(625-0973)

PROJECT PAPER

Volume 2: Annexes

January, 1987

ANNEX A:

PROJECT DESIGN SUMMARY: LOGICAL FRAMEWORK

COUNTRY: WEST AFRICA REGIONAL

PROJECT TITLE AND NUMBER: SAHEL WATER DATA & MANAGEMENT III; 625-0946

LIFE OF PROJECT: 5 YEARS
FROM: FY 87 TO: FY 91
TOTAL U.S. FUNDING: $6.9 MILLION
DATE PREPARED: DECEMBER, 1986

NARRATIVE SUMMARY	OBJECTIVE VERIFIABLE INDICATORS: Indicators of Progress Toward Planned Targets-Benefits	OBJECTIVE VERIFIABLE INDICATORS: SPECIFIC TARGETS	OBJECTIVE VERIFIABLE INDICATORS: Indicators of benefits incidence target groups participating in benefits: Production or Consumption	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS	MEANS OF VERIFICATION
Program or Sector Goal Contribute to food self sufficiency via: 1. A steady production of agric-related research, recommendations, tested practices, improved seeds, etc. 2. Gradual farmer acceptance of such improved practices	**Measure of Goal Achievement** 1. 5% of farmers adopting improved practices by 2016; 10% by 2021; 19% by 2026. 2. 30% yield improvement for farmers adopt improved practices.	**GOAL TARGETS** (Pct of Farmers Adopting New Methods) 2006 2016 2026 2036 1.6% 4.9% 14.8% 18.9%	**INDICATORS OF BENEFITS INCIDENCE AT GOAL LEVEL:** 1. Farmers who use production methods -dry land. 2. Economy of Sahel gets extra import replacing production	1. On farm research. 2. Cereal production research. 3. Material import statistics. 4. Research station trials, results	**PURPOSE/GOAL:** 1. Institutions needed to promote or support replication or dissemination strengthened and on the job. 2. Strengthen public radio with weather farm services. 3. Host countries provide recurrent budgets to support AGRHYMET and agro-meteorological network, and donor support obtained	1. Extension training, budgets, size of staffs. 2. National administrative budgets for meteo and hydro services
Subsector Goal Strengthen the capacity to do agro-meteorological work in the Sahel	**Subsector Achievement** Improved links between agricultural research and meteorological and hydrological services. Specific national projects to apply improved agroc/meteorological methods to production.	**SUB SECTOR TARGETS:** 1988 1991 1995 2000 —To Be Determined—	**MEASURE OF BENEFIT INCIDENCE:** 1. Institutions engaged in agronomic research. 2. Farms participating in trade.	1. Research plans 2. Project plans 3. National agriculture plans 4. Donor supported projects	**SUB-GOAL:** 1. AGRHYMET project completed along agreed lines; 2. Technical capacity in place to use installed analytic capacity. 3. Agronomic capacity in place to use meteorological data. 4. Countries (donors) support needed system and research. 5. Links established with CGIAR network	1. MTR review, evaluation of implementation of AGRHYMET. 2. CILSS report on project. 3. Evaluation of research capacity. 4. Supporting donor projects. 5. CGIAR, ICRISAT, IITA, etc.
Purpose To develop a regional system, including national elements, to record, process, interpret, transmit, disseminate and document complete, timely, accurate and meaningful weather and climatic information on the Sahel	**Conditions Indicating Success** Establishment at AGC and each NMC of computer-based analytic mechanism which are modular, highly reliable, cost-effective and of sufficient capacity to meet system needs. These systems must also support a wide range of off-the-shelf software.	**PURPOSE TARGETS** 87 88 89 90 91	**INDICATORS OF BENEFIT INCIDENCE EXPECTED AT END OF PROJECT:** 1. National meteorological services and their technical status.	1. End of project evaluation	**OUTPUT/PURPOSE:** 1. Financial plan completed conveying donor, CILSS, home country commitment to carrying out phase III. 2. Agreement with host countries in reference to retention and conditions of work for project trainees.	1. Financial plan. 2. Agreements. Evaluation of implementation
Outputs 1. Establishment of redesigned modular data processing systems for Agrhymet 2. Establishment of logistical network support 81 3. Establishment of methodologies and operational system for crop yield forecasting using satellite and other data.	**Magnitude of Outputs** 4 MicroVax IIs plus AIs at AGC 8 NMC systems (4 configs each) 40 SSB Radios at NMCs 160 Person-months of long and short term training in data processing for AGC and NMC staffs 75 AGC and NMC staff members trained in crop yield forecasting	**OUTPUT TARGETS:** 87 88 89 90 91 Units 1 2 3 4 CF 81 CF 82 CF 83 CF 84 Training 79 67 53 39 26 (Person-Months)	**INDICATORS OF BENEFIT INCIDENCE EXPECTED AT OUTPUT LEVEL:** 1. Trainees 2. Functioning Data Processing Systems	1. Evaluation, mid-term 2. Monitoring of disbursement of money 3. Regular reports by contractor	**INPUT/OUTPUT:** 1. Training done in-country.	Monitoring, contract, GDSP
Inputs (000s of US $) First Year / All Years USG 2,401 / 8,907 CILSS* 1,500 / 12,000 OTHER* 3,000 / 20,000 TOTAL 6901 / 40,907 * Estimates still in design	**Input Categories** 228 P-H Long Term T.A. 156 P-H Short Term T.A. 186 P-H Short/Medium Term Training 4 MicroVax II Computers Software and Peripherals 9 National Configuration Systems (4 configurations each, consisting of AIs, software and peripherals) 40 SSB Radios	**BUDGET AND IMPLEMENTATION SCHEDULE:** 87 88 89 90 91 MONT 79 83 47 91 18 DP 1595 997 748 934 333 RS 433 626 550 589 186 BUY-IN 200 200 200 200 200 TOTALS 2301 1825 1412 1696 777	**INPUT SCHEDULE:** 1. Contracts	**PROJECT PERFORMANCE TRACKING:** 1. PP 2. PMO/AG 3. Contract 4. PIOI,C,P.	**PROVISION OF INPUTS:** 1. Supplier is private contractor. 2. Commercial software can be purchased to extent possible.	1. CONTRACT; annual performance reports.

SAHEL WATER DATA AND MANAGEMENT III

(625-0973)

PROJECT PAPER

ANNEX B: TECHNICAL ANNEX

-Part One: Financial Summary
-Part Two: Data Processing Component
-Part Three: Remote Sensing Component
-Part Four: Agricultural Component

Earle Nay and Asif Shaikh

January 1987

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PART ONE
FINANCIAL SUMMARY OF PROJECT COMPONENTS

This section, Part One of the Technical Annex, provides three summary tables (Tables D.1-D.3) which show the budgets for the "Recommended Project Design", the "Higher Budget Option" and the "Low Budget Option", respectively. The principal differences in these options are changes in the Data Processing Component (in all three options), and, for the "Higher Budget Option", addition of the component to monitor pilot agricultural projects. The "Lower Budget Option" is considered unrealistic, and carries with it two major uncertainties: first, that repair costs may be higher than anticipated because failure to put in new equipment will increase reliance on the existing systems; second, that post-project recurrent costs to be borne by Sahelian countries will be much higher than in the other options.

Finally, it should be noted that in all three options, there is a $1 million allowance for eventual Mission "buy-ins". Further descriptions of each component and of the three options are contained in the remainder of the Technical Annex and in the main body of the Project paper.

Table D.1
SUMMARY OF COSTS FOR RECOMMENDED PROJECT DESIGN

Remote Sensing Component

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Long Term Technical Assistance	$28,938	$147,584	$154,962	$162,711	$0	$494,195
O/S Allowances, Educ. Housing, Etc	$55,067	$104,454	$110,233	$149,543	$0	$419,297
Travel and Per Diem	$29,370	$85,711	$87,864	$92,263	$0	$295,177
Training	$214,189	$224,761	$170,129	$119,434	$119,434	$847,946
Consultants	$62,837	$63,979	$72,989	$72,989	$72,989	$327,783
Other Direct Costs	$41,340	$28,938	$30,385	$31,904	$33,499	$166,066
Subtotals	$472,590	$657,956	$649,564	$638,442	$186,422	$2,445,984

Data Processing System Component

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Long Term Technical Assistance	$142,210	$149,320	$156,786	$74,636	$78,368	$601,320
O/S Allowances, Educ. Housing, Etc	$66,804	$34,771	$37,509	$16,949	$0	$156,033
Travel & Per Diem	$63,836	$68,040	$67,466	$40,578	$34,986	$270,907
Consultants	$120,000	$120,000	$80,000	$80,000	$0	$400,000
ARC Logistics	$100,000	$60,000	$30,000	$30,000	$30,000	$270,000
NAC Logistics	$180,000	$120,000	$90,000	$60,000	$30,000	$480,000
Telecommunications	$45,000	$50,000	$50,000	$45,000	$30,000	$220,000
Training	$250,000	$200,000	$100,000	$50,000	$50,000	$650,000
ARC New Equipment	$343,000	$145,000	$50,000	$200,000	$230,000	$968,000
NAC New Equipment	$274,000	$30,000	$30,000	$337,000	$30,000	$701,000
Subtotal (Cons-NAC...)	$1,312,000	$725,000	$430,000	$602,000	$420,000	$3,669,000
Subtotal	$1,584,849	$997,131	$707,762	$934,183	$533,374	$4,757,300

U.S. Support	Year 1	Year 2	Year 3	Year 4	Year 5	Total
U.S. Support Labor	$64,422	$67,643	$71,025	$74,576	$0	$277,665
U.S. Support Travel	$14,469	$15,192	$15,952	$16,750	$17,587	$79,950
Subtotal Management	$78,891	$82,835	$86,977	$91,326	$17,587	$357,615

Totals		Year 1	Year 2	Year 3	Year 4	Year 5	Total
Contingency	5%	$104,817	$66,8[illegible]	$67,215	$6[illegible],745	$[illegible]	$[illegible]
Direct Training		$200,000	$200,000	$200,000	$200,000	$200,000	$1,000,000
TOTAL		$2,401,147	$2,124,814	$1,611,822	$1,[illegible]	$774,182	$[illegible]

Best Available Document

Table 0.1
SUMMARY OF COSTS FOR HIGHER BUDGET OPTION

Remote Sensing Component

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Long Term Technical Assistance	$[illegible]	$147,584	$154,963	$162,711	$0	$464,1[illegible]
D/S Allowances, Educ, Housing, Etc	$56,027	$104,984	$110,233	$149,642	$0	$420,847
Travel and Per Diem	$29,330	$83,711	$87,869	$92,263	$0	$295,[illegible]
Training	$214,059	$224,761	$133,129	$114,934	$114,934	$811,816
Consultants	$62,607	$65,979	$92,989	$92,989	$92,989	$227,787
Other Direct Costs	$41,740	$28,938	$30,385	$31,904	$33,499	$166,366
Subtotals	$472,550	$657,96[illegible]	$549,[illegible]	$[illegible]	$[illegible]	$1,[illegible]

Data Processing System Component

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Long Term Technical Assistance	$142,210	$149,320	$156,786	$164,625	$72,088	$691,030
D/S Allowances, Educ, Housing, Etc	$66,304	$54,771	$57,509	$77,334	$0	$256,418
Travel & Per Diem	$63,836	$68,040	$77,292	$73,898	$34,936	$318,002
Consultants	$120,000	$120,000	$80,000	$80,000	$80,000	$480,000
ARC Logistics	$100,000	$60,000	$30,000	$30,000	$50,000	$270,000
NAC Logistics	$200,000	$150,000	$120,000	$90,000	$60,000	$620,000
Telecommunications	$120,000	$80,000	$80,000	$80,000	$50,000	$410,000
Training	$250,000	$200,000	$200,000	$50,000	$20,000	$810,000
ARC New Equipment	$343,000	$145,000	$50,000	$200,000	$230,000	$968,000
NAC New Equipment	$274,000	$30,000	$30,000	$337,000	$30,000	$701,000
Subtotal (Cons-NAC...)	$1,407,000	$785,000	$590,000	$897,000	$580,000	$4,259,000
Subtotal	$1,679,849	$1,057,131	$881,587	$1,212,857	$693,374	$5,524,799

Monitoring Pilot Projects	Year 1	Year 2	Year 3	Year 4	Year 5	Total
U.S. Labor	$20,000	$21,000		$22,050		$63,050
Sahelian Labor	$15,000	$15,750		$16,538		$47,288
Travel & Per Diem	$30,000	$31,500		$33,075		$94,575
Subtotal	$65,000	$68,250		$71,663		$204,913

Management		Year 1	Year 2	Year 3	Year 4	Year 5	Total
Management Labor		$64,422	$67,643	$71,025	$74,576	$0	$277,662
Management Travel	$10,000	$14,469	$15,192	$15,952	$16,750	$17,587	$79,950
Subtotal Management		$78,891	$82,835	$86,977	$91,326	$17,587	$357,616

Total		Year 1	Year 2	Year 3	Year 4	Year 5	Total
Contingency	5%	$112,817	$97,099	$75,907	$46,164	$44,869	$426,856
Mission Support		$200,000	$200,000	$200,000	$200,000	$200,000	$1,000,000
TOTAL		$2,569,147	$2,159,491	$1,794,009	$2,125,552	$1,147,257	$9,815,457

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Table 0.3
SUMMARY OF COSTS FOR LOWER BUDGET OPTION

Remote Sensing Component	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Long Term Technical Assistance	$29,933	$147,534	$154,963	$162,711	$0	$494,1[illegible]
D/E Allowances, Educ, Housing, Etc	$56,087	$104,984	$110,233	$149,643	$0	$420,947
Travel and Per Diem	$29,370	$58,711	$67,369	$72,263	$0	$228,177
Training	$214,039	$224,761	$133,129	$119,934	$119,934	$811,815
Consultants	$62,337	$63,979	$32,989	$32,989	$32,989	$227,782
Other Direct Costs	$41,340	$23,438	$31,333	$31,914	$32,499	$160,[illegible]
Subtotals	$423,890	$627,456	$549,569	$529,444	$181,422	$2,4[illegible]

Data Processing System Component	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Long Term Technical Assistance	$150,473	$150,221	$156,732	$53,339	$56,279	$527,[illegible]
D/E Allowances, Educ, Housing, Etc	$110,167	$54,771	$57,509	$16,949	$0	$239,[illegible]
Travel and Per Diem	$70,136	$66,040	$63,460	$53,320	$50,225	$283,181
Consultants	$100,000	$40,000	$20,000	$0	$0	$160,000
ARC Logistics	$60,000	$50,000	$30,000	$30,000	$30,000	$200,000
NAC Logistics	$200,000	$180,000	$150,000	$100,000	$60,000	$710,000
Telecommunications	$2,000	$12,000	$10,000	$15,000	$20,000	$59,000
Training	$150,000	$90,000	$70,000	$70,000	$0	$380,000
ARC New Equipment	$250,000	$145,000	$25,000	$10,000	$10,000	$440,000
NAC New Equipment	$240,000	$46,000	$0	$200,000	$0	$486,000
Subtotal (Cons-NAC...)	$1,002,000	$563,000	$305,000	$423,000	$140,000	$2,435,000
Subtotal	$1,333,331	$816,032	$562,708	$528,868	$246,507	$3,487,4[illegible]

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Management		Year 1	Year 2	Year 3	Year 4	Year 5	Total
Management Labor		$35.139	$36.896	$38.741	$40.675	$0	$151.453
Management Travel	$10.000	$14.469	$15.192	$15.952	$16.750	$17.587	$79,950
Subtotal Management		$49.608	$52.088	$54.693	$57.427	$17.587	$231.404

Totals		Year 1	Year 2	Year 3	Year 4	Year 5	Total
Contingency	5%	$60.777	$76.304	$55.348	$58.787	$22.526	$313.742
Minus Guy-line		$200.000	$200.000	$200.000	$200.000	$200.000	$1,000,000
Tot		$1,1[illegible].327	$1,302.731	$1,423.[illegible]	$1,474.556	$573.142	$7,441.[illegible]

Lower Cost Option

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PART TWO
THE DATA PROCESSING COMPONENT

I. OBJECTIVES OF AGRHYMET DATA PROCESSING SYSTEMS

In general terms, the data processing facilities provided by USAID through NOAA/OOPS provide a high level of technical support to experts at the AGRHYMET Regional Center (ARC). It is clear from the 1985 Mid-Term Evaluation Report that without extensive computer support, Phase III objectives of the center can not be reached. However, as of 1985, sufficient computing capacity was not available to achieve these objectives and an appropriate upgrade of capacity and features was called for.

In the National AGRHYMET Centers (NACs), data processing has yet to become an integral part of the national services operation. This is due to many factors but primary is very late and inappropriate implementation. Without significant changes in the design philosophy, the national centers will never achieve adequate computerization.

In concise form, Phase III objectives of AGRHYMET data processing have been identified as:

1. Minimize recurring costs during Phase III
2. Provide a reliable system at all sites
3. Build a sustainable system beyond Phase III
4. Meet or exceed processing requirements, leaving room for growth
5. Design an upgrade schedule which anticipates advances in technology
6. Choose technology appropriate for the region

Program versès Project Sustainability

In this writer's opinion, ARC functionality can not be sustained without continued donor support past the end of Phase III. However, sufficient computer resources can be sustained through a combination of CILSS and other donor support if different configurations are implemented during Phase III which maximize effective capacity while keeping recurrent costs to a minimum.

The national services can function without donor input after the end of project, but only with low recurrent cost data processing systems.

II. MAJOR PROJECT FUNDING OPTIONS

While the USAID component of AGRHYMET funding is not a major one, it is a very important part of the overall project. However, due to changing priorities in Washington, continued funding at the levels of Phases I and II is unlikely. Four approaches can be identified, from complete withdrawal to a realistic design which minimizes recurring costs during and after Phase III. The following brief descriptions of these approaches references certain technical issues that are covered in more depth elsewhere.

A. Total Withdrawal

Total withdrawal of USAID support at the beginning of Phase III will have a profound effect on present and future operations of AGRHYMET. In the near term, maintenance and logistics tasks would become the responsibility of either Sahelian staff or other donor expatriates, leaving less time for their own duties.

At the ARC, the absence of U.S. technical support would be felt as soon as repair parts were needed from the US. Depending upon circumstance, this could happen within anywhere from two months to two years. Other donor funding to maintain the new VAX 780 computer would be essential and probably forthcoming, as both current modeling activities, the new French satellite receiving station, and future data base activity will depend heavily on it. Without the added capacity which the new VAX is slated to provide, ARC data processing needs will continue to exceed the capacity of the present systems.

At the national level, USAID support levels depend upon local talents and the status of installations. Those countries currently without operational systems will not be able to complete installation. In countries with installed systems but ineffective repair staff, ARC Sahelian staff can provide support without USAID but not without overextending their resources.

As a worst case, if another AGRHYMET donor were unable or unwilling to pick up data processing support, the regional center could lose its central data processing capacity within two years or less. The French remote sensing application could not be developed at Niamey, and any computing would be limited to that possible on personal computers.

At national levels, where few countries yet depend upon national data processing systems, the loss of the USAID component would be much less dramatic in the short run.

Data processing capability is a necessary component of continued developments in Phase III. Without additional support, national services will not be able to progress beyond current levels of manual analysis and document preparations. Furthermore, database development can not even begin.

B. Minimum Funding to Complete Objectives of Phase II

With respect to national data processing and telecommunications, the objectives of Phase II have not been completed by the end of the phase. Some lower level of USAID funding could assure completion of these objectives. However, data processing objectives, especially for the national components, were not appropriate for conditions in every country.

More importantly, as explained elsewhere in this paper, realistic recurring costs are of upmost importance. Current Phase II objectives have not adequately addressed the issue of realistic recurring costs, and will leave Phase III and beyond with unobtainable funding requirements.

C. Sustain Project at Current Rate of Progress

NOAA was requested to submit a budget for Phase III before the Project Design Team was fielded and there was no obvious effort at design. Thus, this budget can be considered as that required for a sustained rate of progress.

While this is almost like approach B, in that it presumes completion of Phase II objectives, it also describes a larger, multi-user computer configuration at NAC's as the solution to unresolved issues of data processing. While multi-user systems are usually more cost effective than personal computer networks, conditions in the Sahelian countries are not supportive of such complex systems.

D. Fund at a Level of Appropriate Technology

Current data processing capacity at the ARC attests to NOAA's technical expertise, and is designed to develop into a complex multi-user system. However, the current system has very high recurrent costs, the largest element of which is system maintenance. Single, large systems such as the present one can have astronomical repair costs if up-time is to be kept near 100%. In the United States, the economies of scale which a complex, multi-user system offers can potentially offset the need to maintain the main system at all costs, both because routine maintenance

is better and because both access to and cost of repairs is lower. In the Sahel, reliance on a single and complex central unit will invariably lead to an exorbitant ratio of maintenance costs to purchase price.

In a new design, total redundancy is not cost effective, as either the standby system is a waste of resources 95% of the time, or the demand for computing resources requires regular use of the standby system and redundancy is lost. A better design calls for the use of modular systems, with a single module specified as large enough to accommodate the largest processing task and enough modules specified to accommodate a normal demand for processing capacity. Failure of a single, and perhaps even of several modules (computers) may still allow critical functions to go on on the remaining modules, and the urgency of repair is significantly lowered. Repair costs can be kept within budget and up-time can approach 100%.

The same reasoning must apply at the NACs. If anything, the capacity to bear recurrent costs is lower, and the liklihood of prolonged equipment down-time is higher at the NACs. Therefore, a simple and reliable data processing solution must be designed at the national level. Personal computer "modules" should also be serviceable and supportable locally, reducing the need for expensive maintenance staff training and/or regional staff travel to backstop local staff. Because personal computer technology is newer than the now ageing PDP-11/34s, and because they are so widely used, they can provide both an increase in effective capacity (memory, storage, speed) and a much broader range of off-the-shelf software at reasonable prices.

III. TECHNICAL ISSUES

A. Data Processing

Much of the data processing equipment installed in the AGRHYMET program is of a 1970 design. Except for mechanical components, most of the system is as reliable as when it was new. However, newer technology is inherently more reliable and less costly to repair, due in part to lower component count (VLSI or Very Large Scale Integration). Newer mechanical designs for printers, tape drives, and disk drives are also designed with fewer moving parts and with better wearing materials.

Referring to the 16-bit address size technology discussion in the 1985 Mid-Term Evaluation Report, newer systems have the ability to run much larger applications programs. More commercially written programs and

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applications tools have been produced for newer technologies at less cost due to the ease of programming and the popularity of newer systems. Such a system has been installed at the ARC, but the national centers still have older technology.

While the large VAX 780 recently installed at the ARC answers questions of address size and program availability, it is not designed with VLSI technology. More importantly, it is an example of putting all of one's computing eggs in one basket. Even with the large set of spare parts delivered with the VAX 780, there will occur occasional component failures that can not be isolated and repaired in a short time (within one or two days). Because ARC staff will depend upon the VAX 780 for operational computing, down-times greater that two days will be an unacceptable level of availability, especially during critical seasonal activities. At such times, repair costs will exceed budget, if up-times must be kept near 100%. Practical budget considerations will permit only 80 to 90% up-time. Redundant or clustered systems are the only way to keep control of repair costs, and can provide more computing capacity at lower cost, especially if newer, VLSI technology is used.

The PDP 11/34 computers at the NAC's are specific examples of inappropriate technology. The dust of the Sahel is very destructive if allowed into a modern disk drive. The non-sealed design of the RA60 disk drive permits contamination if dust control is not rigorously practiced at the centers. The 11/34 has very little memory and program size capability by today's standards. As a multi-user system, the 11/34 can not serve the national users in their place of work (the ministry offices) without expensive, unreliable interactive terminal communications lines. (For example, a number of countries have received estimates of $3,000 per month to rent a remote, dedicated terminal circuit from the local telephone company that connects the ministry offices to the computer.) Even travel to and from the location of the 11/34 has become an obstacle to productive use of the system in some countries. Finally, a multi-user system is a single point of failure. If the PDP 11/34 goes down (as all have for extended periods), virtually all computer operations must come to a halt.

