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A SUGGESTED PROGRAM OF IRRIGATION RESEARCH AND KNOWLEDGE TRANSFER IN ARID AND SUB-HUMID AREAS

by
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Logan, Utah, U.S.A. June, 1973

(DRAFT)

PREFACE

Much of the argument in this paper hinges on my recollection of discussions with colleagues that have been intimately associated with the USAID/TAB contract (CSD 2167) for on-farm water management in arid and sub-humid areas.

The direct and simple way to rationalize all overseas irrigation field research comes almost entirely from David James. To my knowledge, he was the first person on the USU team to emphasize publicly that the single, ultimate goal, of all on-farm water management field studies should be to obtain production function estimates.

The adaptive research phase, providing 1:1 complementary in-country technical assistance overlap, comes from Don Kidman/Kern Stutler and is based on their experience in Chile and El Salvador.

A number of meetings with Paul Riley have been devoted to planning an effective evaluation program for the water management contract.

My thinking has also been influenced by George Hargraves, Jerry Christensen, David Daines, Ted Olsen, Richard Griffin, Boyd Wennegren, Percy Aiken, Jose Alfaro, Morris Whitaker, Byron Palmer, and by the experience of observing the USU team in El Salvador set up a complex, three-year interaction experiment with the support of CENTA and USAID/E.S.

Allen LeBaron
15 May 73

(USU - USAID Contract AID/CSD 2167)

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INTRODUCTION

What follows is an outline of a viable program for international on-farm water management research that has reasonable, clear-cut goals, predictable costs, a definite time horizon, and a high probability of generating irrigated farm management knowledge for vast areas of arid and sub-humid lands that have some water control potential.

The outline emphasizes a research program, but it has inherent, complimentary, immediate technical assistance benefits to the areas or countries where primary field research is conducted. This automatic spin-off feature should have great appeal to host countries and AID missions that are under day-to- day pressures to achieve agricultural management objectives.

The program is flexible -- if drainage information is important, for example, it can be obtained. Particular adaptations to local host country or Mission requirements can be made, however, the need for such adoptations is minimized from the start because the goals and procedures are clearly understood by all parties. Accomplishments and progress easily can be monitored. The program is integrated in all phases and all extraneous expenditures are eliminated.

Personnel and other research requirements can be programmed several years in advance. And, finally, the program allows all participants to evaluate probable scientific and professional advantages of association with the endeavor (this applies to universities and all other agencies as well as to individuals).

The program is flexible another way. Each primary field experiment is designed to eventually service a region. As long