B. Telecommunications

In review, present telecommunications consists of single side band (SSB) transmission of instrument data from field to national service; telex or GTS transmission of national data to regional center; and telex or GTS

transmission of decadal bulletins from regional center to national services. Each activity has room for improvement (ref: 1985 Mid-Term Evaluation and 1984 Caliez and Kerherve reports).

More SSB radios are needed to increase the volume of real-time data. Better power supplies are needed for the existing radios. AGRHYMET computers at the national center are not interfaced to the Telex network or to the GTS. Telex and GTS transmission is non-interactive, so long delays are present for any transmission error correction task. Finally, GTS message handling is designed for short-lived, real-time weather advisories, so AGRHYMET messages can be lost if the GTS system overloads due to radio transmission failure.

None of the methods presently in use permit either an economical or reliable media for general data transmission. The AGRHYMET system can be viewed as a distributed computer network only if high-speed, interactive data communications is possible. More timely, accurate, and greater detail messages can be shared. Remote maintenance of system and application programs and data bases by a small cadre of regional center staff is possible, resulting in a better maintained system with lower transportation costs.

The only other network available in the region is the Panaftel long distance voice network. Questions of reliability, government regulation, and cost must be answered before this media can be integrated into the AGRHYMET program. Equipment to interface to Panaftel (MODEMS) should be purchased to prototype a network.

Long term cost of the Panaftel approach (in long distance charges) becomes a recurring cost issue. This approach may have to be only an interim method until a more cost effective approach becomes available.

One of the more promising transmission methods involves the use of one or more weather satellites (such as MeteoSat) with spare transponder capacity available to regional programs. Relatively inexpensive ground transmit and receive stations are available that would provide more than enough data transmission capacity for AGRHYMET with potentially very low recurrent costs.

Whatever approaches are investigated, the nature of facilities available in the Sahel requires a multi-donor approach to improving telecommunications for AGRHYMET. Enough studies have been done to define the problems and limitations of available media. Phase III should see some immediate prototype efforts of new approaches so that by the latter part of Phase III there can be a working distributed processing network for AGRHYMET. Again, the

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resulting telecommunications must have affordable recurring costs after the end of the project.

C. Software

Software applications development and implementation have not kept pace with requirements, due to the limitations of current systems, deferred system installation, and insufficient software staff. What has been written is appropriate to the requirements, well documented and easy to use. The project needs more sophisticated application software tools such as data base management systems, spread sheets and word processors that are uniform and compatible between national and regional centers. These tools will permit more rapid development and implementation of appropriate applications.

The only software development tool currently available is FORTRAN. Applications that are useful to AGRHYMET and that run on current systems have not been available commercially.
This had forced in-house development with all of the attendant problems of programming, including extended development times, staff turnover, unpredictable debugging times, very high development costs relative to the price of available PC software, and the limitations of available expertise. More funds should be available for applications programmers and experts to investigate commercial sources and communicate with colleagues involved in the same work elsewhere.

D. Technical Support

In order for AGRHYMET to achieve overall goals within a limited budget, regional and national staff need the best technical advice available to make effective use of available resources. While the NOAA technical manager has become familiar with the problems of the Sahel, there needs to be a continued flow of technical advice and information from all sources. The project needs short term consultants, properly briefed on conditions found in the Sahel (as this project has had enough written about it to more than adequately brief any future consultant, time must be set aside for reading it).

Much of the technical support has been in the form of maintenance and logistics supervision. This is necessary but not sufficient. Travel difficulties do not permit rapid response when national centers call for assistance to the regional staff. Experience has shown that it is very difficult to train and keep effective repair technicians at the national centers. A number of sites have remained inoperable for long periods of time due to support problems.

US-based training of maintenance personnel has proven to be very costly with significant inefficiencies. Personnel loss and inadequate job performance resulted in very spotty success in keeping national center computing systems operational. Less complex national systems, local support available to national centers, and more cost effective training will help make better use of available personnel. More emphasis must be placed on on-the-job training (OJT) of operations and maintenance staff working toward self-sufficiency.

Phase III should see an emphasis put on the Sahelianization of technical support. It could take the full five years to institute improved selection, training, and conversion of equipment as well as implementation of a logistics chain of supply that is affordable after the end of project.

Now is the time to find alternative sources of technical support through competitive bidding. This would include advice, maintenance, and training. After 10 years of experience, AGRHYMET and USAID contractors can write a set of performance requirements that can assure adequate and monitorable performance of a commercial contractor at the best cost benefit.

The issue of adequately monitoring the progress and performance of the various USAID components of the project has been raised numerous times during the Mid-Term Evaluation and the Project Design Paper mission. A satisfactory method must be applied no matter who is the provider of Phase III technical services. The mission at Niamey has the final responsibility for monitoring the project but has limited in-house technical expertise and severe time limitations.For the project design to be complete, specific time-based objectives must be identified and agreed to by all parties and periodic reviews of status and performance held at the regional level. This activity alone can justify the effort required to improve the data communications capability of AGRHYMET.

E. Training

One of the more important aspects of technical support is training. The project can not meet its objectives without a cadre of trained and experienced Sahelians to operate and maintain all telecommunications and data processing components.

US-based training of maintenance personnel has proven to be very costly with significant inefficiencies. Attrition and inadequate job performance resulted in very

spotty success in keeping national center computing systems operational. At the current rate of loss of trained maintenance personnel, 20-30% of the proposed Phase III USAID budget will be needed to maintain adequate staffing levels with current equipment during Phase III.

Phase III must include actions to reduce the cost of technical training and the requirement for US-based training. At the ARC, facilities are available to provide most of the vendor specific training, if expatriate instructors are provided. In Niamey, the local university should be tapped for either graduates or a course of study that will satisfy the requirements for a general, technical education that the Phase II US-based training supplied.

As is emphasized elsewhere in this annex, the current level of data processing equipment is too old and complex to be successfully maintained in the long run. A redesign in Phase III must take into account reducing the requirements for trained, dedicated maintenance personnel.

Two main rationales have been given for US-based training:

- that to become proficient in computer maintenance, trainees would in any case need to learn English
- that such training would "add to the general education base of the Sahel"

With respect to the first point, the computer industry is becoming increasingly international (this was not the case when the training programs were begun), and French-language training and documentation is now widely available.

While the second rationale may have some internal merit, it seems unjustified to conclude that training Sahelians in maintenance of costly and sometimes unecessary equipment is the best way to do it. Moreover, the high attrition rate combined with the poor repair record at NACs suggests that whatever the secondary benefits, this approach provides little value for the money to the AGRHYMET Program.

Finally, the cost to the countries after the end of Phase III of keeping a satisfactory level of US-trained staff at a 50% attrition rate is obviously unaffordable. Other sources of training must be identified or developed.

IV. PHASE III DATA PROCESSING PLAN

A. Project Requirements

The following project requirements are based upon interviews with ARC and NAC staff, the 1985 Mid-Term Evaluation and an number of reports written by ARC staff and consultants. Almost all of the software required can be purchased in the US or Europe but requires a significant redesign of the hardware systems.

1. Regional Center

Software requirements include but are not limited to:

	Personal	Multi-User
Software development tools	x	x
Data collection		x
Model development	x	o
Spread Sheet	x	o
Statistics	x	x
Communications		x
Word Processing	x	
Data Bank	x	x
Data Base	x	o
Mapping	x	o
Image Processing		o
Presentation Graphics	x	o
Inventory control	o	[illegible]
Training and tutorial	x	[illegible]
Networking	o	

The table indicates what is available as of 1986 (x) and what should be available in Phase III (o).

Online data storage requirements (multi-user)

1200 MB base level
150 MB average annual addition

Central processor requirements (multi-user)

High degree of reliability
4 MB Applications software size
Simultaneous support of 30 users and 10 automatic tasks

None of these requirements are met with current production systems at the ARC. When the VAX 780 becomes productive, the high reliability requirement can not be met and the system will not provide a satisfactory response when loaded with 30 users and 10 automatic tasks.

Input/Output requirements (multi-user)

Graphics plotting to 300 steps per inch
Color graphics display
40 serial transmission lines
Network interface (Telephone MODEMS, Telex, or GTS)
20-30 ANSCI CRT Terminals
High speed printer
Removable Media for backup, program distribution, and archive including industry compatible tape drive

Color graphics requirements are not currently met either with software or hardware.

2. National Centers

The NAC's have very little in the way of productive software as yet installed and applied, except on various personal computers scattered throughout the ministries. At a few of the NAC's, local staff have written productive programs to solve some of the needs, but these programs have not been shared through the region.

Software requirements include but are not limited to:

	Personal	Multi-User
Software development tools	x	x
Spread Sheet	o	
Statistics	x	
Data collection	o	x
Communications	o	x
Word Processing	x	
Data Bank	o	x
Data Base	o	
Mapping	o	
Presentation Graphics	x	
Training and tutorial	x	

The table indicates what is available at some national centers as of 1986 (x) and what should be available in Phase III (o).

Online data storage requirements

620 MB when all applications are operational

Central processor requirements

High degree of reliability
3.4 MB Applications software size
Simultaneous support of 4 users and 4 automatic tasks

Input/Output requirements

Graphics plotting to 300 steps per inch
Color graphics display
4 serial transmission lines
Network interface (Telephone MODEMS, Telex, or GTS)
High speed printer
Removable Media for backup, program distribution, and archive

The color graphics requirement is not met either with hardware or software at present.

3. Technical Services

AGRHYMET Phase III activities and applicable advances in technology change the requirements for technical services beyond that provided by the USAID contribution during phases I and II.

The overriding concern for lowering recurring costs changes the needs for maintenance and logistics. Since local (and European) vendors must play a larger support role, ARC technical services must provide more of a liaison between multiple vendors rather than the sole source of maintenance and logistics support as is now.

The network design for Phase III will require new technical expertise to maximize the utility of the ARC network. This expertise must extend beyond maintenance and logistics to include multi-disiplinary systems analysis abilities.

A successful telecommunications network throughout the region will require additional expertise, especially a knowledge of satellite communications technology but especially the conditions and problems found in the region.

At the ARC, the technical staff is forming into a closely knit team, working together to resolve the many problems of the program. During the crucial Phase III, US technical services must become an integral part of that team, working with ALL of the staff.

More emphasis must be placed upon training in country looking toward a Sahelian operation after the end of the project.

Listed together, the requirements of technical assistance are:

1. Maintenance
2. Logistics
3. Technical advice
4. Liaison to Western expertise pool and fellow users
5. Telecommunications design, selection and implementation
6. System network design
7. System software selection and implementation
8. Technical administration of USAID budget
9. Training toward Sahelianization of maintenance and logistics staff
10. Liaison between system vendors and ARC staff

Project-Furnished Staff at ARC:

One full-time manager of technical services responsible for maintenance and logistics (as now) but also as liaison between hardware and software staff serving as a systems analyst in OS, telecommunications and networking, for three years.

One or more short-term instructors to provide on-the-job training of Sahelian maintenance, software and logistics staff.

One part-time U.S.-based manager (shared with the remote sensing component) who understands problems and possibilities of the Sahel and can communicate with all technical staff at ARC to act as technical backstop. Requires a technical background in computer system analysis, telecommunications, software, and networking and experience with Sahelian projects, USAID proceedures, WMO, and CILSS functions.

A part-time U.S.-based logistics staff person to expedite purchase orders and repair parts shipments.

One or more short-term experts in telecommunications and networking to set up a workable data communications system throughout the region.

Two local hire staff, one for logistics and one for maintenance. These persons could be replaced by CILSS-provided staff, but it is recommended that they be paid by the U.S. during Phase III because: (a) Their functions are necessary to this component, but it is more cost-effective to use local hire personnel than to use expatriates, and (b) technically qualified Sahelians or other local hires are available.

B. Project Design

1. Regional Center

Data processing implementation can be divided into three stages for purposes of discussion. The first is the current capability at the ARC. The second is the additional capability provided when the VAX 780 becomes operational. The third includes how the center evolves until the end of Phase III to satisfy the major criteria of reliable, adequate data processing capacity with a minimum recurrent cost.

The older technology Digital Equipment VAX 780 (non VLSI) does not meet any of the major criteria of this design as it is currently configured. One of the major rationales for its purchase was a future capability to cluster a group of 780's to permit versatile sharing of main memory, disk and input/output between elements of the cluster. Until recently, the 780 was the only processor that was compatible with current software and storage devices at the center and could be clustered. Now, Digital Equipment can provide a clustering capability with newer technology in the MicroVax product line that is 90% of the capacity of a 780 for as little as 20% of the cost of a 780.

The cluster concept provides reliable, cost effective central processing capability with the ability to add additional elements as processing requirements dictates. An Ethernet local area network can be used to interconnect the MicroVaxes, terminal clusters and personal computers throughout the center complex at Niamey. Major mass storage can be either distributed among "cluster elements" or concentrated on one "file server" processor.

One of the stronger reasons for specifying Digital Equipment is not current software and hardware compatibility, although that is a necessary condition. Digital is one of the few major computer vendors that can now deliver compatible hardware and software networking between their multi-user systems and the MSDOS-based personal computer that provides most of the communications, mass-storage sharing and file transmission capability that is required at the regional center.

2. National Centers

The Digital Equipment PDP 11/34 multi-user system installed in six of the eight countries has proven to be unsupportable and inappropriate technology for the national centers and can not support most of the software applications that are required.

A small number of personal computers, some with multi-terminal capability to support data entry, stationed in each of the active GTP ministries will better serve the users. Each of the systems will be tailored with software, mass-storage, and special peripherals (plotters, digitizing tablets, and color displays) to match the needs of the specific ministry. IBM compatible personal computers can be serviced locally in a number of the capital cities, and the distributed nature of the configuration eliminates any critical single point of failure, an absolute necessity to contain recurring repair costs.

Programmers at the ARC are already developing applications that run on personal computer spread sheets and have studied the feasibility of transporting the SUIVI water data bank software to MSDOS. Data Base Management software is commercially available which will run on ARC Digital computers and NAC personal computers.

Data communications costs within the national capitals remain a serious reliability and cost problem. However, short and periodic data transmissions between personal computers can be made much more reliably and cost effectively than that required by terminals located in divergent ministry buildings connected to a central timesharing PDP 11/34. One or more of the personal computers will be designated the data collection and regional communications processor and will have to be connected to the telephone, telex, GTS, or satellite system.

C. System Configurations

1. Regional Center

The building block of a redesigned ARC processing system is the cluster element. Two or more elements would form the network that would support a growing demand for computing and data communications between staff at the center.

Software

Multi-user operating system (VMS)
FORTRAN compiler
BASIC interpreter and compiler
Program development tools
Data Base Management System
Spread Sheet
Image Processing
Mapping
MSDOS support software
DECNET network communications
Serial data acquisition
Word Processing
Presentation Graphics

Cluster element

MicroVax with 4 Mb main memory,
2 RA60 disks,
1 DHV11 serial line multiplexor
Diskette drives
Ethernet interface

An increasing role for MSDOS-based IBM compatible personal computers is expected, provided increasingly by the donor countries of the various experts at the center. The cluster network must be available to these systems to increase the ability to share data and ideas among staff. This would be accommodated by Ethernet interfaces on each PC, integrating them into the cluster network and making available extensive MSDOS support tools in cluster elements.

It is envisioned that up to four cluster elements will be needed to satisfy computing demand over Phase III. It is also expected that the cost of each cluster element will decrease over time. At current prices, a cluster element is estimated to cost $125,000, including software and spare parts.

2. National Centers

Four system configurations are recommended for each of the national centers:

- Hydrology application: water budget and report generator ($15,000)
- Meteorology Application: image processing ($14,700)
- Hydro and Metec Application: data base management ($19,650)
- Meteorology Application: models ($16,850)

The total cost for the four configurations is approximately $66,000 per country, inclusive of all software and hardware. The configurations are specified in greater detail on the following pages.

System configuration #1 (Hydrology application: water budget and report generator)

One of the most important modules that must be installed as soon as possible. Software can be adapted and operational very early through the use of advanced applications development tools, such as the spread sheet.

Software

Spread Sheet
Statistics
Word Processing
Mapping
Communications
Utilities

Hardware

PC AT compatible with 2 Mb of main memory,
math coprocessor,
140 Mb of fixed, winchester technology disk
2x20 Mb of removable, winchester technology disk,
Quad Density, Double Sided diskette drive,
Matrix printer/plotter with greater than 300/in resolution,
4 communications channels (communications, digitizer, terminal, and plotter interface),
Terminal,
Digitizing Tablet,

Inverter, Battery and Charger (UPS),
and Communications Interface.

System configuration #2 (Meteorology application: Image Processing)

The second most important module, requested by the national services to display and manipulate remote sensed satellite data currently available from the US and eventually available from French furnished facilities at the ARC.

Software

Word Processing
Mapping
Image Processing
Communications
Utilities

Hardware

PC AT compatible with 2 Mb of main memory,
math coprocessor,
70 Mb of fixed, winchester technology disk
2x20 Mb of removable, winchester technology disk,
Quad Density, Double Sided diskette drive,
Color monitor with greater than 720x540/in resolution,
Matrix printer/plotter with greater than 300/in resolution,
3 communications channels (communications, digitizer, and plotter interface),
Digitizing Tablet,
Inverter, Battery and Charger (UPS),
and Communications Interface.

System Configuration #3 (Hydro and Meteo application: Data Base Management)

The system which will take the most development work and may have to be deferred to later in Phase III for this reason.

Software

Data Base Management System
Statistics
Spread Sheet
Word Processing
Communications
Utilities

Hardware

PC AT compatible with 4 Mb of main memory,
140 Mb of fixed, winchester technology disk
2x20 Mb of removable, winchester technology disk,
Quad Density, Double Sided diskette drive,
Matrix printer/plotter with greater than 300/in resolution,
2 communications channels (communications, and plotter interface),
Inverter, Battery and Charger (UPS)
and Communications Interface.

System Configuration #4 (Meteorology application: Models)

This is the one module for which software already has been developed on the existing PDP 11/34 system -- the SUIVI software chain. Therefore, development of a new PC-based module can be delayed until just before the PDP 11/34 is phased out in each country. This in no way argues that the PDP 11/34s should be used any longer than is necessary, however, since maintenance costs at the NACs will be higher for each year they continue in use.

Software

SUIVI Chain
Spread Sheet
Data Base Management System
Word Processing
Statistics
Communications
Utilities

Hardware

PC AT compatible with 2 Mb of main memory,
math coprocessor,
70 Mb of fixed, winchester technology disk
2x20 Mb of removable, winchester technology disk,
Quad Density, Double Sided diskette drive,
Matrix printer/plotter with greater than 300/in resolution,
2 communications channels (communications, and plotter interface),
Versitec interface,
Inverter, Battery and Charger (UPS),
and Communications Interface.

V. IMPLEMENTATION SCHEDULE

Figure 1 shows the proposed schedule for planning purposes. The actual time-line will depend upon how long the VAX 780 is kept at the center, when software and training is complete for national services staff, and budget constraints. It is strongly suggested that an evolutionary method of conversion be followed, using the present equipment as long as no other functional replacement is available (with adequate development, testing and training), but bringing in lower cost equipment as soon as possible in order to hold maintenance costs in line.

At the National Centers, a schedule for new computer installations is suggested that will phase in "modules" as needed that are appropriate for each country situation. For instance, at NAC's with operational PDP 11/34s, delivery of the models module can be deferred until all parties agree that there is no longer any use of the PDP 11/34. A number of countries can continue to use the special environmental space that was prepared for the PDP 11/34 as it will serve as excellent space for one or more of the new modules.

VI. TRAINING

A. Regional Center

A less-complex cluster of super-microcomputers will reduce the need for highly trained maintenance staff in the long run and will provide a means to train local staff in maintenance and operations duties by taking one of the cluster elements off- line for OJT troubleshooting and repair simulation sessions.

The budget includes funds for training of one more ARC permanent maintenance staff, expatriate instructors to serve part time at the ARC, and training materials.

B. National Centers

As the PDP 11/34 systems are phased-out, the very specific training received by remaining maintenance staff in each country will be perceived as wasted. An effort (through an orientation seminar, for example) should be made to council remaining staff that their lessons and experiences can be applied to new technologies as well if the techniques of diagnosis and the basic principles of computing are shown to apply to new situations.

IBM-compatable computing modules will not require two full-time maintenance personnel in each country. The remaining personnel should be redistributed among various

Figure 1

EQUIPMENT AND OPERATIONS: IMPLEMENTATION SCHEDULE

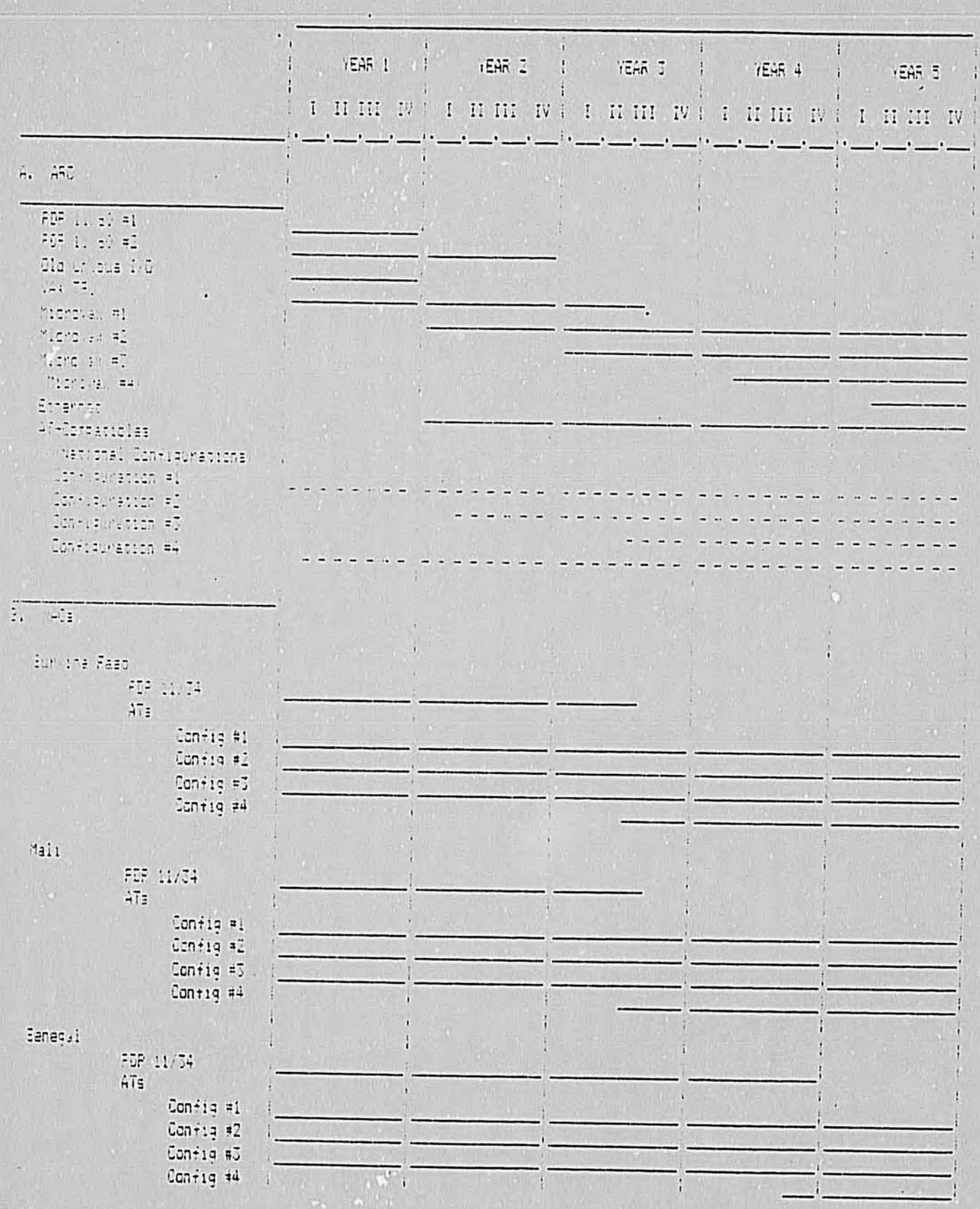
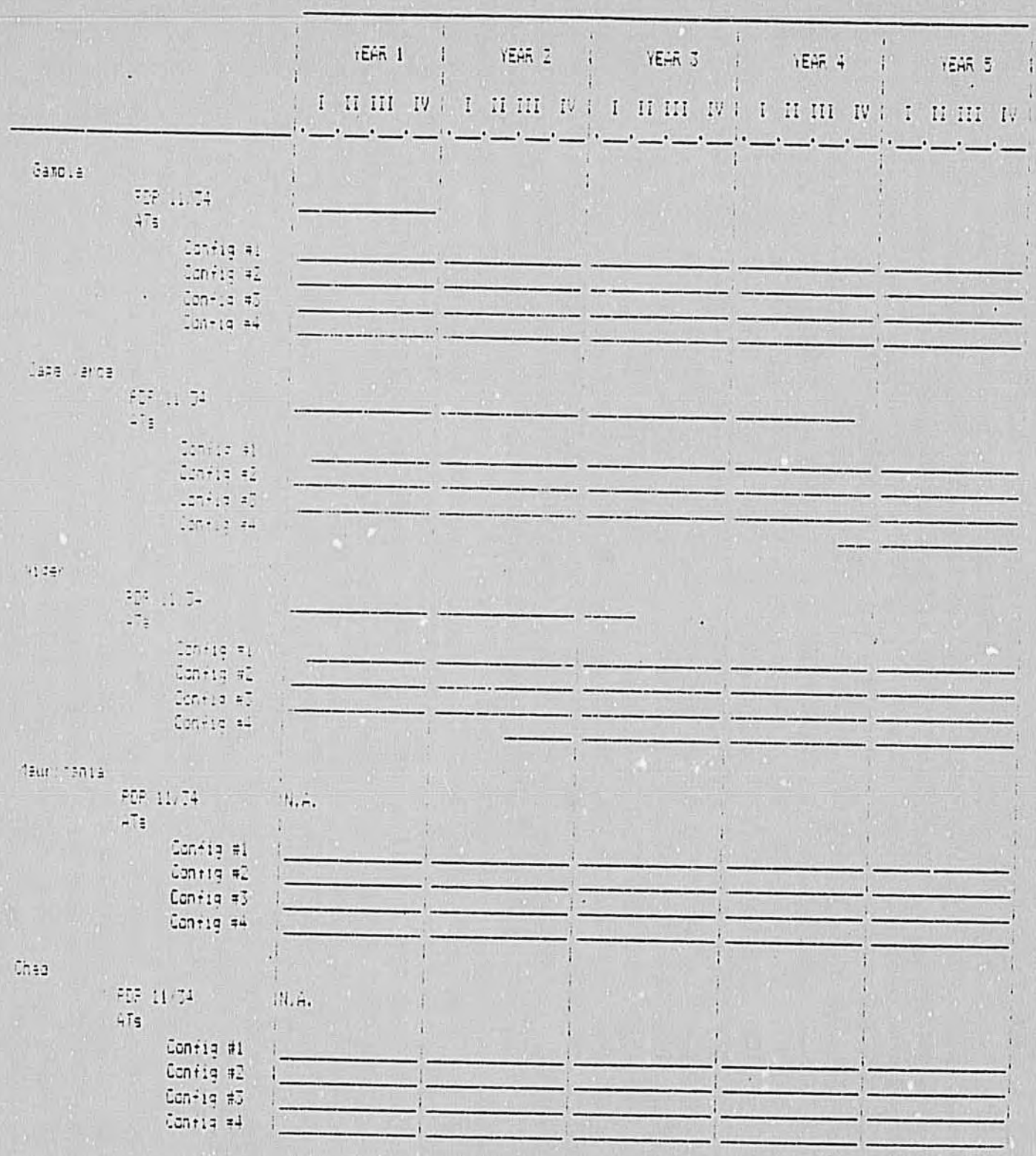


Figure 1

EQUIPMENT AND OPERATIONS: IMPLEMENTATION SCHEDULE



countries and the regional center if conditions permit. A few of the national center staff who have already shown good work performance and applications of training could be considered as a source of instructor material at the ARC.

The new computing modules can be repaired by locally available vendor staff in a number of the countries. Additional training of the technical staff (hydrologists, meteorogists, etc) to recognize, diagnose and deal with system failures will prove to be the most efficient as these will be the direct and everyday users of the modules. This additional training should be added to the ARC training curriculum of new technical staff and as continued training of existing staff. In addition, the chances of retaining trained subject-matter staff in the national centers after the end of Phase III seem much greater than retaining specialized computer repair staff.

Any further US-based training (beyond current candidates now in the states) will be completed too late to apply their training to national PDP 11/34 systems. The budget includes funds to develop (or contract) instructors at the regional center for OJT and additional training of technical staff, training materials, and tuition at European or Sahelian technical schools for two to three more "back-stop" maintenance staff based at the regional center. All of these measures should significanty reduce recurring costs after the end of the project.

One of the most powerful new techniques of technical support in the United States is the "hot line" or central telephone support services offered by a large number of computer vendors. Due to long-distance costs, current practices and telephone reliability, this technique is not currently applicable in the Sahel. A hot-line type of support could be developed only if telecommunications facilites were made availabe through satellite channels as discussed in the technical issues. Then a small number of highly trained maintenance staff at the ARC could assist technical staff in each country deal with occasional difficult hardware and/or software problems.

Table 1 below shows the recommended training program for the data processing component:

Type of Training	Number of Trainees	Length of Training	Location of Training
PC Maintenance	27	3 weeks	Niamey

Software Devt	36	3 weeks	Niamey
VAX/MicroVax	6	3 months	Europe
LT Training	3	1 year	Europe/US
Refresher Courses	10	1 month	Niamey/Europe
User Groups (Software)	80	2 weeks	NACs
Electronics, etc.	18	2 months	Niamey/Europe

VII. BUDGET OPTIONS

Three budgets are proposed, in line with instructions to the design team. For purposes of discussion, these are referred to as the "recommended configuration", the "lower cost option" and the "higher budget option". Summary tables for all three are provided in Table D.1-D.3, which also summarize the budgets for the remaining project components.

The recommended design configuration has a total cost for the data processing system of $4.76 million (exclusive of the U.S.-based management, which is included in the integrated project budget.

The lower cost option has a data processing system cost (exclusive of management) of $3.49 million. It is considered a "bare bones" budget which reduces technical assistance substantially reduces both ARC and NAC new equipment purchases. This implies greater continued reliance on the existing equipment, and, as importantly, on existing design philosophy. The consequence of continued reliance on existing equipment is that anticipated repair and maintenance costs are higher, as reflected in the line items ARC Logistics and NAC Logistics. The principal disadvantage of this option is that it increases the long term recurrent costs of the post-transition system by saving capital costs during Phase III.

Finally, the higher budget option reflects changes the design team would propose if AID had more funds available for Agrhymet. The philosophy underlying this option is that more money should not be spent on a task simply because it is available. Specific increases are proposed only in areas where the marginal value of increased expenditure is high or where a new and useful subactivity can be undertaken. The principal line items which increase in this budget are Long Term Technical Assistance (the resident expert is extended for a fourth year), short term technical assistance, NAC Logistics (repair and maintenance and support to national centers) and a sizable increase in telecommunications, allowing AID to make a larger contribution to solving this critical

program obstacle. In the integrated budget (combining both the data processing system and other components of the project), this option also allows funds for AID to monitor the Agricultural Pilot Projects in the hopes of helping keep the interpretations and expectations with regard to these pilot projects within reasonable limits. The cost of the data processing component in this option is $5.52 million.

VIII. CONCLUSIONS

The data processing facilities provided by USAID through the NOAA/OOPS technical management provide a high level of technical support to experts at the AGRHYMET Regional Center. However, sufficient computing capability is not yet available to achieve all of the overall objectives of the AGRHYMET program.

In the National AGRHYMET Centers, data processing has yet to become an integral part of the national services. Without significant redesign, the national centers will never achieve adequate computerization.

The Phase III objectives of the AGRHYMET data processing component have been determined to be:

1. Minimize recurrent costs during Phase III
2. Provide a reliable system at all sites
3. Build a sustainable system beyond Phase III
4. Meet or exceed processing requirements, leaving room for growth
5. Design an upgrade schedule which anticipates advances in technology
6. Choose technology appropriate for the region

Of the various funding options available to USAID, the one which meets these objectives is proposed in the Technical Annex. In addition to meeting the objectives, it answers a number of technical issues; including accommodating software not now available to the ARC, reducing repair costs, putting national computing resources closer to the user, solving some of the problems of telecommunications, and reorienting the thrust of specialized computer training.

The design calls for the gradual phase out of older or inappropriate technology and its replacement by newer equipment that is compatible with previous hardware and software, yet more available in and adaptable to the region. By gradually phasing in new technology, the supply of data processing capacity can track an expected increase in the demand for such capacity while also

providing future options to accommodate advances in technology.

Of all of the problems found in the region, data communications is the most difficult to solve by the efforts of a single vendor. Exciting and potentially very cost effective solutions may be available using other donors' satellite communications capacity. An immediate and major effort should take place as soon as possible to begin taking advantage of this media as rapid and accurate data communications is a necessary component of a successful Phase III AGRHYMET program.

Phase III should see an emphasis put on the Sahelianization of the technical support of AGRHYMET. It could take the full five years to institute improved selection, training, and conversion of equipment as well as implementation of a logistics chain of supply that is affordable after the end of the project.

In today's market, there are more organizations with the capability to provide Phase III technical support than were available at the beginning of USAID support. It is strongly recommended that the proposed design and future technical support be obtained through competitive bids.

PART THREE
THE REMOTE SENSING COMPONENT

This component will provide the basic technical assistance and training required for the Agrhymet system to interpret AVHRR satellite data, to calculate and use normalized vegetation indices and other measures of vegetation status, to refine interpretation methods, to develop simple user friendly software packages which permit broader application of the NVIs and other results of the remote sensing information and to transfer the skills necessary to the use and interpretation of satellite data to ARC and NAC staffs.

The AID financing for this component will complement two on-going activities financed outside the AID system. France has financed and begun construction on placement of an AVHRR receiving station in Niamey which will permit the ARC to receive daily satellite data from the NOAA (U.S.) satellite in real time. France has further committed to provide ARC with the technical assistance necessary to put this data on diskette in a format consistent with the current NOAA AISC system requirements (using the U.S.-supplied ARC computer facilities). The French effort is scheduled to be fully operational by December 31, 1987. While France has committed to this effort and has begun implementation, the utility of the contribution is linked to the assumption that some other donor (presumably the United States) will provide the forward linkages proposed under this funding component.

Simultaneously, the ARC is using staff trained by NOAAS/AISC, with the assistance of a resident expatriate advisor, to perform vegetation assessments based on the AVHRR data, NVIs and satellite imagery now being provided by the United States. ARC expects this cadre of trained Sahelian specialists to bear the main burden for ten-day assessments and crop yield forecasting using satellite data. Again, this expectation is premised on the assumption that the United States will provide the hardware, technical assistance and training required to make the overall system operational.

Technical Assistance

This proposed component of the SWD&M III Project calls for provision of two long-term resident technical advisors:

A Satellite Data Analysis Programmer for 42 months, commencing in month 1. This advisor must be a qualified programming specialist familiar with microcomputer technology and with available software packages for database management, spreadsheet, mapping programs and lower level programming languages (basic, Pascal, etc). He/she need not have a degree in computer programming, but should have a technical graduate degree (Masters or above) with at least five years experience in programming and computer program design and development, preferably in a natural resources-related field. Developing country experience is highly desirable but not essential. Good French language reading and speaking is required (FS 3), especially for counterpart training and training of NAC staffs in software applications.

A senior Satellite Data Use Specialist for 36 months, commencing in month 12 and ending in month 48. This individual should have an advanced degree in agrometeorology or some closely related discipline, with specific expertise in working with satellite data on agriculture, natural resources and meteorology. She/he must be fully conversant with satellite and computer technology uses for agrometeorology, and should have proven experience in biomass/vegetation assessment methodologies and program development. Long-term developing country experience is highly desirable but not essential. FS 3 French speaking and reading skills are required.

A total of 26 person-months of short-term specialists will be required to provide focused technical support to the assessment and skills transfer activities being conducted in the field. This technical assistance will be largely in statistics, crop yield monitoring, photointerpretation and other specialized assessment techniques.

Training

Annual training courses are recommended for each of the five years of the project. The purpose of the training is to thoroughly familiarize participants with the methodology, uses and techniques of the satellite data-based crop yield assessment and forecasting process,

and the create a corps of specialists in each country and at the ARC capable of implementing an operational assessment program. The annual training program will consist of a six week course similar in scope and contents to the course offered by NOAA/AISC and CIAM at the University of Missouri, Columbia.

Up to fifteen (15) Sahelian participants from the NACs and the ARC will be financed each year. The training program will take place in the United States in years 1 and 2, and at the ARC in each of the next three years. It is essential to the success and the cost-effectiveness of the training program that there be strict selection criteria for limiting the number of participants to those with appropriate background and aptitude for taking the lead in future implementation. The recommended training program is also built on the expectation that up to two of the trainees from the first two annual courses can become sufficiently proficient to serve as instructors in subsequent courses in Niamey. Use of some Sahelian instructors and of ARC facilities will reduce training courses substantially in years 3-5.

Equipment

All hardware and most of the software required to offer this component of the project will be purchased under the Data Processing component. Hardware will consist of AT- compatible microcomputers with hard disk at the ARC and each NAC, plus high resolution color monitors and some plotting equipment. Software will consist primarily of off-the-shelf packages for which applications templates (modules) will be developed by resident expert staff. Additional budget is included for consumables and miscellaneous items.

Budgets

Tables D.1-D.3 summarize the budgets for the Remote Sensing as well as the other project components. The total estimated cost of the Remote Sensing component is $2.42 million, exclusive of the U.S. management support costs, which will be shared with other project components. Tables D.1-D.3 show the Recommended, High and Low budget options for the project. It should be noted that the differences in these options results from changes in the Data Processing component and from inclusion, in the High Budget Option Case, of the Agriculture Monitoring component. The Remote Sensing budgets remain the same in all three budget options.

Part Four: Agricultural Component

A. E. Hall

January 1987

Agricultural Technical Annex

SAHEL WATER DATA AND MANAGEMENT III

Executive Summary

The objectives of this annex are: to evaluate the utility of the AGRHYMET regional and national programs and the pilot projects in several CILSS countries; and to suggest ways by which USAID can contribute to the overall AGRHYMET program. The goal of the program is to improve food security in the CILSS countries by assisting farmers to increase food production and by contributing to the development and operation of systems for predicting the extent and severity of famines. The main opportunity for AGRHYMET to meet this goal is through the provision of weather data and agroclimatological analyses to assist government planners, agronomists and extension agents to provide farmers with more effective cropping systems. AGRHYMET, however, is beginning to move away from this traditional approach and through the pilot projects it is attempting to help farmers directly through the use of agrometeorological advice based upon real-time weather data. Unfortunately, no convincing agruments have been presented to show concrete ways by which real-time weather data are useful to farmers, and this approach is expensive. The successes of the pilot projects in increasing productivity are mainly due to the provision of agronomic rather than agrometeorological advice. Recommendations are presented in the annex for the redesign of the pilot projects.

USAID can contribute to the traditional and effective activities of the AGRHYMET program by providing computer equipment and software, weather station instrumentation, and training in the use and maintenance of the equipment. An option is described whereby USAID could contribute to improved weather data collection, transmission, analysis and storage, the acquisition and analysis of remote sensing data for predicting famines, and a support services unit at AGRHYMET center. This USAID component would be sufficiently complete to guarantee its success, if properly executed, irrespective of variations in performance by other components of the AGRHYMET system. The continuing availability of reliable weather data and agroclimatological analyses is essential for virtually all agricultural development projects in the CILSS countries, and this will require an effective AGRHYMET system.

Agricultural Technical Annex

SAHEL WATER DATA AND MANAGEMENT III

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1. Sorghum Yields in the Pilot Project in Mali (Konaté and Traoré, 1986)

2. Millet Yields in the Pilot Project in Mali (Konaté and Traoré, 1986)

3A. Cultural Operations in the Pilot Project at Tanghin, Burkina Faso 1985

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D. Travel schedule of A. E. Hall

E. Discussion of some key questions raised by USAID/W

1. Preface

This Technical Annex for the USAID Project Paper for "Sahel Water Data and Management III" was prepared following the terms of reference described in the Project Identification Document (625-0973) which are identical with the scope of work (Appendix A) described in the Associate Employment Agreement with Development Alternatives Inc., Washington D.C. A more detailled description of the overall objectives of the team provided by AID/W (Appendix B) and comments from the AID project committee in Washington (Appendix C) were consistent with the scope of work. This project is the USAID component of the extensive AGRHYMET PROGRAM which also receives major funding from UNDP, WMO, FAO, CILSS and several countries.

The preparation of an individual report, rather than an integrated report was the most effective way for this consultant to contribute to the team effort given the short period of time available and tight travel schedule (Appendix D). The main conclusions concerning the applications of meteorology and climatology to agriculture in the CILSS countries of West Africa are largely independent of the subjects analyzed by the other members of the team. The consultant interacted closely with the team leader, Asif Shaikh, the agricultural economist, Martin Billings, the computer engineer/systems analyst, Earle Nay, and the institutional analyst, William Rutherford to insure that the recommendations concerning USAID assistance to AGRHYMET are reasonably consistent with recommendations of other members of the team.

The time available and working conditions did not permit a complete evaluation of the agrometeorological and agroclimatological activities of AGRHYMET. However, some conclusions were reached which should be carefully considered if USAID decides to assist AGRHYMET to contribute to improving food security in the CILSS countries comprising Burkina Faso, Cape Verde, Chad, Guinea Bissau, Mali, Mauritania, Niger, Senegal and The Gambia.

This consultant particularly appreciated the discussions, advice and assistance provided by C. Dancette, Agroclimatologist at AGRHYMET Center, Niamey, and the logistics support provided by D. Maxwell and the staff of the AID Mission in Niger and the Missions in Mali and Burkina Faso.

A draft of this technical annex was provided to all members of the team, the AID Mission in Niger and representatives of AGRHYMET Center on November 18, 1986 prior to my departure from Niger. The main conclusions and recommendations in the draft are the same as in this final version which provides additional analysis and documentation.

A. E. Hall

2. Introduction

Sahel Water Data and Management III would be the third phase of a USAID project designed to help the AGRHYMET Program. The goal of this program is to improve food security in the CILSS countries by assisting farmers to increase food production and by contributing to the development and operation of systems for predicting the extent and severity of famines. The terms of reference of this consultant (Appendix A) are discussed under headings 3, 4 and 5. Key questions raised by AID/W (Appendix B), which were not explicitly covered in the main part of the report are discussed in Appendix E.

3. Evaluate the utility of the AGRHYMET regional and national programs particularly the pilot projects currently programmed in Niger, Mali, Senegal and Burkina Faso

3.1 The National Programs are involved in the collection, processing and analysis of weather station and hydrological data, and in providing information based upon these data to different organizations and individuals in their countries, and to the regional center of AGRHYMET at Niamey, Niger. To evaluate the utility of the national programs it is necessary to consider the ways in which weather station data can assist farmers to increase food production and contribute to systems for predicting the extent and severity of famine.

A major conclusion of this Technical Annex is that agroclimatological information can be extremely useful for increasing food production, whereas agrometeorology has much less significance for agricultural

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development in the CILSS countries at this time. Consequently, it is necessary to define what is meant by these terms and discuss their actual and potential contributions to food security. This major conclusion has important implications for the future directions of AGRHYMET and the Pilot Projects as will be discussed later.

3.1.1 Agroclimatology includes the analysis of several years of weather data to describe the "average" weather characteristics or predict the probability that specific weather events, such as drought, will occur in a particular location. This permits the definition and subsequent delineation of climatic zones (e.g. Sivakumar et al., 1984 and Sivakumar, 1986), which enables scientists, extension agents and ultimately farmers to choose the most effective cropping systems, varieties and managements methods for specific regions. It also permits governments to develop more effective plans for rural development.

An important example of the utility of these analyses is provided by the hydrological balance studies of C. Dancette (Dancette and Hall, 1979) and others working in the CILSS countries. These studies predicted that the average rainfall after 1968 in the Sahelo-Sudanian zone would have supported an average growing season which is substantially shorter than was available prior to the extended period of drought (e.g. a growing season of 70 days compared to 90 days prior to 1968). This explained why peanut, millet and traditional cowpeas were failing in this zone in dry years and guided plant breeders and

agronomists to seek solutions. By substituting new, shorter cycle cowpea varieties for the longer cycle more drought susceptible peanut varieties grown by farmers, substantial increases in food production were achieved in dry locations in northern Senegal during 1985 and 1986. National cowpea production in Senegal in 1985 was at least 300% greater than the average production in the last 10 years (EEC, 1986).

Agroclimatological studies of the hydrologic balance also can be used to determine the regions of the other CILSS countries where the same type of approach has the potential to be effective in increasing and stabilizing crop production. Shorter cycle millet and peanut varieties have now been developed which can contribute to food security. Representatives of the national meteorological service in Burkina Faso are conducting studies to specify the lengths of the available growing season in different regions to help agronomists, extension agents and farmers to choose crop varieties and species with improved productivity and stability. Government representatives in Senegal and Mali are using agroclimatology data to plan rural development projects.

Simulations of the hydrologic balance using many years of data combined with agronomic experiments have produced useful guidelines concerning optimal sowing dates for crops grown in the Sudanian zone of the CILSS countries. For example, the Pilot Project in Mali has developed recommendations concerning plowing and sowing dates for sorghum in the Banccumana sector (Meteorological Services Mali, 1986)

that can be used by extension agents. They recommend using rains that occur in April or May for plowing, and that sorghum should not be sown before the first of June. Sorghum should be sown between the first and tenth of June if more than 40 mms of rain have occurred. For sowing between the eleventh and twentieth of June, less rain is required, 10 mms, to provide a reasonable probability that the crop will become established. If sufficient rain has not occurred by the twentieth of June, sorghum should be sown into dry soil. After the thirtieth of June, only sorghum varieties requiring a cycle length of less than 135 days should be sown. After the tenth of July, varieties are needed that have a cycle length less than 120 days. Similar practical recommendations based on amounts of rainfall have been developed for peanut and millet in Senegal by C. Dancette. These guidelines are based on the probabilities of future rainfall and enable farmers to choose a sowing date that has a reasonable probability of avoiding the death of young plants, which necessitates resowing, while being early enough to achieve maximum yields. To facilitate the application of these guidelines by extension agents and farmers it would be useful to convert the critical amounts of rainfall into depths of soil that would be wetted by this rainfall for major soil types in the region. Farmers could readily determine the depth of soil wetted after a rain using a hoe. This would be a more convenient and reliable method for determining when to plow or sow than using rainfall data from a raingauge some distance away.

The recommendations developed for Bancoumana illustrate another use of

agroclimatological analyses. When farmers have to sow late in drier zones due to late beginning of the rains or other causes, they often should sow shorter-cycle varieties or more drought resistant crops. Sivakumar (1986) reported for Niamey that there is a linear relation between the length of the growing season, as determined by the hydrologic balance and the date of the beginning of the rains. When rains started in mid-May a 120 day growing season was available; whereas when rains started in mid-June the growing season was only 90 days. The explanation for this is that the end of the rains is fairly consistent from year to year occuring in mid-September; whereas the onset of the rainy season is highly variable. To more fully exploit information of this type agroclimatologists and agronomists should work together to study relations between the onset of the rainy season and the length of the growing season for different regions and relate the predicted availability of water to the needs of different crop species and varieties. In addition, effective seed multiplication agencies would be needed so that seed of shorter-cycle varieties or more drought resistant crops are available to farmers who have to sow late.

The irrigation projects under way or being developed by the CILSS countries (e.g. along the Senegal and Niger Rivers) require information concerning the water use of different crops during different seasons. Climatological studies have provided effective methods for predicting crop water-use based upon estimates of the average evaporative demand of the atmosphere using weather station

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data and crop coefficients (Rijks, 1976). These predictions are essential for planning new irrigation projects and can be used to assist management by providing reasonable estimates of intervals between irrigations and the amounts of water that should be applied to different crops.

These examples were intended to illustrate the fundamental necessity of sound agroclimatological studies and associated weather data for many aspects of rural development and effective crop management. This is supported by the fact that weather data and agroclimatological studies played a key role in the development of irrigated agriculture and rainfed farming in the U.S. and other countries with strong commercial agriculture. These examples also demonstrate that rural development results from agroclimatologists, plant breeders, agronomists, soil scientists, engineers, etc. working as a team and that it is virtually impossible to estimate the monetary value of the agrometeorological or agroclimatological contributions because they interact with agronomic contributions which are of major importance.

A final example is presented which is of particular significance to AGRHYMET. The development of early warning systems to predict the extent and severity of drought could increase food security in the CILSS countries. Drought has been a major factor responsible for famines in the CILSS countries since 1968. Real-time simulation of the water status of crops, using hydrologic balance models and

weather and soils data, when coupled with crop yield models and methods for projecting forward based upon agroclimatological evaluations can be used to forecast crop yields. AGRHYMET is already using models of hydrologic balance and crop yield developed by F. Forest, IRAT/CIRAD and FAO. The forecasts from these models are crude at this time but the enhanced data base being developed, improved models and increased computing capacity could enable national programs in the CILSS countries to make useful crop yield forecasts in the future. Yield forecasts also can be made using satellite data, as will be described later, but none of these approaches are perfect and several different approaches should be used because they can be complementary.

3.1.2. Agrometeorology involves the real-time, immediate use of weather data or weather forecasts to guide agricultural management. Weather data can be used in a real-time manner to estimate crop water-use and provide advice concerning the scheduling of irrigations and amounts of irrigation water that should be applied. However, it is likely that a real-time approach to irrigation management may only be practically useful on large schemes, such as sugar cane plantations, which have precise control of water supplies. The most practical approach for helping farmers to irrigate small holdings may be to provide data on average irrigation amounts and intervals based upon agroclimatological, crop and soil analysis. Also measurements of rainfall at the beginning of the season can be used to determine when rainfed crops should be sown but, as was described earlier, more

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practical methods can be developed based upon the depth of soil wetted which do not require any rainfall data for their operation.

In addition, in some of the documents developed to justify the pilot projects of AGRHYMET it has been claimed that real-time weather data can be used in the CILSS countries to guide the choice of dates for thinning, weeding and applying fertilizer or plant protection chemicals, but these claims are unrealistic at this time. Rain after weeding reduces its effectiveness because some of the weeds recover. Also rain can wash plant protection chemicals from leaves and reduce their effectiveness. Forecasts of fair weather are needed for farmers to avoid these problems and they are not yet available. Delaying weeding or insecticidal sprays, due to the risk of rain, could also result in losses in yield. Weather forecasting is conducted in Senegal but the information is not designed for use by farmers. Forecasts which predict the probability of dry weather or rain during the next 24 or 48 hour period for specific regions could be useful to farmers. The timing of thinning and fertilizer applications is even more complicated than weeding or insecticidal sprays. Agronomic guidelines based upon agronomic, agroclimatological and soil studies provide the most effective mechanism for farmers in the CILSS countries to optimize the timing of thinning, fertilizer applications and weeding, and real-time weather data is of little value at this time for making management decisions. Real-time uses of weather data for other aspects of crop managhement, such as integrated pest management and prevention of

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disease epidemics, may be developed in the future for the CILSS countries. One possible approach which should be investigated for the northern Sudanian zone would consist of using real-time simulation of hydrologic balance in a cereal crop and agroclimatological analyses to predict the years and locations when it would be worthwhile for farmers to sow a relay crop of cowpea into the cereal crop.

Any proposed improved management methods that require real-time weather data would have to be reasonably effective to justify the moderately high costs of applying them. Rainfall in the CILSS countries tends to follow localized paths and can vary considerably over small distances. Many weather stations and technicians would be needed to provide and interpret weather data, in a timely manner, for a significant number of farmers. In contrast, improved management methods based on agroclimatological analyses can be developed and extended using a more modest network of weather stations and technicians. This same modest network would also be adequate for yield forecasting on a regional scale using real-time hydrologic balance simulations.

The various pilot projects of AGRHYMET are attempting to apply agrometeorological and agroclimatological data to crop management, and they will be discussed one-by-one, after which overall conclusions concerning the utility of the pilot projects are presented.

3.1.3. The Pilot Project in Mali (Konaté and Traoré, 1986) is being conducted southwest of Bamako in the Bancoumana sector in an area having a USAID-funded agricultural extension project called Operation Haut Valeé. The four villages are located on the humid boundary of the semiarid zone with an average rainfall of 900 mms occurring in one season between May and October. The pilot project involves 16 farmers growing either sorghum or millet with 4 farmers per village. On each farm a field of 1/2 hectare is divided into two equal plots. Both plots receive a moderately high level of input including plowing and incorporation of 100 kg/ha of ammonium phosphate prior to sowing and 50 kg/ha of urea at the stem elongation stage.

There is an "advised" plot in which the crop is sown in rows with precise spacing, and a multidisciplinary team tells the farmer when the plot should be sown, thinned, weeded and supplied with fertilizer. For the "traditional" plot, the farmer sows, thins, weeds and applies fertilizer at the same times and in the same manner as in his main fields.

The "advised" plots produced moderately higher yields than the "traditional" plots in 1983, 1984 and 1985 for both sorghum and millet (Tables 1 and 2). The "advised" plots of sorghum examined by the consultant in 1986 should produce more grain than the "traditional" plots. The difference in yield may be attributed to their being sown three days earlier and being thinned and weeded more effectively. The more effective thinning and weeding may be

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partially due to the higher priority assigned to the "advised" plots because the agents require that the work is done when they request it but it is also clear that the multidisciplinary team is providing effective advice in agronomy and agrometeorology.

The multidisciplinary team felt that the recommendation concerning date of sowing was the most important agrometeorological advice provided, but the difference between the sowing dates of the "advised" and "traditional" plots was small in 1986. They have conducted empirical and simulation studies of the effects of sowing date on yield and developed practical guidelines for farmers that were described earlier. At this time it is not possible to separate the value of the individual contributions from agrometeorology and agronomy; although the agronomic advice is certainly of major importance. In comparing the plots with nearby fields it is apparent that fertilizer has a major impact on sorghum production in this environment. However, in earlier years, yields of "advised" plots were substantially higher than average yields in farmers fields where fertilizer also was applied (Tables 1 and 2). The comparison is somewhat compromised by the fact that in conditions where labor is a limiting factor, the "advised" plots will be managed better simply because they are smaller than the main fields of the farmers. Socio-economic studies of the influences of labor availability, animal-draft mechanization, and the availability and cost/benefit aspects of fertilizer would help the team.

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The multidisciplinary team was impressive with excellent leadership, cooperation and coordination, and effective communication with farmers. The farmers appeared to appreciate the pilot project, saying that they had learned the value of growing a small area with good management and of basing the choice of sowing date on rainfall data. The farmers said that they would apply the improved methods on their main fields if they could obtain credit to purchase fertilizer and equipment such as ox plows and cultivators, further indicating the need for economic analyses. My overall impression is that the sound advice provided by the team for management of the test plots did not require real-time weather data. It could have been based on the agroclimatological studies conducted by the team, digging the soil to see how deep rain had penetrated and the results of agronomic studies conducted in earlier years in Mali.

3.1.4. <u>The Pilot Project in Burkina Faso</u> (Ministry of Transport and Communications 1985a and 1985b) is being conducted in three villages north, west and east of Ouagadougou at the humid boundary of the semiarid zone. The average annual rainfall is 800 mms occurring in one season between May and October. The project began in 1985 with 12 farmers (4 in each village). In 1986 trials are being conducted with 6 farmers in each village. In each case a field of 1/2 hectare is divided into two equal plots. The farmer manages one of the plots in a "traditional" manner. The other plot is managed in one of three different ways depending upon the level of advancement of the farm

with respect to cultural operations. The timing and types of cultural operations practiced in the three villages in 1985 are described in Tables 3 A,B and C. A multidisciplinary team tells the farmer when the "advised" plot should be sown, thinned, weeded and supplied with fertilizer.

In 1985 the "advised" plots produced moderately higher yields than the "traditional" plots, in some cases, and substantially higher yields than those obtained on the remainder of the farmers fields (Tables 4 A,B and C). Examination and on-site visits indicated that the higher yields in the "advised" plots were mainly due to the provision of sound agronomic advise, including more timely applications of fertilizer, and some additional inputs to "advised" plots (refer to Tables 3 A,B, and C), such as rock phosphate and an insecticide spray in one case. The higher yields of the plots compared with the farmers fields were mainly due to effective use of more fertilizer. A more detailed analysis is not warranted until data are available for 1986 and possibly 1987. As in Mali, the advice provided by the team for management of the test plots did not require real-time weather data and was mainly based on agronomy, and included increased inputs in some cases. The degree to which farmers will adopt the treatments advised by the team will depend upon the availability of the inputs and credit or cash to buy them, and the opportunity cost/return relationships for this use of the cash compared with other possible uses. Clearly, as in the case of the Pilot Projects in Mali, socio-economic analyses of the agronomic packages are needed.

3.1.5. The Pilot Projects in Senegal and Niger have just been initiated. Insufficient information is available to permit an analysis of these projects. Two aspects of the projects are noted. AGRHYMET contracted with the Institut Senegalais de Recherches Agricoles to conduct a socio-economic survey and diagnosis of the village prior to initiating the pilot project (ISRA, 1986). Projects of this type do require substantial socio-economic base line data. The multidisciplinary group in Niger responsible, on paper, for managing the pilot project does not appear to be functioning. Projects of this type should not be initiated if sufficient agronomic support and cooperation are not available.

3.1.6. Conclusions and Recommendations concerning the Pilot Projects. The pilot projects mainly consist of plots demonstrating advanced agronomic techniques together with complementary use of agroclimatologic and weather data to provide advice concerning the most appropriate dates for sowing. It should be clearly recognized that the various papers including the recent project paper for Senegal (AGRHYMET, 1986) describing many ways in which weather data can be directly useful to farmers are unrealistic and missleading.

The major beneficial outcomes of these projects, to date, are that they have strengthed communication between meteorologists, agronomists, plant protection specialists and others, and that they have encouraged meteorologists to become directly involved in agricultural development. These are major improvements whose values for rural development should not be underestimated.

These pilot projects do not demonstrate, as was claimed by WMO as early as 1983 (WMO, 1983), that applications of real-time weather data could substantially increase crop productivity in theCILSS countries. They do demonstrate that multidisciplinary teams of agronomists, meteorologists and others can develop technicological packages and apply them in a manner that substantially increases productivity on farmers fields. However, they are not effective as extension exercises because there have been insufficient socio-economic analyses and the pilot projects are too expensive in terms of the number of dollars or person years of effort per number of farmers contacted or influenced by the projects.

It is extremely unfortunate that unreasonable pressure on AGRHYMET and national programs from donors seeking projects with high visibility has resulted in meteorologists attempting to adopt leadership roles in agronomic extension. The most valuable role that agrometeorologists can serve is to work with and help agronomists, extension workers and others by developing improved management practices and by providing weather data and climatic anaylses. It is unrealistic to expect the agrometeorologists to act as directors of extension or demonstration activities.

For the future it is recommended that the multidisplinary teams be retained and reinforced, by the inclusion of more socio-economists.

The teams should direct two types of activities consisting of:

a) On-farm research led by agrometeorologists with the dual objective of developing and testing improved methods for applying agroclimatological and agrometeorological information to help farmers.

b) Demonstration plot exercises led by agronomists specializing in extension in which complete, practical technological packages are demonstrated and extended to farmers.

For both types of activities to be effective it is essential that the teams are truly multidisciplinary and cooperative and include experienced agronomists. It is the agronomic component that has the greatest opportunity to increase crop productivity and stability in the CILSS countries. Any USAID contributions to these activities should be bilateral, rather than through the AGRHYMET system, to insure adequate linkages with other host country projects.

3.2 The Regional Program at AGRHYMET Center in Niamey. The major role of AGRHYMET Center is to assist national programs to collect, process and analyse weather station and hydrological data. This is being achieved through training programs and the development of improved methods for analyzing weather data. The AGRHYMET center could also act as a regional coordinator, facilitating cooperation among the CILSS countries. Regional hydrological studies of the Senegal and Niger river systems, which cross several countries, would enable one country to help another, as would the monitoring of migrating insects.

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The regional program should promote the standardization of methodologies, where this is appropriate, because this also will facilitate cooperation in the exchange of data and comparisons of the results of analyses. Finally, since the various functions of the national meteorological services depend upon the acquisition of high quality weather data, and since working conditions in the CILSS countries can be difficult, it is recommended that the CILSS countries give AGRHYMET the mandate and responsibility for assisting the national programs to produce reliable weather data in a timely manner. This could be achieved by training programs, visits to evaluate procedures and equipment in weather stations, computerized monitoring of weather data produced by national weather stations and by establishing a department in AGRHYMET Center which is responsible for monitoring and storing data. For monitoring weather data, a programming algorithm can be used to provide a warning when transmitted data are highly improbable in relation to data in earlier years from the same station or internal checks of data sets can be conducted by including and recalculating means.

4. Suggest ways in which the AGRHYMET agrometeorological program might be improved, including operational linkages between the regional and national aspects of the programs. Some recommendations and suggestions for improving AGRHYMET were presented in earlier sections. In this section specific recommendations are made concerning ways in which "Sahel Water Data and Management III" can help AGRHYMET to improve food security in the CILSS countries.

The USAID component could mainly consist of providing computer equipment and software, weather station instrumentation, and training in the use and maintenance of the equipment, as was the case during phases I and II.

4.1. <u>USAID could contribute to improved weather data collection in the CILSS countries.</u> Insuring that high quality and reasonably complete weather data are taken should be a high priority of the AGRHYMET Program. The Penman Equation is presently the most accurate general method for predicting potential evapotranspiration and is valuable for estimating crop water use and conducting agroclimatological studies. Daily solar radiation is an important variable in the Penman Equation and it is also useful in models for predicting crop yields. Daily solar radiation in the CILSS countries is usually estimated from sunshine hours using empirical relations with the solar irradiance above the atmosphere but this can result in substantial errors. Robust instruments should be provided to measure instantaneous solar irradiance, provide time-integrated values and obtain more complete information on temperature. One such instrument is the LI-1200S Minimum Data Set Recording System from Lambda Co., Lincoln, Nebraska, USA including the recorder, pyranometer, mounting fixture and air temperature sensor at a cost of $1160 each. On average 10 are required per country.

Wind speed is another important variable in the Penman equation. In addition wind speed data are useful for evaluating problems due to wind and blowing sand during seed germination and crop establishment

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and for roads and airports. Wind speed data also can be used to estimate the value of wind machines for providing energy to pump water. There are relatively few functional anemometers in the rural weather stations of the CILSS countries at this time. Robust anemometers with totalizers are needed (e.g. the Lambrecht, Co. West Germany can provide a suitable model for approx. $1000). On average, 15 are needed per country. The total cost of the equipment, including shipping and accessories is $250,000. The maintenance and repair costs should be very low since the instruments are robust.

4.2. <u>USAID could contribute to improved weather data transmissin within and between the CILSS countries.</u> More effective and timely transmission of data could dramatically improve the overall functioning of the AGRHYMET system. In some cases transmission of weather data within countries can be improved by providing more sideband radios. Transmission of data between CILSS countries and the AGHRYMET Center could be improved by installing microwave transmitters and receivers providing permission can be obtained to use an available channel on the Meteosat satellite. A new Meteosat satellite will soon be in orbit so this possibility should be checked out reasonably soon.

4.3. <u>USAID could contribute to improved data analysis and storage by national programs and the regional center.</u> The USAID component could provide the software required to process the Advanced Very High Resolution Radiometer data transmitted by the NOAA satellite to the AVHRR receiving station in Niamey, which is to be provided by France

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in 1987. Normalized vegetation indices are calculated from the radiation reflected by vegetation in the near infrared, and in the visible wavelengths affected by chlorophyll. They provide an estimate of the extent and activity of plant foliage. Obtaining the radiation data from the AVHRR receiving station would permit the calculation of normalized vegetation indices for the CILSS countries with higher resolution and in a more timely manner than is presently possible. The present resolution of 6000 km^2 is inadequate for forecasting the area impacted by drought, whereas a solution as high as 1 km^2 may be achieved with the new system which would provide adequate estimates of areas. Expert advice should be obtained concerning the value of this approach to remote sensing from a recent evaluation by the National Academy of Sciences in the U.S. and other sources because the consultant has limited expertise in this area. Additional software would be needed, and is available, to enable the national meteorological services to use the data on normalized vegetation indices as part of an overall approach to forecast yields. Present evaluations of relationships between crop yield and the vegetation index are crude and should be extended. For example, relationships for the peanut basin in Senegal where there is substantial cropping would be different from the relationships for north western Burkina Faso where cropping is confined to a small area and the remainder consists of lateritic outcrops with little soil or vegetation and optical properties that are different from crops.

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Advanced personnal computer systems could be provided to the Meteorological and Hydrological services in the CILSS countries to permit them to use the NOAA satellite data which could be provided to them by AGRHYMET Center as floppy disks or through the microwave transmission system described earlier. These computer systems would also suffice for the storage, manipulation and analyses of weather data for forecasting water deficits and yield and for the other types of hydrological balance studies needed in agroclimatological analyses.

4. <u>USAID could contribute to a support services unit at AGRHYMET center.</u> This unit would provide training for national program staff in the use and repair of all equipment and software provided by the project and in the analysis of data. To the maximum extent possible this training should be conducted at AGRHYMET Center, Niamey or at national program headquarters since training in the U.S. is expensive and requires that technicians spend more time away from their normal work.

By providing equipment, software and training, the USAID component should be sufficiently complete to guarantee its success, if properly executed, irrespective of variations in performance by other donors and components of the AGRHYMET program.

5. <u>Assist in deriving appropriate cost and benefit information in conjunction with the team Agricultural Economist and Design Specialist.</u> Since the decision has already been made to proceed with AGRHYMET, this consultant agrees with an earlier suggestion (Weiler, 1986) that further cost/benefit analyses of the impact of AGRHYMET on crop production would not be useful. Economic analyses of the cost effectiveness of various training options and of recurrent cost burdens would be particularly useful. Cost/benefit analyses of the Pilot Projects are not warranted because these projects should be redesigned to have separate efforts focusing on the development and demonstration of technological packages. Any USAID Missions wishing to support these efforts as bilateral projects should consider the following recommendations which were discussed in earlier sections of the report.

a) Require that an effective multidisciplinary team is available with adequate agronomic and socioeconomic support in addition to the agrometeorologists.

b) Require that sufficient socioeconomic base-line information is available for project areas prior to initiating on-farm research or demonstration exercises. This would facilitate the design of project activities and future evaluations of the impact of the projects.

c) Consider a dual approach with i) on-farm research led by agrometeorologists for developing and testing improved methods for applying agroclimatological and agrometeorological information to help farmers, and ii) demonstration plot exercises led by agronomists specializing in extension in which complete practical technological packages are demonstrated and extended to farmers.

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d) Conduct socioeconomic analyses of the suitability and profitability of technology that is developed and of the effectiveness of the demonstration exercises.

6. Rural development in Africa mainly depends on the activities and effectiveness of national programs. Major emphasis should be given to the training of national program staff, and this should be a major priority for AGRHYMET Center. Students should be taught both theory and practical applications, and they should be given the opportunity to gain practical experience. The 70 hectare farm at AGRHYMET Center has sufficient land area and diversity with respect to soils and topography to provide an effective field laboratory for both training and applied research.

The effectiveness of national programs also depends upon the adequacy of funding for operational costs. UNDP provided substantial funding to national programs in previous years. Proposed reductions in UNDP funding could seriously impair the effectiveness of national programs. A special plea is made to potential donors for the provision of financial support to the multidisciplinary team in Mali because they have been pioneers leading the AGRHYMET System and they have the potential to be extremely effective in phase III. Weather data are valuable to both national programs and the international community; consequently, long-term contributions to the AGRHYMET program by international donors are warranted and may be necessary for the continued effectiveness of the national meteorological and hydrological services in the CILSS countries.

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Table 1. Sorghum Yields in the Pilot Project in Mali (Konaté and Traoré, 1986).

	Bancoumana								Kenieroba							
	1		2		3		4		1		2		3		4	
	A	T	A	T	A	T	A	T	A	T	A	T	A	T	A	T
1983	1635	1485	1675	1617	827	725	1818	1777	1345	863	763	872	405[a]	345[a]	1075	533
1984	1340	1230	1543	1220	1940	1910	1300	1403	1398	920	1050	795	1310	1408	1380	1203
1985	1310	810	1773	1785	1588	1233	1203	1223	1195	320[b]	475[c]	440[c]	960[d]	820[d]	504[e]	483[e]
Mean	1428	1175	1664	1541	1452	1289	1440	1468	1313	892	763	702	892	858	986	740
$100 \times \frac{Y_a - Y_t}{Y_t}$ %	22		8		13		-2		47		9		4		33	
$100 \times \frac{Y_a - Y_f}{Y_f}$ %	43		66		45		44		46		1		46		36	

A = Advised plot

T = Traditional plot

Y_a = Yield in advised plot

Y_t = Yield in traditional plot

Y_f = Average yield in farmers fields
1000 kg/ha for Bancoumana
900 kg/ha for Kenieroba

a = Planting occurred very late

b = The plot was abandoned for one month

c = Death of young plants for unknown reasons

d = Damage due to cattle

e = Persistence of puddles of water in the field

Table 2. Millet Yields in the Pilot Project in Mali (Konaté and Traoré, 1986).

	Kongola								Makandiana							
	1		2		3		4		1		2		3		4	
	A	T	A	T	A	T	A	T	A	T	A	T	A	T	A	T
1983	525*	383*	755*	738*	595*	483*	700*	536*	803*	750*	1032*	855*	585*	388*	513*	410*
1984	1050	863	1025	1000	975	908	1028	828	1463	915	1645	733	925	763	995	800
1985	1083	701	1000	780	968	1120	868	785	1300	1278	1325	1046	773*	505*	903	683
Mean	886	649	927	839	846	837	865	717	1189	981	1334	878	761	552	804	631
$100 \times \frac{Y_a - Y_t}{Y_t}$ %	37		10		1		21		21		52		38		27	
$100 \times \frac{Y_a - Y_f}{Y_f}$ %	19		13		8		5		63		75		9		12	

A = Advised plot

T = Traditional plot

Y_a = Yield in advised plot

Y_t = Yield in traditional plot

Y_f = Average yield in farmers fields
900 kg/ha for Kongola
850 kg/ha for Makandiana

* = Damage due to birds (the authors did not include these yields when calculating the % of the advised plots compared with the average yield in farmers fields).

Table 3B. Cultural Operations in the Pilot Project at Pabre, Burkina Faso 1985

Month &	No		No		N1		N2	
decade	Tradit.	Advised	Tradit.	Advised	Tradit.	Advised	Tradit.	Advised
1	-	-	-	-	-	-	-	-
June 2	-	-	-	sow	-	-	-	-
3	-	-	sow	manure	plow&sow	phosphate plow&sow	plow&sow	phosphate plow&sow
1	sow	sow	manure	-	-	-	-	-
July 2	-	-	-	weeding	-	-	-	-
3	weeding	weeding	weeding	-	weeding	NPK & weeding	weeding	NPK & weeding
1	-	-	-	-	-	-	NPK & weeding	urea & weeding
Aug. 2	-	-	-	weeding	NPK & ridging	&transpl urea & ridging	-	-
3	-	-	weeding	-	-	-	-	-
1	weeding	weeding	-	-	urea & ridging	-	-	-
Sept. 2	- ridging	-	-	weeding	remov disease plts		urea & ridging	-
3	-	-	weeding	-	-	-	-	-
1	-	-	-	-	-	-	-	-
Oct. 2	-	-	-	-	harvesting		-	-
3	harvesting	10 Nov	harvesting		-	-	harvesting	

Traditional plots and advised plots

Levels of Technology
No = low
N1 = medium
N2 = high

phosphate = rock phosphate at 200 kg/ha

NPK = probably 15:15:15 at 160 kg/ha

urea = 46 % N at 50 kg/ha

Table3A. Cultural Operations in the Pilot Project at Tanghin, Burkina Faso 1985

Month &		No		No		N1		N2	
decade		Tradit.	Advised	Tradit.	Advised	Tradit.	Advised	Tradit.	Advised
	1	-	-	-	-	-	-	-	-
June	2	marking	marking	manure & plow	phosphate & plow	-	-	-	-
	3	sow	sow	-	-	plow&sow	phosphate plow&sow	plow&sow	phosphate plow&sow
	1	-	-	sow	sow	sow	sow	-	-
July	2	-	-	-	phosphate & weeding	-	pesticide NPK & weeding	-	NPK & weeding thinning
	3	weeding	weeding	weeding	-	weeding		weeding	
	1	-	-	-	-	transpl.	thinning &transpl	-	thinning
Aug.	2	thinning &transpl	-	NPK & ridging	ridging	-	-	NPK & weeding	urea & ridging
	3	-	-	-	-	NPK+urea weeding	urea & weeding	urea & transpl.	-
	1	-	weeding ridging	weeding	weeding	-	ridging	-	-
Sept.	2	weeding ridging	-	-	-	ridging	-	-	-
	3	-	-	-	-	-	-	-	-
	1	-	-	-	-	-	-	-	-
Oct.	2	-	-	begin harvesting		-	-	-	-
	3	begin harvesting		harvesting		begin harvesting		harvesting	

Traditional plots and advised plots

Levels of Technology
No = low
N1 = medium
N2 = high

phosphate = rock phosphate at 200 kg/ha

NPK = probably 15:15:15 at 160 kg/ha

urea = 46 % N at 50 kg/ha

Table 3C. Cultural Operations in the Pilot Project at Gonsé, Burkina Faso 1985

Month &	No		No		N1		N2	
decade	Tradit.	Advised	Tradit.	Advised	Tradit.	Advised	Tradit.	Advised
1	-	-	-	-	-	-	-	-
June 2	-	-	mark & dry sow	-	plow	phosphate & plow	plow	phosphate & plow
3	sow	sow	resow	mark & sow	sow	sow	sow	sow
1	-	-	-	-	-	-	-	-
July 2	weeding	weeding	-	weeding	weeding	NPK & weeding	-	NPK & weeding
3	-	-	weeding	-	-	thinning	weeding	thinning
1	weeding	weeding	-	weeding	NPK & weeding	urea & weeding	NPK & weeding	urea & ridging
Aug. 2	-	-	-	-	-	-	-	-
3	-	-	-	-	urea & weeding	weeding	urea & ridging	-
1	-	-	weeding	weeding	-	-	-	-
Sept. 2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-
Oct. 2	-	-	-	-	-	-	-	-
3	harvesting		harvesting began in November				harvesting	

Traditional plots and advised plots

Levels of Technology
No = low
N1 = medium
N2 = high

phosphate = rock phosphate at 200 kg/ha

NPK = probably 15:15:15 at 160 kg/ha

urea = 46 % N at 50 kg/ha

Table 4A. Production data from Tanghin, Burkina Faso 1985

	No Millet var P8			N1 Peanut var KH149A			N1 Sorghum var S29			N2 Millet var P8		
	Trad	Advs	Farm	Trad	Advs	Farm	Trad	Advs	Farm	Trad	Advs	Farm
Living plants #/10m²	30.5	33.0	29.1	23.8	22.6	26.1	28.0	31.9	18.9	36.4	33.1	26.8
Pockets without plants #/10m²	16.4	5.7	5.9	-	-	-	6.0	1.4	1.4	1.5	0.3	5.2
Head weight kg/ha	200	390	400	1720	1920	880	1480	3090	1190	1370	1540	590
Grain weight kg/ha	160	210	180	1200	1400	640	770	1840	810	930	1060	470
Rainfall sow-har mms	581	581	593	524	524	524	547	598	633	581	581	593

Trad = traditional plot

Advs = advised plot

Farm = from other fields of farmer

Levels of Technology
No = low
N1 = medium
N2 = high

Table 4B. Production data from Pabré, Burkina Faso 1985

	No Millet			No Millet			N1 Millet			N2 Red Sorghum		
	Trad	Advs	Farm	Trad	Advs	Farm	Trad	Advs	Farm	Trad	Advs	Farm
Living plants #/10m²	18.4	16.1	-	17.5	23.9	17.8	18.4	32.2	32.0	19.9	26.5	76.4
Pockets without plants #/10m²	-	-	-	-	-	-	-	-	6.0	0.3	1.5	-
Head weight kg/ha	520	610	-	900	1220	770	1390	1900	780	2780	3140	1170
Grain weight kg/ha	320	380	-	720	920	570	910	1350	420	2140	2550	900
Rainfall sow-har mms	433	433	-	426	461	426	406	406	406	406	406	406

Trad = traditional plot

Advs = advised plot

Farm = from other fields of farmer

Levels of Technology

No = low

N1 = medium

N2 = high

Table 4C. Production data from Consé, Burkina Faso 1985

	No Red Sorghum			No Millet			N1 Sorghum var S29			N2 White Sorghum		
	Trad	Advs	Farm	Trad	Advs	Farm	Trad	Advs	Farm	Trad	Advs	Farm
Living plants #/10m²	25.1	28.6	23.4	28.1	29.9	27.1	32.0	33.2	24.4	21.1	22.5	21,7
Pockets without plants #/10m²	0.9	0.6	1.2	1.0	1.5	0.8	0.9	1.1	1.2	1.7	1.0	4.7
Head weight kg/ha	2950	3720	2810	560	660	-	1630	1850	1090	1040	2200	520
Grain weight kg/ha	2220	2610	2120	450	560	-	1310	1340	810	750	1570	300
Rainfall sow-har mms	594	620	560	833	829	757	829	829	846	620	620	623

Trad = traditional plot

Advs = advised plot

Farm = from other fields of farmer

Levels of Technology
No = low
N1 = medium
N2 = high

APPENDIX A

SCOPE OF WORK
for
Anthony Hall

As the team Agro-meteorologist, the Associate will carefully examine the theoretical and operational basis upon which the AGRHYMET program will apply agrometeorology to the Sahelian context. Following a brief orientation in Washington, he will travel to the field with the team Agricultural Economist to:

a. evaluate the utility of the AGRHYMET regional and national programs particularly the pilot projects currently programmed in Niger, Mali, Senegal and Burkina Faso;

b. suggest ways in which the AGRHYMET agro-meteorological program might be improved, including operational linkages between the regional and national aspects of the programs;

c. assist in deriving appropriate cost and benefit information in conjunction with the team Agricultural Economist and Design Specialist.

APPENDIX B

AGRICULTURAL TEAM

Composition: Martin Billings, Anthony Hall

Overall Objectives of Team

The principal objective of the team is to contribute to the quality, accuracy and realism of the main Project Paper document. They will do this by gaining an in-depth knowledge of the issues pertaining to agricultural production/forecasting, and by then bringing this information to bear, through interaction with the whole design team, on the overall Project Paper.

The team's focussed analysis of the agricultural issues will be transmitted in the form of a concise (15-20 page) Technical Annex. This Annex will contain a discussion of issues, tables containing relevant cost and technical data, and a detailed set of funding options for the AID project. The principal activities to be considered for AID funding are :

- support to the crop/rangelands monitoring and forecasting system
- a project evaluation and monitoring plan

Only through interaction of the whole team will final project design emerge. Therefore, it is essential that the Agriculture Team consider and elaborate two or more OPTIONS for AID funding. These options will depend on level of funding available and on the findings of other team members.

Direct Responsibilities:

Prepare annex on technical feasibility of agriculture objectives, including:

- Increasing agricultural production via advice to farmers
- Crop yield forecasting

For each objective, the team will determine:

- Data inputs required to generate needed information
- Sources and reliability of data being used
- Analytical tools needed/used to process data
- Frequency and usefulness of information output
- How input data is transmitted to processors and how output data reaches users
- Evidence that processed information from Agrhymet is being used
- Whether successful uses can be replicated
- What is needed to perform a scientifically valid monitoring/evaluation of the pilot projects in Burkina and Mali, as well as of the proposed pilots in Senegal and Niger?
- How does the agricultural research being performed on these projects relate to other ag research projects in the Sahel?
- How potential as they see it compares to Program goals
- Bottlenecks/deficiencies at each point in above system
- The level, timing and objectives of proposed AID funding

Information Sources

The Agricultural Team will visit Niger, Burkina and Mali.

Niamey

ARC
USAID/Niamey
Niger Agriculture, hydrological and meteorological services
(Agrhymet Cell)

Burkina

USAID/Ouaga
Agrhymet pilot project outside Ouaga
Burkina Agriculture, hydrological and meteorological services
(Agrhymet Cell)

Mali

USAID/Bamako
Agrhymet pilot project in the Haute Vallee
Mali Agriculture, hydrological and meteorological services
(Agrhymet Cell)

The Agriculture Team will draw on the computer team as a source of information about communications systems, and will interact with that team about institutional development issues at the national levels.

Secondary responsibilities

The team will collect information relevant to the economic and financial costs/benefits of the agriculture objectives, and on the recurrent cost implications of what they observe or recommend.

Dr. Billings will participate with A. Shaikh in the preparation of the Economics Annex to the report.

systems

11 + Recurrent cost implications of national and regional level information systems operations in Agrymet

12 + Proposed AID strategy for funding Agrymet information systems needs (especially at the national level) — including training funding levels and specific equipment recommendations

Information Sources

THE INFO SYSTEMS TEAM WILL VISIT NIGER, BURKINA, MALI & SENEGAL

~~The Agricultural Team will visit Niger,~~ Burkina and Mali.

Niger

GRC
USAID/Niamey
Niger Agriculture, hydrological and meteorological services (Agrymet Cell)
ASECNA

Burkina

USAID/Ouaga
Ouaga Remote Sensing Center
Burkina Agriculture, hydrological and meteorological services (Agrymet Cell)
ASECNA

Senegal

USAID/Dakar
ASECNA
Senegal Agriculture, hydrological and meteorological services (Agrymet Cell)

The information systems team will interact with the Agriculture Team on communications needs for agricultural objectives, and on institutional issues which affect both agriculture and information systems needs.

Secondary Responsibilities

The team will collect information relevant to the economic and financial costs/benefits of the information systems and on the recurrent cost implications of what they observe or recommend.

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INFORMATION SYSTEMS TEAM

Composition: Earle May, William Rutherford

Overall Objectives of Team

The principal objective of the team is to contribute to the quality, accuracy and realism of the main Project Paper document. They will do this by gaining an in-depth knowledge of the issues pertaining to information systems (including computers and telecommunications) and national level institutional issues, and by then bringing this information to bear, through interaction with the whole design team, on the overall Project Paper.

The team's focussed analysis of information systems will be transmitted in the form of a concise (15-20 page) Technical Annex. This Annex will contain a discussion of issues, tables containing relevant cost and technical data, and a detailed set of funding options for the AID project. The principal activities to be considered for AID funding are :

- support to existing information systems
- upgrade of national level information systems
- maintenance, training and institutional development

Only through interaction of the whole team will final project design emerge. Therefore, it is essential that the Information Systems Team consider and elaborate two or more OPTIONS for AID funding. These options will depend on level of funding available and on the findings of other team members.

Direct Responsibilities:

Prepare an Annex on the technical feasibility of proposed AID support to AGRHYNET information systems and on associated institutional issues

The principal issues the team will consider include:

1 + appropriateness of computer and telecommunications systems at the national and regional levels
2 + evolution of information system needs at national levels
3 - what are the major institutional costacles within the system (affecting both <u>information systems</u> and agriculture objectives)?
4 - what imbalances exist between both institutional development and program funding of institutional support between the regional vs national levels?
5 + Are the PDP-11s now in place being fully utilized?
6 + Is upgraded equipment needed? For what purpose(s)?
7 + what equipment should be considered for upgrade? In what timeframe (may vary by country)
8 + what additional training needs will upgrade create?
9 + A detailed review of the cost of proposed support to information systems, including technical assistance requirements, training and maintenance, and new equipment purchases
10 + An elaboration of major options for AID funding of information

PROJECT PAPER INTEGRATION TEAM

Team Composition: A. Shaikh, Martin Billings, Earle May
Shaikh will bear primary responsibility for integration, but Billings and May will devote the majority of their time in the field after November 20 to this activity, plus additional time allocated in the United States.

Direct Responsibility

To produce a project paper, in appropriate format, which addresses the objectives set forth by the EDPR:

1 - Delineation of Program short, medium and long term objectives, including timeframe and cost
2 - Understanding of AID's role in the overall funding proposal
3 - Analysis of a range of AID funding options and documented recommendations of most appropriate funding packages, including discussion of computer and telecommunications issues.
4 - Identification of outstanding program issues and detailed recommendations on how AID should deal with them, including possible use of conditionality
5 - Design of an appropriate monitoring/evaluation plan to:
  - assure that AID objectives and timeframes are on track
  - permit ongoing AID input to development of the Program during Phase III

These objectives will be treated in the context of the EDPR's larger concerns about the definition and realism of overall Program objectives. These concerns are best summarized in the four questions raised at the EDPR:

1 - What are the Program's products and who are the beneficiaries of these products?
2 - How realistic are the agricultural production objectives, and what is the timeframe within which specific agricultural production targets are to be met?
3 - What are the implications of the recurrent cost burdens created by the program (national and regional)?
4 - What should be the respective roles of the national and regional levels in the Agrnymet Program?

These concerns must be explicitly treated in the Project Paper in order for the final document to be acceptable to AID.

Shaikh and Billings will also have responsibility for producing analysis of the project and will define the major recurrent cost implications of proposed AID inputs.

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APPENDIX C

UNCLASSIFIED

AID/AFR/PD/SWAP:JHRADSKY:FAF:3597M
10/30/86 647-6331
AID/AFR/PD/SWAP:CPEASLEY

AID/AFR/SWA:EAMUNDSON
AID/AFR/DP:SGROSSMAN
AID/AFR/TR/PRO:JOLSSON
AID/AFR/TR:ABURGETT
AID/AFR/TR/ENG:BMOSLEY
AID/GC/AFR:BBRYANT

PRIORITY NIAMEY

PRIORITY PRAIA, DAKAR PRIORITY, BANJUL PRIORITY, NOUAKCHOTT PRIORITY, BAMAKO PRIORITY, OUAGADOUGOU PRIORITY,

AIDAC PARIS FOR SLOCUM, OECD/CLUB DU SAHEL

N/A

CP
JH
EA
AB
SG

ECPR FOR SAHEL WATER DATA AND MANAGEMENT III
PID (625-0973)

1. SUBJECT PROJECT PID-LEVEL ECPR WAS HELD ON 10/23/86. ECPR WAS CHAIRED BY AFR/PD DIRECTOR PEASLEY AND INCLUDED REPRESENTATIVES OF AFR/SWA, AFR/TR, AFR/PD, AFR/DP, AND ST/AGR. ECPR CONCURRED WITH PROJECT COMMITTEE RECOMMENDATION TO MOVE ~~PROJECT DESIGN TO PP LEVEL~~ FORWARD WITH PP DESIGN. PP REVIEW ~~WILL~~ BE HELD IN AID/W. PROJECT COMMITTEE COMMENTS FOLLOW.

2. PROGRAM ATTAINABLE OBJECTIVES: THE PROJECT COMMITTEE EXPRESSED ITS STRONG CONCERN OVER THE LEVEL OF DEVELOPMENT OF THE OVERALL AGRHYMET PHASE III PROGRAM WITHIN WHICH THE AID PROJECT PROPOSAL WILL BE HOUSED. THE PROGRAM PROPOSAL PRESENTED AT THE 9/86 CAC MEETING IN GENEVA DOES NOT SHARPLY DELINEATE SPECIFIC PROGRAM OBJECTIVES, TIMEFRAMES AND COSTS FOR PHASE III AND BEYOND, NOR DOES IT CLEARLY ALLOCATE RESPONSIBILITIES AND FUNDING AMONG DONORS. THIS, IN ITSELF, RAISED SUBSTANTIVE SUB-ISSUES IN AT LEAST FOUR AREAS: (A) WHAT WILL BE THE SPECIFIC PRODUCTS OF THE AGRHYMET SYSTEM AND WHO

UNCLASSIFIED

WILL UTILIZE THEM OVER THE COURSE OF PHASE III AND BEYOND? (B) IN WHAT TIMEFRAME DOES AGRHYMET ASSUME THAT SIGNIFICANT IMPROVEMENT OF AGRICULTURAL PRODUCTION WILL BE REALIZED AND IS THIS REALISTIC? (C) WHAT IS THE LONGER-TERM RECURRENT COST BURDEN OF THE AGRHYMET SYSTEM AND TO WHAT EXTENT SHOULD SELECTION OF PHASE III TECHNOLOGIES BE CONDITIONED BY THAT BURDEN? (D) PENDING ANSWERS TO ALL THE ABOVE, WHAT IS THE MOST APPROPRIATE DIVISION OF LABOR BETWEEN THE NATIONAL AND REGIONAL-LEVEL CENTERS? THE PROJECT COMMITTEE FIRMLY SUPPORTS THE PHASE III INTENTION OF REINFORCING THE CRITICAL NATIONAL CENTERS. IT IS HOPED THAT THE FUNCTIONS ASSIGNED TO THE REGIONAL CENTER WILL BE KEPT TO AN ESSENTIAL MINIMUM.

THE PROJECT COMMITTEE EXPRESSED THE STRONG PREFERENCE THAT THESE BASIC PROGRAM ISSUES BE RESOLVED PRIOR TO THE FINAL DESIGN OF AN AID PROJECT FOR PHASE III. IT ALSO RECOGNIZED, HOWEVER, THAT THE 9/66 AGRHYMET III PROGRAM PROPOSAL REPRESENTED A SIGNIFICANT STEP IN THE RIGHT DIRECTION AND THAT SUPPLEMENTAL DEFINITION OF THE PROGRAM COULD BE DEVELOPED BY THE PP DESIGN TEAM. IT WAS ULTIMATELY DECIDED TO PERMIT THE PP TEAM TO TRAVEL TO THE FIELD IN NOVEMBER AS PLANNED. DEPENDING ON THE PROGRESS WHICH IT CAN MAKE IN DEALING WITH THE ABOVE-NOTED ISSUES, THE TEAM MAY PRODUCE (A) A FULLY DOCUMENTED PROJECT PAPER WHICH, IF REQURIED, MAY USE CONDITIONALITY TO ENCOURAGE GREATER ATTENTION TO OUTSTANDING ISSUES, OR, (B) A WELL DOCUMENTED ISSUES REPORT WHICH CAN BE UTILIZED BY AID AND OTHER DONORS TO FOCUS ATTENTION ON THE SPECIFIC WORK TO BE DONE BEFORE AID CAN PROCEED WITH THE DEVELOPMENT OF A PROJECT PAPER.

3. FUNDING LEVEL: AFR/SWA IS STILL UNABLE TO PROVIDE AN ACCURATE ASSESSMENT OF FUNDING AVAILABILITY FOR THIS PROJECT, ALTHOUGH CURRENT ESTIMATES ARE THAT AID SHOULD BE ABLE TO COVER THE MINIMAL REQUIREMENTS OF THE PHASE III PROGRAM. THE PP TEAM IS TO EXAMINE A RANGE OF LEVELS OF EFFORT, DETERMINE THE ADVANTAGES AND DISADVANTAGES OF THESE DIFFERENT LEVELS AND RECOMMEND TO AID A COST-EFFECTIVE YET TECHNICALLY SOUND LEVEL OF SUPPORT BASED ON ITS INVESTIGATION. IT SHOULD BE ASSUMED BY THE TEAM THAT MOST PROBABLE POTENTIAL LEVELS WILL BE UNDER DOLS 6 MILLION FOR THE LOP. THE COMPUTER ACTIVITY DESIGN SHOULD BE DEVELOPED IN A MANNER WHICH WILL PERMIT PROGRESSIVE AID DISENGAGEMENT, AS DEEMED APPROPRIATE, OVER THE COURSE OF PHASE III.

4. AFR BUREAU PROGRAM INTERESTS: THE AGRHYMET III

PROJECT WILL HAVE POTENTIAL LINKAGES TO AT LEAST FOUR AFR BUREAU ACTIVITIES. THE PP TEAM SHOULD EXAMINE THESE LINKAGES AND ENSURE THAT THEY ARE APPROPRIATELY INTEGRATED INTO THE PP DESIGN.

A. NOAA/AISC: THE AGRHYMET PROJECT IS AN OPPORTUNITY TO FIELD TEST THE UTILITY OF NOAA/AISC TECHNOLOGY IN AN INSTITUTIONAL SETTING IN AFRICA. AFR/EA AND AFR/SA WILL BE KEPT INFORMED OF THE PROJECT DESIGN AND, DEPENDING ON THE RESULTS OF THE AGRHYMET ACTIVITY, MAY WISH TO ~~BRING~~ BUY-IN INTO THE PROJECT FOR A SIMILAR NOAA OPERATION IN THEIR RESPECTIVE REGIONS.

B. CRTO: WHILE AID IS PHASING OUT DIRECT SUPPORT TO THE OUAGADOUGOU REGIONAL REMOTE SENSING CENTER, IT WOULD LIKE TO ENCOURAGE APPROPRIATE LINKS (E.G. TRAINING) BETWEEN IT AND THE AGRHYMET NETWORK.

C. LOCUSTS/GRASSHOPPERS: WHILE AID HAS YET TO DEFINE ITS NASCENT LOCUST/GRASSHOPPER PROJECT, IT IS PROBABLE THAT IT WILL HAVE A TECHNICAL FOCUS IN EARLY WARNING OF PEST INFESTATION AND A GEOGRAPHICAL FOCUS IN THE SAHEL. IT WOULD SEEM LOGICAL THAT LINKAGES HERE WILL ALSO BE FORGED WITH THE AGRHYMET PROJECT.

D. FEWS: AS AGRHYMET FURTHER DEVELOPS ITS CROP/RANGELAND MONITORING CAPACITY IT IS LIKEWISE LOGICAL THAT MUTUALLY ADVANTAGEOUS LINKS COULD BE ESTABLISHED WITH FEWS AND OTHER USG EARLY WARNING PROGRAMS.

5. DATA PROCESSING: IT REMAINS YET TO BE DEMONSTRATED THAT AGRHYMET HAS THE TECHNICAL CAPACITY TO RECEIVE, PROCESS AND REDIFFUSE NECESSARY DATA IN A COST-EFFECTIVE AND TIMELY MANNER. BECAUSE THE DEVELOPMENT OF THE TELECOMMUNICATIONS PORTION OF THE AGRHYMET PROGRAM WILL BE DEALT WITH BY DONORS OTHER THAN AID, THE PP TEAM WILL BE INSTRUCTED TO EXAMINE THAT ISSUE WITH KEY DONOR AND TECHNICAL GROUPS AND FACTOR THAT ASSESSMENT INTO ITS FEASIBILITY REPORT. BECAUSE THE COMPUTER PORTION OF THE AGRHYMET PROGRAM IS UNDER THE LONG TERM TECHNICAL SUPERVISION OF WMO, PD/SWAP IS REQUESTED TO CONTACT WMO TO ATTEMPT TO ARRANGE FOR A COMPETENT COMPUTER SYSTEMS ANALYST TO AUGMENT THE PP DESIGN TEAM.

6. SOLE-SOURCE CONTRACTING: WHILE IT IS RECOGNIZED THAT NOAA/AISC MAY HAVE A UNIQUE CAPACITY TO SUPPLY SUPPORT TO THE CROP MONITORING PORTION OF THE AGRHYMET PROGRAM, IT IS ALSO RECOGNIZED THAT OTHER POTENTIAL

COMPETITORS MAY EXIST IN THE FIELD.. THE PP TEAM IS THEREFORE DIRECTED TO EXPLORE THE WIDEST POSSIBLE RANGE OF IMPLEMENTATION AGENTS FOR THIS PART OF AGRHYMET III. FURTHERMORE, IT IS EXPECTED THAT THE PP FIELD ANALYSIS WILL CONTAIN NO SPECIFIC REFERENCE TO NOAA/AISC UNTIL A APPROPRIATE DETERMINATION CAN BE MADE BY AFR BUREAU ON THIS TOPIC. YY

APPENDIX D

Travel Schedule--A. E. Hall--while preparing technical annex for " Sahel Water Data and Management III " in 1986.

Mon,11-3 ,	4:00	Riverside to Los Angeles by shuttle service
	9:00	Flight LAX-JFK-CDG Paris read documents concerning AGRHYMET
Tue,11-4 ,	11:40	CDG-Niamey, Niger, discussions with team leader, Asif Shaikh and agroeconomist, Martin Billings on the plane
	18:00	To hotel and discussions with Shaikh, Billings, computer engineer/systems analyst, Earle May and institutional analyst, William Rutherford to plan work schedule
Wed,11-5 ,	8:00	Team discussion to plan strategy
	9:00	Meeting at AGRHYMET center with DG Coly and his team C. Dancette, D. Lambergeon, J. Domergue and M. Rousselot, AID Project Officer, Dennis Panther, UNDP rep Mme Tevoedjre and team
	12:30	Meeting with Panther and acting Deputy Director, Dayton Maxwell at USAID
	15:30	Meeting with Dancette and Billings at AGRHYMET
	18:00	Full team met with USAID mission personnel
Thu,11-6 ,	9:00	Meeting with Domergue, Shaikh and Billings at AGRHYMET
	12:30	Met with Dancette, Rousselot, Domergue and M. Forest
	15:00	Discussions with Dancette and staff
	20:00	Meeting with ICRISAT agronomist, B. Ntare
Fri,11-7 ,	8:30	Team met with UNDP reps M. Caballi and Tevoedjre, Panther and Asst to ADO, Flynn Fuller
	11:00	Met with Lambergeon and Dancette, and visited experimental farm at AGRHYMET with C. Jacobsen
	13:00	Discussions with Domergue and full team
	16:00	Meeting with ICRISAT agroclimatologist, M. Sivakumar and Billings
	17:00	Team met with directors of Hydrology and Meteorological service in Niger
	19:15	Team meeting
	20:00	Dinner with Coly, Domergue, Lambergeon, Maxwell and team
Sat,11-8 ,	8:00	Team meeting
	10:00	Team met with NOAA computer engineer, Fred Welden
	15:40	Flight Niamey-Abidjan missed connection and stayed night
Sun,11-9 ,	10:00	Flight Abidjan-Bamako with Shaikh and Billings
	14:00	Discussions with Shaikh and Dancette
Mon,11-10,	8:00	Meeting with USAID mission in Mali, acting director, Wilbur Thomas, Emmi Simmonds, Ben Hoskins, Elzadia Washington, Project Officer, Abdoul Diallo and asst Mamadou Fofana

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	9:00	Meeting with DG of the Met Service, Konare, Director Agrometeorology, Konate and Traore, and Fofana, Dancette, Shaikh and Billings
	11:00	Visited Pilot Project at Bancoumana with Konate, Traore and others working for the met, agric and extension services, Fofana, Dancette, Shaikh and Billings, met with a large group of farmers and examined field plots. Visited the agrometeorological station serving this project and returned to Bamako at 18:00
Tue,11-11,	8:00	Meeting with Director Hydrology Services, Ba, Sidibe, Diabate and an expatriot involved in training, Fofana, Dancette, Shaikh and Billings
	9:30	Meeting with the multidisciplinary work group (GTP) including the directors and reps of Met and Agric depts, Operation Haut Valee, CMDT, Plant Protection and Livestock Rearing, Fofana, Washington, Dancette, Shaikh and Billings
	11:00	Meeting with the representative of the National Committee to help victims of drought, Christian Remy, of the early warning project, Phillippe Autier, Fofana, Washington, Traore of the Met Serv, Dancette, Shaikh and Billings
	12:00	Examined computer facilities at the old airport in Bamako with Traore, Fofana, Washington, Dancette, Shaikh and Billings
	15:30	Meeting with UNDP rep, Charles Larsimont, asst Clemenceau, the FAO rep in Mali, Traore, Washington, Fofana, Dancette, Shaikh and Billings
	16:30	Met with the director of Ag Met(Konate) and Dancette
Wed,11-12,	8:00	Debriefing at USAID mission in Mali with Thomas, Simmonds, Hoskins, Diallo, Fofana, Washington, S. K. Reddy, Dancette, Shaikh and Billings
	10:00	Met other team members, Nay and Rutherford, at airport
	10:30	Flight Bamako-Ouagadougou with Billings and Dancette
	14:00	Discussions with Bonaventure Traore, Project Officer, and Mike Sullivan, Special Projects Officer USAID mission, Burkina Faso, Billings and Dancette
	16:00	Meeting with the Director of the Meteorological Service, Jean Pierre Ouedraogo, Hama Kontongombe, Dennis Ouedraogo, Billings and Dancette
Thu,11-13,	8:00	Meeting at the Dept of Studies and Planning with Director, Daoda Kontongombe, Andre Sawadogo (GTP coordinator in 1985), Statistician, Gaspard Badolo, Billings and Dancette
	10:00	Meeting with B. Traore, Billings and Dancette at USAID
	11:00	Meeting at Met Service with H. Kontongombe, D. Ouedraogo, Billings and Dancette
	15:45	Went to visit Pilot Project at Gonce with D. Ouedraogo and an ORD representative, Billings and Dancette. Met with a farmer and visited his fields and the experimental plots. Returned at 18:30
	18:30	Discussions with Dancette

Fri,11-14,	8:00	Billings met with acting Mission Director USAID
	10:00	Hall and Dancette met with reps of the multidisciplinary work group (GTP) Chairman, Bougousare, Dpt of Ag rep, Sanoussi Fofana, and H. Kontongombe
	12:00	Meeting at USAID mission with B. Traore, Billings and Dancette
	15:00	Visited the Pilot Project at Tangin with the Met Service rep, Etienne Zongo, Ord rep, Phillippe Ouedraogo, Billings and Dancette
	19:00	Discussions with Dancette
Sat,11-15,	8:00	Went by road from Ouagadougou, Burkina Faso to Niamey, Niger with Billings and Dancette, arrived at 15:00 hrs
	16:00	Began preparing report
Sun,11-16,	8:00	Continued preparing report
	12:00	Meeting with Billings and Dancette
	15:00	Finished report
Mon,11-17	8:00	Left report for typing by USAID mission Niger and had discussions with Panther, Maxwell, Fuller and Quincy Binbow
	11:00	Confirmed flights with UTA
	16:00	Meeting with Panther and proofed draft report
	21:00	Meeting with Shaikh and May who had just returned from Senegal
Tue,11-18,	8:00	Meeting with Panther, had report corrected, made copies and provided them to the mission
	12:00	Provided copies of report to members of team and members of AGRHYMET
	13:00	Discussions with team
	15:00	Discussed Niger Applied Agric Res Project with Lynn Graybeal, USAID
	16:00	Discussed project paper with full team
Wed,11-19,	8:20	Team presented provisional findings to AGRHYMET team, Panther and Welden
	10:50	Debriefing with Deputy Mission Director, Cary Colter, Maxwell, Panther, Program Officer, Randy Casey and team
	14:00	Left for airport to fly to Abidjan
Thu,11-20,		Worked on report in Abidjan and on flight to Cameroon
Sun,11-30,		Finished off draft report for transmittal to DAI
Fri,12-26 through Tue,12-30		Completed Technical Annex

APPENDIX E

Discussion of Some Key Questions Raised by AID/W.

The principal activities to be considered for AID funding (Appendix B) were a) support to the crop/rangelands monitoring and forecasting system, and b) a project evaluation and monitoring plan. The recommendations of this consultant that AID should contribute to improved weather data collection, transmission, analysis and storage would support crop/rangelands monitoring and forecasting and the general agroclimatological activities of AGHRYMET and the national programs. The evaluation and monitoring of the Pilot Projects would be of limited value. The main assumption on which they are based, that real-time weather data can help farmers in the CILSS countries, is invlaid. They should be redesigned to take advantage of what can be achieved through agroclimatological analyses.

Several options for AID funding were requested but only one general option was provided which dealt mainly with information collection, transmission and analysis. It is assumed that the Information Systems Team will provide detailed funding options in this general area which could accomodate different levels of funding.

AID/W asked how the agricultural research being performed on these projects relates to other agricultural research projects in the Sahel. The overall AGRHYMET program is obtaining data and conducting agroclimatological analyses that are extemely useful for virtually all agricultural research and development projects. AID Missions in CILSS countries should insure that their bilateral projects are making full use of the available weather data and agroclimatological analyses. After the necessary redesign it would be useful to integrate the Pilot Projects with other complementary agricultural research and extension projects.

The project committee in Washington (Appendix C) asked the following questions.

a) What will be the specific products of the AGRHYMET SYSTEM and who will use them over the course of Phase III and beyond? The main products should be high quality weather data and agroclimatological analyses that can help planners, research scientists and extension agents involved in rural development to be more effective, and remote sensing data that helps various agencies to forecast the extent and severity of famines.

b) In what timeframe does AGRHYMET assume that significant improvement of agricultural production will be realized and is this realistic? My estimate is that the main contributions of AGRHYMET to agricultural production will be indirect. It will be one component of the multidisciplinary team effort that is needed for agricultural development, and the contributions will be long-term and cummulative.

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c) What is the longer-term recurrent cost burden of the AGRHYMET SYSTEM and to what extent should selection of Phase III technologies be conditioned by that burden? I start by assuming that the core activities of the national meteorological and hydrological services and the AGRHYMET center are essential for agricultural development, long-term and continuing in nature. This assumption is supported by the history of agricultural development in the U.S. and elsewhere. It is also clear that the future capacity of AGRHYMET center and most of the national programs to pay recurrent costs is extremely low. Consequently, Phase III technologies must be selected that have low long-term recurrent cost burdens.

d) What is the most appropriate division of labor between the national and regional centers? I agree with comments by the project committee that support to national centers should have major emphasis because they play a central role in data collection and provision of information and advice to the primary users. It should also be recognized that the regional center in Niamey has an essential and important role to play in supporting the national centers. Due to the difficult operating conditions in some of the CILSS countries, there will be a tendency for some of the national programs to become ineffective in the main core activity of collecting high quality weather and hydrologic data. AGRHYMET center should be designed to assist national programs to overcome operational problems. AGRHYMET center can also play an important role in coordinating the activities of national programs and in the standardization of methodologies of data collection and analysis, reinforcing the role of WMO.

SAHEL WATER DATA AND MANAGEMENT III

(625-0973)

PROJECT PAPER

ANNEX C: INSTITUTIONAL ANNEX

William Rutherford

January 1987

I. AGRHYMET PROGRAM OBJECTIVES

A. Evolution of Program Objectives Phase I - III

There has been a subtle and subterraneanly gradual, as well as overt, shift of focus in the evolution of AGRHYMET Program objectives since Phase I program inception in 1975 and the current inception of Phase III.

Overt planning called for the following:

Phase I, 1975 - 1981:	Strengthening of national meteorological, agrometecrological and hydrological networks; creation of an AGRHYMET Regional Center (ARC) and the carrying out of various training.
Phase II, 1982 - 1986:	Implementation of basic operational activities such as the collection, analysis and distribution of national and regional agrometeorological/ hydrological data and training.
Phase III, 1987 - 1991:	Extension of operational activities in providing data and information to farmers, herders and other end users; the Sahelianization of the program by CILSS member countries including staffing and financial support.

USAID and UNDP evaluations indicate that results achieved in Phases I and II include a large proportion, but not all, of the initial objectives. However, Phase II saw the introduction of new operational activities and objectives, particularly in the introduction of an initial experimental agrometeorological based pilot project in Mali. The results

of the Mali pilot project led to a call by the donors (CAC) for the extension of pilot project methodology to other countries. The strengthening of national services as well as the training as called for in Phase I are long-term, on-going undertakings that were also major activities in Phase II. These aspects of the program will doubtless continue into Phase III and perhaps beyond. However, some major donors have been pressing for operational activities, initially planned for Phase III, to reach end users, during Phase II. To a large degree this is beyond the current capabilities of most national services given the complex problems they face in the areas of extension and communications.

Nevertheless, several CILSS/AGRHYMET member countries (viz, Niger, Burkina Faso, Senegal) have initiated or are initiating pilot projects based on the Mali model. Most are also publicly broadcasting and publishing meteorological and hydrological information on a frequent and sustained basis.

However, these efforts to reach end users are limited in scope and impact. The number of villages and farms involved in the pilot projects is quite small averaging perhaps 4 villages and 25 farms in each country. Simultaneously the donors are becoming more and more impatient to see the fruits in concrete terms of the past several years of activities and investment of resources. Unfortunately, instead of examining the current state of the national services (agricultural, meteorological and hydrological), as compared with 1975-1981, the donors are raising the question as to how many farmers are presently benefiting directly from the AGRHYMET Program.

This subtle and creeping shift in focus has led to a number of institutional frustrations: AGRHYMET Center feels compelled to reach end users in a time frame never before envisaged; national services are organizing limited pilot projects that are only partially conclusive; and the donors are demanding more and greater concrete results.

In addition to the donor-led thrust to reach end users there have been considerable pressures to involve the program in advanced meteorological technological developments such as remote sensing, early warning systems, agricultural research and other related agricultural sector development projects (viz, INCRISAT, IPM, etc.). In fact, AGRHYMET Center, in addition to its role as regional catalyst and coordinator is engaging in direct tangential operational activities (in addition to training) through the operation of an experimental farm and more recently through the implementation of a Netherlands funded crop protection project.

The impact of these frustrations and divergences on program developments and resources allegation is portentous and is discussed below.

B. Divergent Perceptions of Objectives

Based on the interviews and research carried out by the USAID PP Design team the divergent perceptions of AGRHYMET program objectives can be summarized/paraphrased as follows:

Donor (CAC) Community

Improvement of the quality of life in the region through increased food production resulting from the provision of appropriate agrometeorological information to end users.

2. World Meteorological Organization (WMO)

Stewardship of the responsibility for accomplishing the above by coordinating and reconciling CAC demands with ARC activities.

3. AGRHYMET Regional Center (ARC)

Strengthening of national services through coordinating provision of meteorological, agricultural and hydrological data; supply equipment, material and training to national services; catalyse and coordinate CILSS countries cooperation in the use of agroclimatological information in increasing food production.

4. National AGRHYMET Centers (NAC's)

Increasing food production through the strengthening of capabilities and cooperation/coordination of efforts by key ministries and services (i.e., agriculture, hydrology, meteorological and, in some cases, information); facilitate and expedite the national collection, analysis and distribution of agrometeorological and hydrological data to national (mainly government) users; and, finally, forward decadal data to ARC.

5. Official Institutional (Collective)

In addition to the observed perceptions of objectives noted above, there are the official, written objectives arrived at by consensus (promulgated by ARC/WMO and endorsed by donors in the CAC). The last version indicates the following:

- Developmental Objectives
  - -- member country food security.
  - -- regional food self sufficiency through the application of hydrological and agrometeorological data.
- Immediate Objectives
  - -- develop and implement hydrological and agrometeorological data observation and collection methodologies for crop,

livestock and surface water monitoring; analyze and store resulting data in the ARC data bank; provide this data to end users upon request.

-- contribute to the development of an early warning system at the national, regional and world levels through the provision of hydrological, meteorological and agrometeorological data and forecasts.

-- contribute to increased food production through the dissemination of advisories and suggestions in a form usable by rural communities.

-- continue the strengthening of appropriate national services and the ARC in view of the progressive assumption of management and support functions, following an indicative ten year schedule, by Sahelian member countries.

II. INSTITUTIONAL DEFINITIONS

Chronicling the above divergent perceptions of program objectives is a clear indication of the need to better define institutional roles and responsibilities.

A. WMO

As the executive agency the parameters of WMO responsibilities vis-a-vis the CAC, ARC, NAC's are not clear. WMO authority for implementing CAC mandates, responding to ARC and NAC needs and requests seem uncertain in terms of WMO performance.

Is WMO responsible for program problem identification (through periodic evaluations, etc.) and the proposition of remedies? To whom is WMO ultimately responsible? Who monitors WMO performance/accomplishment of its mandate?

B. ARC

As the regional catalyst/coordinator of the AGRHYMET program, ARC activities should be confined to that role and not be allowed to overlap into operational activities that are actually the implementation of tangentially related discrete projects (eg. early warning systems, forecasting, crop protection).

C. NAC's

It is questionable whether the national services have a formal and binding (legal) responsibility/relationship with ARC. The relationship is unclear, aside from ARC's provision of material, training and services in return for national data (principally the decadal bulletins) and marginal consultations

by the NAC's. The role of the NAC's in accepting responsibility for and planning the achievement of the objective to Sahelianize the AGRHYMET Program over the next 5-10 years has yet to be determined.

III. VIABILITY OF AGRHYMET PROGRAM

The AGRHYMET Program is currently functioning in a viable manner, with certain shortcomings, due largely to considerable external financing through donor support.

A. ARC

The ARC is well staffed at present and is pursuing the mandate well in the areas of training, data collection, analysis storage and dissemination. Similarly the center fulfills a key role as a catalyst and in funneling material and services to the NAC's. Shortcomings at the ARC include management and structural anomalies (discussed below under critical issues) as well as the problems of confused program objectives and institutional role definitions discussed previously.

B. NAC's

The National Centers (with the exception of Niger) are currently functioning at an all-time historically high level. The multidisciplinary groups (GTP's) are meeting regularly and frequently. The level of cooperation achieved between the various ministries and services involved is unprecedented in most of the countries visited. The basic institutional problems for the NAC's include limited funding in most cases (Mali being the exception), and the ubiquitous problem of national and international telecommunications (with Senegal being perhaps the sole exception). It is strongly recommended that the WMO/ARC/CAC mandate and implement a telecommunications needs assessment and that this area be highlighted in future planning and closely monitored in subsequent program reviews and evaluations.

C. CILSS National Components

There is a CILSS representative in each member country and his role is to monitor and coordinate all CILSS programs and projects. It was the design team's finding that this system is currently functioning poorly as regards AGRHYMET. In some countries there is sporadic contact and exchanges of information between the CILSS representative and the NAC, in others there is virtually none.

IV. SUSTAINABILITY OF PROGRAM

The question has been raised by USAID and others as to whether the AGRHYMET Program can be sustained over time and mainly supported by member countries by the end of 1991. The clear answer is a resounding negative given prevailing circumstances and those that can be reasonably anticipated.

A. Budget/Finances

The regional project has been funded 1976-1986 by UNDP for a total of $11,490,000. The UNDP has also allocated (through 1986) to NAC's a total of $14,000,000. UNSO has also contributed to the program: $1,550,000 to ARC and $650,000 to the NAC's. Substantial material and financial support has also been provided by several donor countries (notably USA, Belgium, Netherlands, France, West Germany and Switzerland). The estimated total donor cash contribution to end 1986 is $10,830,000 plus $11,750,000 of additional in kind material and assistance. It is not possible to really compare this international support with member country contribution which have evolved in the greatest period of growth as follows:

ARC Budget Evolution (CILSS Contribution)

Year	Budget	% Increase
1976	FCFA 5 million	
1977	10 million	50
1978	23 million	130
1979	46 million	50
1980	55 million	9

In addition the CILSS budget contribution has been frozen for the past five years, and given the current economic situation in Africa there appears to be little likelihood of substantial change in the immediate future.

This freeze is in effect despite the CAC finding that a phased take over of support by member countries would have to include the following budget increases:

% Budget Increase Needed to Sahelianize AGRHYMET Program

Base Budget 1980:	FCFA 55 million	
Rate of Needed Increase	1981 - 1982	42,27%
Rate of Needed Increase	1982 - 1983	22,15%
Rate of Needed Increase	1983 - 1984	22,33%
Rate of Needed Increase	1984 - 1985	12,53%
Rate of Needed Increase	1985 - 1986	17,12%
Rate of Needed Increase	1986 - 1987	12,29%
Rate of Needed Increase	1987 - 1988	14,03%
Rate of Needed Increase	1988 - 1989	10,12%
Rate of Needed Increase	1989 - 1990	11,17%

At the national level (with the exception of Mali) agrometeorological services budgets are very small and have been static in recent years or have actually declined.

B. Levels of Support

There is strong political and administrative support for the AGRHYMET Program in member countries. However, as previously noted, there is little evidence of intended early change in resource flows to the program. To the contrary, the CILSS budget has declined in real terms (taking in inflation and normal salary increases) each year since 1980, despite increased ARC activities and responsibilities.

Donor support is also declining at the NAC level. UNDP, by far the largest AGRHYMET donor, is reducing its bilateral contributions in all three countries visited during the PP team's field trip as follows:

	Phase II 1982 - 1986	Phase III 1987 - 1991	% Change
Burkina Faso	$1,100,000	$450,000	- 60%
Mali	713,000	250,000	- 7[illegible]
Senegal	1,076,000	600,000	- 58[illegible]

The decline in UNDP support reflects both tighter world economic conditions and the frustration discussed early with actual and perceived AGRHYMET Program objectives and achievements.

The ability and the will of member countries to move forward with Sahelianization of the ARC is very much open to question. Currently of 35 professional staff 12 are Sahelians and excluding the Director (supported by WMO) and 3 other Sahelian experts (supported by other donors) only 8 Sahelian professional are supported by CILSS. It is projected that this number will grow to only 15 by 1991. Sahelian supported staff growth at ARC since its inception has been as follows:

CILSS Supported Personnel

Year	Support	Expert		Budget
1976	7	2	FCFA	5,062,500
1977	7	2		10,915,900
1978	13	2		15,564,000
1979	34	2		45,427,000
1980	39	3		97,928,000
1981	42	4		61,926,582
1982	43	4		76,601,544
1983	43	5		78,125,170
1984	43	5		78,125,170
1985	49	6		78,125,170

The non-growth in the budget and the glacial increase of CILSS supported expert staff, as shown above, has effectively blocked implementation of plans to Sahelianize the program and threaten its future.

V. ARC MANAGEMENT

The organizational structure of the AGRHYMET Program which is a complex management connundrum that makes the identification and resolution of problems difficult. Decision making and management responsibility is decentralized and diffused to the extreme, compounding the complexity of the governance of the program.

For example, there are eleven layers of management, if one includes the implementing agencies and the Club du Sahel, that impact upon the direction and operation of the Center. They range from the Heads of State meeting every two years to the various technical, administrative and donor committees to the new three member Director's Committee recently established in the reorganization of CILSS. The Director General must be constantly responsive to the perspectives, concerns and priorities of these varying management constituencies whose perceptions of program focus and needs evolve in obviously unsynchronized directions.

A further complication is the internal coordination and management of personnel. A notable anomaly has been the T/A expert, appointed by NOAA under a pasa arrangement with AID, who is responsible for all ADP installation, procurement, servicing and maintenance as well as repair and logistical support and the procurement of radio and other communications equipment. This person has no immediate superior at ARC and carries out his activities and duties in an Ad hoc and basically unstructured manner.

It is the design team's minimal recommendation in this matter, that the duties and responsibilities of this T/A be precisely defined in a job description and assigned to a new technical services line division within ARC which will also be responsible for ADP training and planning.

In addition to the stress that these organizational anomalies impose at the operational level, it makes problem identification difficult and problem resolution burdensome and time-consuming. In effort to reduce some of these problems the XI CAC meeting agreed to institute a system of management by objective. After completion of a brief (12 days) WMO observation mission an attempt was made to organize the ARC work plans and divisions according to MBO procedures. However, this effort has been largely unsuccessful due to the fact that ARC staff do not understand the procedures or how to apply them. A management expert should be assigned to ARC for several weeks to teach the MBO methodology and to work closely with each division head in setting up the system in his unit.

SAHEL WATER DATA AND MANAGEMENT III

(625-0973)

PROJECT PAPER

ANNEX D: ECONOMIC ANALYSIS

Martin Billings and Asif Shaikh

January 1987

I. Introduction:

In this section an attempt will be made to determine how soon and to what measure society is likely to benefit from the substantial investment(s) made in AGRHYMET. It will be argued that AGRHYMET should not be viewed as a conventional project producing a quantifiable benefit from a discrete input. AGRHYMET is rather an effort to create in a single stroke a major piece of social overhead whose benefits may not be felt for at least another generation. The 'key' operative word is social; AGRHYMET is an investment to produce a product - weather related data - which will reach and affect all users of agricultural products in addition to those specially identified with the project - agriculture, farmers and crop production. Publically produced and distributed meteorological information is a universal phenomena. It's importance to agriculture is widely recognized. Sahelian governments and populations have only recently begun to benefit from tne presence of such service.

The section will note the niche filled by the AGRHYMET project as a social investment and then go on to at least touch on some of the benefits which are potential to the project, in forecasting and as input to agronomic work. Building upon the projects' tangible benefits, which are principally to be found in agriculture, an effort will be made to determine when and under what circumstances AGRHYMET can produce a positive rate of return for the project and society. Because the conventional tools of economic analysis produce distorted results when applied across thirty to forty years, dependant as they are upon very strong assumptions required for the analysis, more than usual dependence must be placed upon qualitative analysis and measures.

AGRHYMET will be viewed as an entity throughout. Although AID has contributed only about 13% of the total, it is a critical part. The many components are intended to fit together to satisfy the projects goal - to contribute materially towards food self-sufficiency in the Sahel. It is practically impossible to separate the various cost streams sufficiently to link a particular benefit to them. The work done by the ARC and national centers, supported by the AID project, can provide an important input to the agronomic research, but it is by no means the only input.

II. AGRHYMET - its economic and developmental context:

a) Background:

Few areas in the world were less prepared for independence in terms of formal infrastructure than the Sahel. In virtually every technical domain these states were and largely remain un-equipped. The large social investments, vital to the operation of a modern society, which produce important information to the public as a whole, were entirely absent. Among the least developed of these structures, in the case of the Sahel, has been the meteorological services.

Sahelian states are ill-placed to develop the service from their own resources. Social overhead investments such as a national meteorological service are demanding of scarce skills and equipment, expensive to operate and slow to yield an often intangible product(s) but are nevertheless vital to society as a whole. Presently developed countries were able to equip themselves with social infrastructure gradually, paid for out of revenues gleaned from growing economies. And they were able to sustain them, sometimes for decades, before any measurable payoff occurred ([1]).

For the Sahelian countries the problem of how to provide themselves with the necessary supporting apparatus of social infrastructure, including strengthened meteorological services, at a time when they cannot establish or continue them from their own resources, appears intractable. There is nothing in the present state of their economies which lend much hope for an early upturn in public revenue which will enable them to support expensive public services.

Although donors have been responsive to the perceived need for social infrastructure on the part of Sahalian countries, they have not fully thought through the implications. Because the returns to social investment may be difficult to perceive, and are typically diffuse, success often goes unrecognized when it comes. In time donor interest flags, and external support declines even as positive social returns may in fact be in prospect. This moment may arrive for AGRHYMET in the early 1990s ([2])

b) AGRHYMET: what realistic expectations should include.

Although only limited economic analysis of the economic value of weather information appears to exist, and most of this has been done in developed countries, the findings are suggestive. The general public apart, a number of sectors can be shown to be direct beneficiaries of weather information, defined here to mean forecasts from six hours to a week in advance. These include mining operations, commercial fishing,

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1. A well-known example is the land grant college system in the United States, which was begun in 1862 (the Morrell Act) and expanded ever since. Economic analysis of the system, if required in the original act, could not have realistically promised a positive carry for years. It is likely that the economy received little in return for its cumulative investment until this century, and probably not until the 1920s - a gross lag of sixty years!

2. Although an extreme case, Sahelian countries are by no means unique in their need for long term help. It is worth bearing in mind that vastly better equipped India and Pakistan (at independence in 1947) continue to receive assistance forty years later. Scarcely developed Sahelian countries will require no less.

activities affected by frost, forest management, offshore drilling, transportation (air in particular), sales promotion, construction and most important agriculture. Of this list only air transportation and agriculture are relevant in the Sahel. And much of the forecasting used to support air transport is affected outside of the AGRHYMET system. AGRHYMET must, therefore, be justified on essentially agricultural grounds. What is the experience elsewhere?

A study in the UK ([3]) showed that a judicious use of weather forecasts to choose the best times for cutting and drying hay increased yield and quality by 10% and thereby increased winter milk production by 2%. Also in UK, weather forecasts were used to choose sowing and harvest times for wheat and barley which raised yields by several percent. A French study reported losses avoided by using weather forecasts to select wine grape harvest dates around Bordeaux are 10 - 15%. A US study found that in a pilot crop weather project in Mississippi, weather reports aided farmers to avoid pre-mature planting and permitted efficient pest control. A benefit/cost ratio of 40:1 was reported. Other studies showed early warning of weather activity was especially beneficial to crops heavily dependent upon spraying (especially fruit) and irrigation.

The Canadian study, reported to be the first effort to measure the value of weather information upon several economic sectors, suggests the major beneficiaries of short term forecasts (less than six hours) are fisheries, transportation (as affected by snow) and construction. The overall benefit/cost ratio for all sectors (including agriculture) was calculated to be 10:1.

Agriculture is primarily affected by intermediate forecasts; 48 hours to a week. Economic benefits chiefly derive from reduced costs (lower chemical and application costs, more timely operations overall), increased yields (more effective use of fertilizer and sprays), improved quality (reduced harvest damage) and overall improved farm management (daily scheduling). Farmers were especially keen on learning prospective temperatures, wind speed and direction, precipitation and humidity. This information directly affected planting (reduced the need for reseeding), tilling (timing of seed bed preparation), spraying (predicted infestation, scheduling application, reduced need for reapplication), fertilizing (best effect obtained when moisture becomes available immediately after fertilization) and harvesting (when the ground is dry).

The Canadian study estimated the economic value to the economy from shorter term weather forecasts upon grain production. While the savings and increased value per acre were small ($5-6 per acre), they affected 55,000,000 acres!

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[3]. This and all succeeding anecdotes derive from Economic Value of Weather Information in Canada, prepared for the Atmospheric Environment Service (Canada), by the DPA group, 1985.

1) savings in cost of production

	millions of $
- either activity specific savings ($6.23/acre)	320.
- or, estimated incremental savings ($5/acre)	256.6
2) value of increased yield	
- quantity and quality ($6.60/acre)	341.8
total	$598.4-661.8

How much of this is relevant to the Sahel? A great deal of the savings accrue from more efficient use of chemicals, which are not now very important, by any measure, in the area. Irrigation, important in several studies, affects only one percent of the Sahels' cropped area. Moreover, much of the particular information used by the Canadian farmers comes in the form of highly local area-specific information provided not by general bulletins but special reports from the local weather station. Farmers often obtain this by farm to station phone calls. This combination is unimaginably remote in the Sahel. Nevertheless a core of analogical practices in the context generally better understanding of probabilities seem to be relevant with respect to tillage, planting, fertilization, harvest. Better scheduling of hired labor, family labor (those with positive opportunity costs), use of seed and fertilizer etc could pay important dividends to Sahelian agriculture. What has been done? What is possible?

1. What AGRHYMET has wrought?

A regional weather reporting system existed in French West Africa up to the time of independence. Only weakly developed in the Sahel (rainfall data has been collected since the early 1900s), the system did little more than support air transport (through ASECNA) up to 1975. Under such circumstances its contribution to development was minimal.

The AGRHYMET program has created modern national meteorological services in each of the eight Sahelian countries (although formally in existence, the eight are in widely differing levels of development). An indigenous technical cadre has come into being and 119 have been trained (16 under US programs in data processing systems). The national services have benefitted directly from the establishment of a Sahel-wide weather reporting network funded under AGRHYMET which includes nine synoptic stations, six main climatological stations, fifteen sub-climatological stations, 509 rainfall stations and twenty seven agro-meteorological stations. Under AGRHYMET the national systems are linked to the AGRHYMET regional center (ARC) located in Niamey. The whole is linked to the world weather watch system (of the WMO) and receives regular inputs from the various weather satellites. Eventually the system will likely contribute to an Africa-wide weather service.

Under AGRHYMET permanent organic inter-ministerial links have come into being. Here, the primary users of meteorological information within each country -agriculture, hydrology, forestry, in particular - meet regularly, exchange information and produce periodic reports on the progress of the annual rainy season. These sessions are chaired by the meteorological service and are usually held at their offices which bestow considerable prestige to a traditionally neglected service. Regular reports generated from these sessions have come enjoy a wide circulation and growing demand.

Senior government officials have learnt the value of continual monitoring of rainfall in each district and have come to demand it. In Burkina, the 200-odd rainfall stations have access to military radio and are expected to report daily during the crop season. This communication network is centered at the office of the chief executive so that the President receives a daily briefing on rainfall and weekly reports on the progress of crops, by district. Monthly summaries of potential local surplus and deficits are prepared by the AGRHYMET-sponsored intra-ministerial committee which are made available to senior government officials. Similarly in Mali, an intra-governmental committee established under the program accomplishes much the same. And in Mali too, military communication systems maybe used in the stead of relatively unreliable civilian channels.

None of this useful cross-ministerial coordination would have been possible without the AGRHYMET project. An example of its impact can be drawn from Niger where in 1985 early warning gave the alert five months ahead (August instead of January) of harvest time that local deficits were likely which allowed authorities to make early emergency food supply plans. Many lives otherwise in jeopardy were saved in consequence.

2. The agricultural potential of meteorological information in the Sahel.

Broadly speaking meteorology deals with two sorts of information: climatological and meteorological. Climatology is the study of climate; the long term regime which determines the effect of the seasons on the ground. Weather, or meteorology, is the study of the day to day or short term changes in atmospheric phenomena. With careful analysis of weather information, improved in recent years by satellite imagery, forecasts of up to several days are possible.

African agriculture is weather driven, being almost entirely dependent upon rainfall. Sahelian farmers plan their crop and work cycles in conformity with time-derived perceptions of what weather patterns are likely to be given certain conventional indicators. Individual farmers, who are skilled in the matter, can make fairly reliable short term forecasts of up to 12 hours. Plowing, seeding, thinning, weeding, application of pesticides and top dressing decisions are made based upon these judgements.

Climatic patterns, however, seem to be changing in ways the farmer can only tell years after the fact, which will affect the odds of particular weather events occurring as they have in the past ([4]). Poor farm decisions made as a result will almost certainly have serious effects upon production. A few weeks late planting, for example, can cost a third of potential production, and further postponement, the entire crop. These sorts of mistakes multiplied across the entire Sahel amount to enormous personal and social losses and represent the real "opportunity" cost of investment in AGRHYMET. Although AGRHYMET may be justifiable on conventional meteorological grounds, it is arguable that its most important product may be agronomic. To the extent AGRHYMET-produced meteorological and climatological information can be used to reduce the weather-related risk element in planting and other cropping decisions AGRHYMET may be justified in terms of incremental crop production. This will taken up below.

a. The value of analysis of longer term trends.

An improved understanding of climatic trends can have profound impact upon agricultural planning. The post 1968 drought, for example, has reduced overall rainfall by 30% in association with delayed arrival of rain of up to several weeks depending upon area. The cropping season appears to be shortened by 20 days on average. The risks associated with growing conventional crops have consequently changed completely. What is happening is that farmers are being compelled to plant crops of say 120 day duration in a climatic regime that may in the particular case only really support a 100 day variety. On the other hand, were a short duration variety of say millet available, a second crop might be attempted (likely cow peas) even while less overall moisture were available.

AGRHYMET can produce information useful to plant breeders, agronomists, farm systems analysts etc which can allow them to design more suitable cropping systems. And, as a consequence of monitoring the progressive change in climate, continue to shift the systems as well. ICRISAT, for example, (which has a station in Niamey) is structuring its entire breeding program around the search for varieties which best fit into the emerging moisture regime, in the context of improved knowledge of soils. The search for improved plant architecture depends upon informed risk analysis of the likelihood of various rainfall events - beginning, duration, incidence - which can most easily be provided for the whole of the Sahel by AGRHYMET.

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[4]. There is growing evidence that a 'greenhouse' effect planet wide may be having, or about to have, an impact upon the Sahel. The effect will render entirely obsolete farmers received understanding of weather and thus all of their judgements based upon this will be in err as well. To the extent the 'effect' is real AGRHYMET may come to play a role scarcely imagined today.

The payoffs to these breeding programs are unmeasurable at present. But their product will, in time, affect every production project in the Sahel and, as seeds become available, a large number of farms as well. Improved varieties can be supplemented by better informed cropping strategies using them, built upon least-risk planting dates and best use of net moisture over the entire crop season.

AGRHYMET-supplied information on moisture levels in the soil (assuming the use of satellite sensing) with continual monitoring can improve the quality of water management in rain fed and irrigated areas alike. When combined with soil, transportation and other information AGRHYMET can support the identification of opportunities and problems and be of use in planning. To the extent the Sahel remains arable, AGRHYMET supported agronomic programs could go a long ways towards reducing the areas' vulnerability to drought. And, the subsequent analysis, will depend to a significant degree upon the cereal production effect of the above research the decades following the official end of the AGRHYMET project.

b. AGRHYMET and intermediate situation evaluations.

More controversial is the use of AGRHYMET in crop forecasting, allied as it is to remote sensing as a primary means of monitoring standing crops. The ability to do this effectively - linking the index of 'greenness' of vegetation with net moisture estimates, detailed knowledge of local soils and topography, in addition to distribution of population, carrying capacities of local crop systems and the complexities of inter and relay cropping gives pause to many.

Nevertheless AGRHYMET-initiated inter-governmental committees in Burkina and Mali are beginning less sophisticated but effective crop monitoring with the view towards early identification of small areas in which either deficits or surpluses may occur. In Burkina this information is provided directly to the office of the President and is published by arrondisement monthly. The information allows government to prepare for shortages by early planning of purchases, arrangements for storage and transport, movement of local surpluses etc. An important saving in lives from such early warning as been claimed in Niger in 1985.

An allied area is that of monitoring and early warning of insect pest. Inasmuch as these pests are often closely linked to moisture levels, AGRHYMENT-supplied moisture information could be a useful adjunct to existing pest monitoring systems.

c. AGRHYMET and short term weather forecasting.

Most controversial is the use of AGRHYMET information to directly support farmers. The argument has been advanced that crop production could be augmented if farmers could be provided directly with weather forecast information together with recommendations with regard to practices affected by rainfall. Such a system pre-supposes the existence of (a) a dense reporting network, (b) a dense and effective extension or

alternative communication capacity, and (c) farmers sufficiently sophisticated to be sensitive to and in need of weather related recommendations.

Each of the core Sahelian countries presently has a 'pilot' project which is attempting to demonstrate that such information has important effects on yield (both Mali and Burkina have reported impressive incremental percentages). In practice it is almost impossible to determine how much if any of the increment is uniquely due to meteorologically inspired recommendations or intensive extension support, fertilizer, good agronomic practices and perhaps the selection of better than average farmers on above average land (see the agronomic section of this paper).

To be successful on a large scale recognition would have to be give to the presence of many micro-environments each with its own farm system(s). Information would have to be made widely available in 'real time' but sufficiently precise to be of use in a micro-environment. If too general the information would be either useless or, worse, misleading. If too precise, it would only be useful to a few farmers. It is doubtful any Sahelian country could attempt such a system large scale, given these limitations. In most instances, recommendations would have to be supplemented by on-the-ground extension personnel. Only the exceptional farmer could reliably interpret meteorological information to be of use in his or her particular circumstance. Given the thin spread and questionable quality of extension this sort of activity would only be possible in areas where support had been concentrated. It is not at all clear that such information would be of much use other than for planting dates.

The view seems widely accepted that Sahelian agriculture has very strong built in tendencies to resist change([5]). And these may be growing stronger. Surveys suggest the identity of farm-level decision makers is changing from one dominated by able middle-aged and experienced men (and in many instances women) to one of poorer women, the least ambitious men, the old and the young. Those more prone to innovation, it is argued, are being tempted away by higher off- farm opportunities reducing the pool of potential rural risk takers. To the extent this is true, and it may be important in areas not selected for 'operation'-type intensive activities,

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5. Although the project paper is following the current wisdom of the Niger mission in this regard it is worth remarking that recent developments in the agricultural sector in Niger tell a story of quick adaptation and adjustment to new economic realities since 1970. Farms appear to be the process of rapidly diversifying their sources of income. Farming patterns are changing, while groundnut sales have fallen away, sorghum and especially cowpeas have made great gains. All of this has happened primarily in response to market signals. Even so, the demographic composition of farms, stressed by the mission, persist and may in time have the effect expected.

the potential for sophisticated decision-making on-farm is greatly reduced and with it a robust rate of spread of innovation of the sort assumed in the 'pilot' projects.

3. Summary.

To the degree AGRHYMET-induced or supplied information is of use to decision-makers operating at levels where such information can usefully determine direction or supply criteria it is likely to produce a stream of benefits. Where the contrary condition prevails, and the decision maker is expected to use AGRHYMET or meteorological information as an input to a particular decision, benefits are much less likely and will be much slower in coming. AGRHYMET shows promise of producing a stream of benefits when it is able to: (a) promote inter-governmental linkages among hydrologists, agronomists and planners who can provide policy and decision relevant information, (b) establish and maintain sufficient data banks that analysis can be usefully attempted, (c) create and test workable models and develop the necessary soft ware, (d) establish and maintain information-providing links outside the particular countries to include the Sahel as a whole and the outside world, (e) create and sustain reliable communications among the national offices and with other centers and (f) do all of the above on a permanent basis (which requires that long term funding be found and sustained).

These conditions will be satisfied only gradually so that the potential stream of benefits may be expected to come only after the passage of many years.

III. AGRHYMET, the model:

The cost and benefit sides of the subsequent analysis will be developed in this section for subsequent application in section IV.

a) Costs:

This project is unusual in that its costs, covered by donors and host countries, will persist at a substantial level every year of the project. Further, given the expected meager, and unmeasurable, levels of benefits during the life of the project, it is likely that the project will sustain a negative cash flow for fifteen years - every year of the project! And, it is likely that a negative cash flow will continue for at least a few years post-project, or until the economic returns from incremental cereal production begin to assert themselves.

The analytic effect of this unusual cash flow profile will be offset to some extent by the decision whether to evaluate the project in its entirety or as 'zero line' activity wherein the last tranche is compared with its perceived benefits. In this latter instance the analyst would compare the third phase against alternative uses of the money, viewing the first two phases as sunk costs. Both will be attempted below. The total value of the project will be approximately $90,000,000: donors having

given approximately $30,000,000 in each phase. Assuming the several donors have followed their own priorities during the life of project, it is unlikely that the project is seriously frontloaded. Instead it will be assumed the rate of expenditure has been continuous; or $6,000,000 annually for the whole life of project.

These outlays covered the establishment of an extensive information gathering network based on the existing weather data services in each CILSS member country (rainfall stations, synoptic stations, climatological stations and agro-meteorological stations together with the beginnings of an effective communication system and training for a very large number of Sahelians at all levels). More recently AGRHYMET related projects have come to include one crop production project, trail plots on farmers fields, per country.

More complex is the problem of recurrent costs. At one level the analyst is indifferent whether a cost is for capital or operations in that both are required to make the system go. Our concern here is whether AGRHYMET will indeed function at some level of efficiency for an indefinite period after EOPS.

b) Recurrent Costs:

Will the Sahelian states cover at least a portion of the total costs required to keep AGRHYMET in service, or at least enough to sustain a minimum benefit flow? The problem in this section is to determine for the purposes of the economic evaluation (1) factors which will influence the level of recurrent cost support for the project five years after the end of donor support and (2) the impact of various levels of budgetary support upon the operation of capacities installed under the project.

AGRHYMET has included a substantial rebuilding and upgrading of Sahelian weather services and services which make use of weather and hydrological data. The system is also dependent upon crop monitoring capacity. This leaves a legacy of larger staffs needy of more extensive operational support than local budgets may be able to manage. What is the post-project support record on the part of Sahelian countries? The ambitious CILSS study of 1980 (Recurrent Costs of Development Programs in the Countries of the Sahel, CILSS, Ouagadougou, 1980) into recurrent costs found that whereas all projects sustained cuts, some fared much better than others and that a pattern could be found indicating consistent criteria had been applied across all of the Sahelian countries. The findings further indicated that level of outlay, although important was not necessarily the factor which determined survival or not.

Heller ([6]) has calculated typical recurrent cost coefficients (r) for projects in seven sectors using numbers from projects world-wide ([7]). Projects having high concentrations of skills are associated with highest 'r', up to .7 (or seventy percent of the initial investment annually). The CILSS study examined 29 projects in eight sectors in seven countries and found that the post-project burden on these countries in terms of skilled staff, claims on scarce resources, continuing demand for imported goods to be substantial. The average annual post project cost of operation for agricultural projects was found to be 15% of the value of the initial investment. The highest equivalent figure produced by the CILSS study is .40, - a rural development project.

An 'r' can be calculated for AGRHYMET at two levels; regional and national. The regional coefficient is the dividend of the installed cost of new equipment, $ 970,000, which will be all that is operational at the ARC by the end of phase III and the annual cost of operation of the equipment, post project, $ 250,000. This produces an 'r' of .26, which places it firmly in the mid-range of the CILSS study-group. This support level would permit the system to operate at 100% of installed capacity, but also reflects a level well beyond what it is reasonable for national budgets to assume. A roughly linear relationship is believed to exist between level of support and operable capacity; such that were support to fall by a half, capacity would fall proportionately. Were support of ARC to be divided equally amongst CILSS members each would have to contribute $31,000 annually, not a large sum in absolute terms, but enormous in the context of the Sahels fiscal problems. Fortunately France is committed to support the technical staff indefinitely, but what of the equipment?

At the national level a somewhat more hopeful long term outlook can be said to exist. The 'r' for a typical Sahelian country is about .14. This represents the dividend of $100,000 in annual support post project divided by $700,000 in new equipment provided during phase III. This 'r' level would support the system at 100% of installed capacity. In this instance the relationship between installed capacity and level of support is not linear but is a five step function reflecting the cumulative impact upon output as each of five computers fails.

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6. Heller, P., "The Underfinancing of Recurrent Development Costs", Finance and Development, 16, #1, 1979, pg 38-42.

7. A measure, 'r', is used by financial planners to rank projects with respect to their likely cost in post-project time 'n'. The coefficient is notably sensitive to large use of consumables and need for high quality skills; both of which are characteristics of AGRHYMET.

The CILSS countries,therefore, will have to provide or find $ 131,000 annually to keep the entire AGRHYMET system functioning at 100% capacity each year after EOP. It is worthwhile noting that Senegal has found it difficult to manage anything above salaries in recent years (only allocating $ 8,000 on consumables last year) in the support of its meteorological department. In the case of AGRHYMET the past may not be a fully reliable guide to future public support.

The CILSS study showed a rather poor correlation to exist between post-project support and a projects 'r'; cost alone is not the operative criteria! By order of priority CILSS concerns appear to be technical (as reflected in the quality of the basic design), economic (contribution to economic growth) and financial ([8]). Given the essential poverty of these countries this seems surprising, but is explained in terms of fungibility, which is to say money even when very scarce is still allocated subject to some criteria. These criteria appear to include - perceived technical complexity, implementation problems during the life of project. import content, importance to the growth process, relationship to proclaimed national objective(s) and identity of beneficiary. Briefly, how does AGRHYMET stand with respect to beneficiaries? With respect to implementation government budgetary planners are likely to focus upon the national dimensions of AGRHYMET, likely the local meteorological service and its ability to produce data. There have been persistent and often computer related implementation problems. Major systems (such as that in Bamako) may often be down. The very high import content (both in terms of skills and parts) is a serious source of concern. There has been concern that left to their own devices only the exceptional government would be able to carry on even a fraction of the work.Set against all this is the growing attention given meteorological data by the national leaders, the recognition of the advantages which early warning (taken alone) can bring, the provision of military communications to supplement civil. And there is ample precedent for staff retention. All of this argues not for a bump at the end of AGRHYMET but a gradual decline to some level which can be supported in the long term topped up now and again with some external financing.

Given this the analysis will assume that sufficient recurrent costs are made available to sustain (15%) of installed capacity which is enough to at least keep agronomic research supplied with weather related data.

c) Benefits:

Two benefit streams derive from this project, one measurable and one not. The unmeasurable or intangible stream is unlikely to be the more important. There is no reason to assume that weather information would be important to sectors in the Sahel different from the cases cited above.

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8. Unspoken in the report is the always important role of politics, surely a vital and continuing arbiter among choices.

And it has been remarked that none of these sectors are at present important in the Sahel except for agriculture and air transport. Inasmuch as the latters' needs are provided outside of AGRHYMET, the project principal benefits are likely to be found for the most part in agriculture.

Additionally, certain intangible AGRHYMET benefits are likely to affect individual cases, including life, safety, health, comfort, convenience etc and these may be shared among the population as a whole not just rural people. These must be discounted from the analysis as virtually nothing is known of them.

AGRHYMET's most important benefits seem likely to be those which affect, directly or indirectly, crop production for reasons noted above. If farm decision-makers are as conservative as many believe, then the rate at which AGRHYMET-influence agronomic inputs and practices are internalized into agriculture is likely to be slow. The pattern may well conform to a conventional Cobb-Douglas function. This function, with respect to its relevant range, is divided into three phases. During the first, the dependent event (in this adoption reflected in incremental levels of production with the project) occurs at an increasing rate from effectively zero. The value of benefits during this early period can be very small if the adoption rate begins and remains at low levels. If the associated discount rate is low, and 10% is assumed to conform to World Bank practice, itself an estimate of the opportunity cost of capital, the pay- off will both low and remote from EOPS. What is a realistic adoption rate?

The adoption rate of an agricultural innovation depends upon (a) how much it costs farmers to buy into the system, (b) the extra risk involved in its use, (c) whether additional complementary inputs are required to use it, (d) whether training is required to use it - in the sense of formal structured training which may or may not be forthcoming and (e) dependence upon external input supply. In this last regard if the new input is seed, which is likely in the case of AGRHYMET, production and distribution of new and refresher seed will be necessary ([9]). Seed production has had a spotty history in the Sahel and may prove to be a continuing constraint.

AGRHYMET promoted farm techniques are likely to be practices - in particular timing, crop programs, and indirectly the potential for multiple or relay cropping as shorter duration seeds become available. Some extension apart, none of these require much out-of-pocket investment, should be risk reducing and seeds apart are not dependent upon supply systems. They are likely to change the pattern of demand for labor and

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[9]. The most likely crop to be affected is open pollinated millet, whose seed would have to be externally supplied to protect the hybrid element.

could raise the overall level of labor demand as an extra planting and harvest may be required as well as extra weeding. On the other hand fewer initial seedings may be required for any individual crop.

Spread of technology is promoted by extension, public information and observation among farmers. The widely dispersed African populations may inhibit rapid intra-farmer spread (as compared with the dense distribution which helped so much in India during the green revolution). Furthermore, it is argued that African farms are becoming more conservative as would-be innovators leave agriculture, the younger men and women, leaving the old, young and less motivated to manage the farms. Extension is not notably strong and public radio almost non-existent in many places. What the above argues is that the rate of spread of even low cost low risk technologies can be slow!

IV. Analysis:

a) Review of the problem:

The economic analysis outlined below,therefore, assumes the payoff from agriculture will be the primary benefit from AGRHYMET and that this will accrue slowly. The AGRHYMET system will continue to function at a level sufficiently high that a steady steam of support to agricultural research and current reporting may continue. The project's net cash flow, negative throughout the life of the project, is likely to continue that way for several years post-project. A positive cash flow stream will eventually emerge, as will be shown below. Ultimately, even with very conservative assumptions, a positive rate of return to AGRHYMET will be achieved.

The AGRHYMT system will produce risk analysis of weather patterns such that likelihoods of various events can be included in planning with a high degree of confidence. This sort of information, in the hands of plant breeders, for example, provide a target; what duration is most desirable, what moisture stress must be built in, what harvest characteristics are vital? Second, and somewhat more controversial, for a given plant or crop program, cultivation recommendations may be developed based upon most likely rainfall data. This last may reduce the number of plantings, saving seed and labor. It can help overall management of water or moisture resources and generally act to reduce the risk in dry-land agriculture.

It is impossible to speak <u>ex cathedra</u> as to how long it takes to convert meteorological information into agronomic material ready to extend to farmers but a five year lag does not seem exceptional given the state of supporting research in the zone. An optimist could model the stream of agronomic benefits to begin in EOPS plus one, for a few hundred farmers, Sahel-wide. By EOPS plus five, assuming the technology to conform to the guidelines outlined above, and assuming extension was able to promote the ideas, and assuming that in areas where farming was concentrated the idea spread autonomously, then it might not be outrageous to see from 1000 - 2000 farmers using a technology which added cereal

increment of say one ton per farm unit. Given a border price of $300, and 2000 tons, and a discount rate of .12%, the increment would have a present value of $385,000, which is not a great deal. The importance of the rate of spread of the technology now become apparent. A low figure for EOPS plus five is likely for any realistic model, but what of EOPS plus ten, fifteen years hence?([10])

To the extent the Sahel remains arable, AGRHYMET supported agronomic programs may go a long ways towards reducing are areas vulnerability to drought. And, the subsequent analysis, will depend to a significant degree upon the cereal production effect of the above research the decades following the official end of the AGRHYMET project.

V. Economic Analysis:

The economic analysis attempts to determine, through a reference case and sensitivity analysis, the likelihood that investments in the Agrhymet Program will yield a positive return for the economies of the Sahel.

The underlying assumptions of the economic analysis must be consistent with realistic expectations on both the level and timeframe of impacts. This has not always been the case for previous economic justifications of the program, leading either to overestimation of the benefits, or equally seriously, to estimated benefits which are not credible when judged by objective observers.

a) The Timeframe of production benefits:

In conformity with the argument put forth in the main body of the Project Paper, it is assumed that benefits to rural production systems will occur indirectly, through existing research and extension communities, and over long periods rather than in the short run. Furthermore, it can reasonably be supposed that benefits will, in early years, be extremely small, will increase very slowly for a number of years, and will continue to be negligeable -- relative to total production -- for over a generation. Thereafter, as a consequence of improvements in infrastructure and communications and advances in scientific research, benefits can be expected to grow somewhat faster, with noticeable overall results realized somewhere between years 30 and 50 from today.

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10. Long-term world trends in all cereal prices have varied. Some have been historically downward since 1900. The rice price of Thai whole CIF Dakar in the early 1980's was as high as $600 MT. A long-term decline toward $300 is not unreasonable, and therefore, allows the economy to save a ton of imported cereal (usually rice).

Therefore, while the investments are heavily front-loaded -- at least with input to the analysis period rather than the LOP -- (some $60 million to date and another $30 million over the coming five years), the benefits are almost entirely in the out years. In economic terms, the discounted present value of benefits far in the future is very low relative to the nominal future values. That is, a dollar promised in fifty years is worth much less than a dollar promised today. This, then is the economic test which must be passed: can we reasonably expect that benefits realized far in the future will be sufficient to offset investments made today?

The "diffusion-of-innovation curve" used is a characteristic "S-shaped" curve embodying a very low initial impact, increasing slowly, and a higher rate of increase in the middle years, tapering off to a stable longer run level in later years, as shown in Figure 1. The point at which the rate of increase begins to taper off (including at a declining rate) is known as the "saddle point", as identified in Figure 1. The vertical axis (Y-Axis) measures the percentage of farmers in the Sahel affected, while the horizontal axis (X-Axis) is time (0-50 years).

The reference case uses a diffusion curve a saddle point at year 35, as shown in Figure 2. This curve assumes that by 1991, less than one-tenth of one percent of farmers will be affected by agricultural improvements which derive from Agrhymet produced data, and that the percentage of farmers affected thereafter will be as follows (Table 1).

Table 1
Reference Case:
Rate of Diffusion of Innovation in the Sahel

Year	Percent of Farmers
1991	0.098%
1996	0.28%
2001	0.64%
2006	1.31%
2011	2.58%
2016	4.99%
2021	9.56%
2026	14.76%
2031	17.51%
2036	18.95%

The practical implications of the assumptions underlying Table 1 is that it will not be until the first decade of the Twenty-First Century that one percent of Sahelian farmers will even indirectly benefit from production induced as a consequence of the Agrhymet Program.

Two other diffusion curves are tested as well: one with a saddle point at year 30, and the other with a saddle point at year 40. The three curves (including the Reference Case) are compared in Figure 3.

b) Underlying Assumptions:

The current (1986) population of the Sahel is put at 35 million. The population is estimated to be 85% rural, with 75% of rural dwellers being sedentary farmers. Average rural household size is 9, yielding approximately 2.5 million farm households. Estimated holdings under cultivation are 5 hectares per household, 25% of which are taken to be under cash crops, the remainder being used for subsistence agriculture. Irrigated hectares are assumed to be extremely low (2% of total holdings). On average, subsistence yields are put at 600 kilograms per hectare, cash crop yields at 1000 kg/Ha and irrigated yields at 1600 kg/Ha. Because the Sahel is now in food deficit, and because deficits are expected to grow, the opportunity cost for food production is measured by the cost of food imports. At the margin, imported grain is valued at 150 CFA francs ($450/MT) per kilogram. Cash crops, while typically higher in market value, are given a lower economic value (100 CFA/kg) because they do not necessarily require ($300/MT) imports to fill a shortfall relative to anticipated levels.

Population growth is put at 2.8% per annum, but agricultural production increases are held to 1% per annum, which corresponds to average performance over the last two decades. In part, this reflects outmigration from rural areas to urban centers, and in part it reflects the per capita deterioration of agricultural production. A higher rate of growth than the 1% rate used here would increase the projected benefits from Agrhymet, but the lower rate is used to be conservative.

The Reference Case analysis takes into consideration all previous costs incurred for the program, starting in 1975. 1987 is taken as the base year, with past investments valued upwards to convert them to 1987 dollars, and future investments and benefits discounted to present values. Investments in the program are estimated at $60 million for the first ten years, $30 million from 1986-1991, and $2 million per year (real) for each year from 1992-2037. This latter figure represents the assumed recurrent cost of the program, whether from donor or national government sources.

The technical annex on agricultural production suggests that, over the long run, sizable percentage increases in yield could accrue from better management of climatological phenomena. In bad years, the percent increase relative to a "no action" case should be even higher than in good years. The current pilot projects suggests that a series of practices to

better manage climate can increase yields by over 50% (even after removing the effects of better agronomic and extension management in the pilot projects). We assume here that the maximum yield increase obtained by farmers who do benefit from the program (see table above for percentage of benefitting farmers) is 30%. Finally, it is assumed that farmers producing cash crops and irrigated crops will also benefit from Agrhymet data (irrigated crops more from hydrological than from meteorological information), and that, over time, better range management will also be a benefit of the program. The same diffusion rate is assumed for all rural producers, with the proportion of overall benefits obtained from each type of production activity being a function of its relative importance in the rural economy, as summarized in Figure 4.

It should be noted that the assumed costs of the program ($60 million + $30 million) include all costs, including setup costs, past mistakes and the costs which presumably can be attributed to the early warning effort.

c) The results:

The discount rate used for the analysis is 10%. For convenience, both the net present value (NPV - at a 10% discount rate) and the internal rate of return (IRR) are presented. A positive NPV or an IRR above 10% implies that the program is economically viable on the basis of production impacts alone.

Reference Case. The reference case gives an IRR of 11.5%, or an NPV of $60.5 million. If this case proved correct, the implication is that the Agrhymet Program will prove economically attractive for the Sahel even when all sunk costs of the past ten years are included on the cost side and when no non-production benefits are considered!

Sensitivity Cases. The results of the full set of sensitivity analyses are summarized below:

Figure 4
Summary of Sensitivity Analysis Results
(NPV in millions of U.S. Dollars)

Sensitivity		NPV	IRR
Case 1:	Saddle point at year 30	$155.0	13.4%
Case 2:	Saddle point at year 40	$ -7.2	9.8%
Case 3:	Sunk Costs of past 10 years excluded	$147.5	18.7%
Case 4:	Annual recurrent cost of $3 million	$ 55.4	11.4%
Case 5:	Food production valued at 100 CFA/kg	$ 17.8	10.5%
Case 6:	Food production in Sahel grows at 1.5% p.a.	$ 91.7	12.1%

Cases 1 and 2 show the results to be quite sensitive to the rate at which improved techniques reach rural producers, with a highly positive NPV if the saddle point occurs at year 30, and a slightly negative NPV if it occurs at year 40. Case 3 presents the economic analysis in a slightly different perspective. In effect, it assumes that all investments to date are sunk costs and that the decision faced by both Sahelian governments and donors today is whether further investments in Agrhymet will yield benefits which justify the investments yet to be made. This is, of course, a rational economic point of view, since even the decision to suspect the program will do nothing to eliminate past costs, nor is their any appreciable salvage value to existing program assets. In Case 3, further investments are seen to be highly profitable for the Sahel. Case 4 tests the impact of a lower assumed price of food (100 CFA vs 150 CFA per kilogram). Returns fall sharply in this scenario, but the NPV remains positive, with an IRR just over 10%. Finally, Case 6 assumes that agricultural production in the Sahel grows slightly faster than it has over the past twenty years (at 1.5% per year vs 1% as assumed in the reference case), thereby increasing the base to which production benefits are applied. This case yields a sharply increase NPV of $91.7 million and an IRR of 12.1%.

d) Conclusions:

The findings that the Agrhymet program is economically viable appears to be robust under a broad range of downside assumptions, based solely on the production benefits. Only if technology diffusion occurs more slowly than the conservative reference case is there an apparent risk of non-viability. To test the importance of this potential risk, a further case was run (Case 7), which is a combination of Cases 2 and 3. That is, for an investment made today (without consideration of sunk costs) would the program be profitable if diffusion occurred at the slower rate assumed in Case 2. Case 7 yields a highly positive NPV of $79.7 million and an IRR of 15.4%. Finally, using Case 3 as the base case, the NPV remains positive even if only a less than 2.5% penetration rate is achieved by year 40 (2026) -- corresponding to a saddle point at year 50.

Because the above results are exclusive of the impact of any benefits from the early warning component, the overall program can be judged economically viable for all cases run, including Case 2. In this respect, it should be noted that, unlike the production gains, the benefits of the early warning component occur evenly throughout the period of analysis, rather than being concentrated in the out years. Therefore, even a relatively low valuation will weigh heavily in the present value of benefit streams, and therefore in the Net Present Value of the program. Even Case 2 (the worst case) implies that if the food, money, and lives saved by all Agrhymet efforts to improve food security planning over the next fifty years are assigned a total (not annual) present value of $7.2 million, the program will break even.

CB

Figure 1

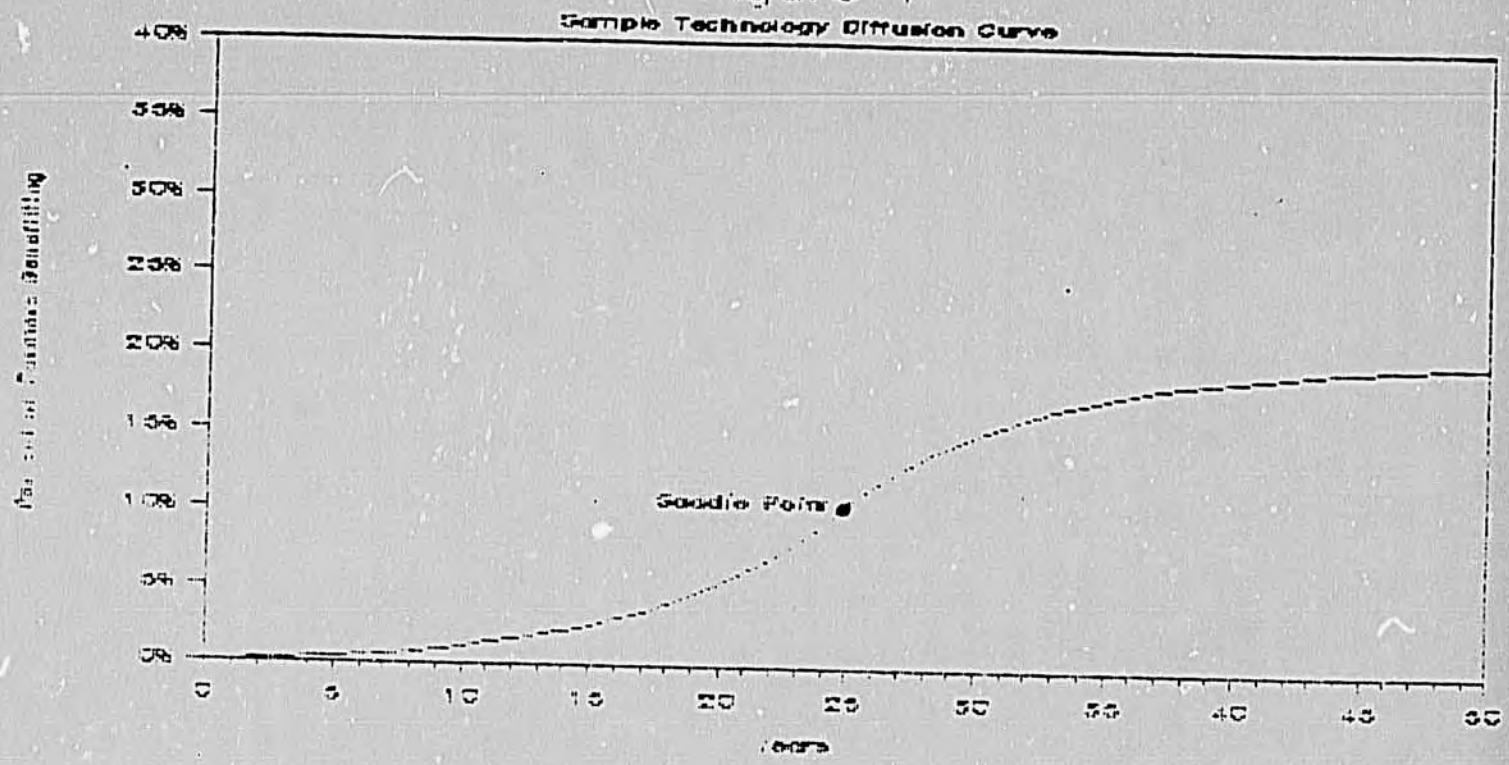
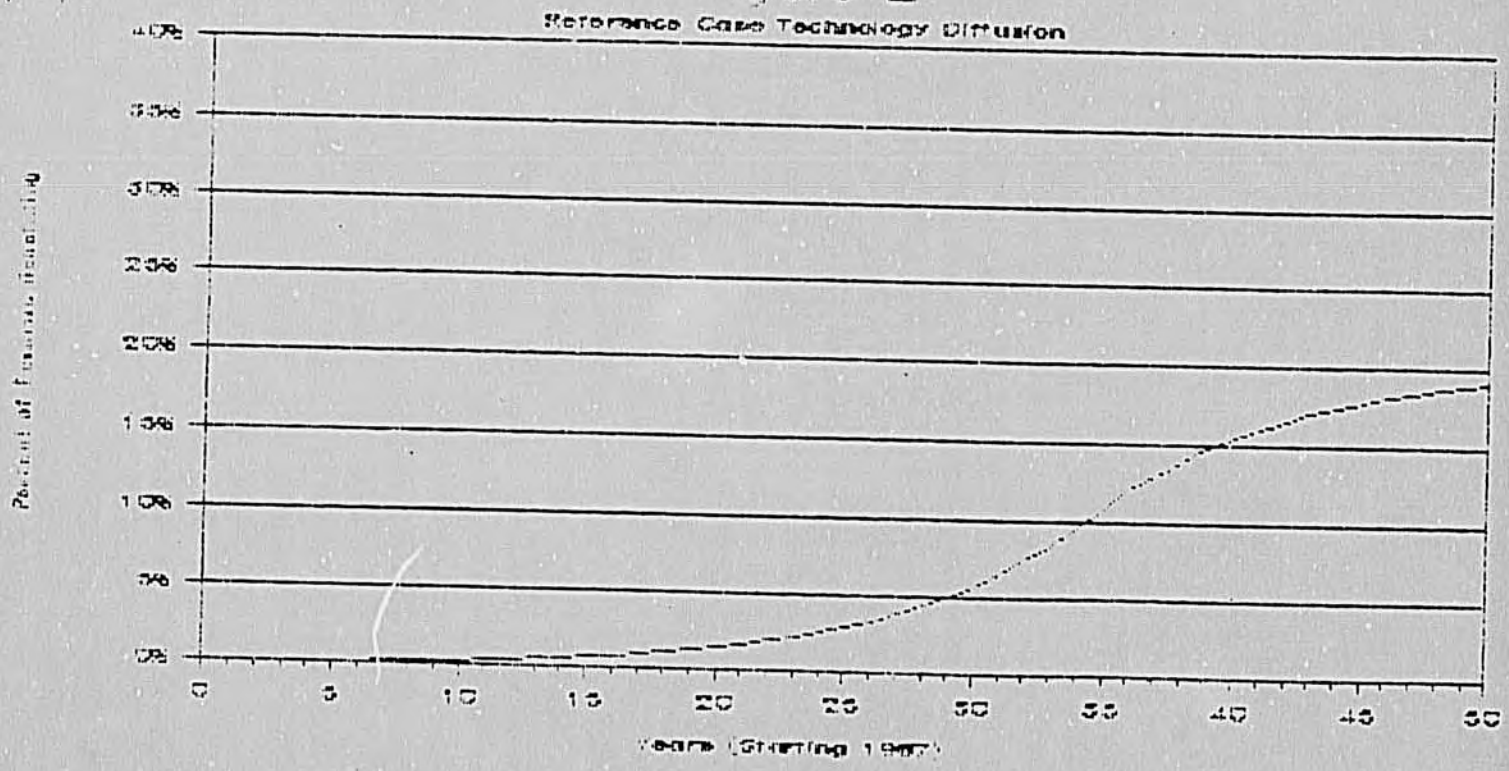
Figure 2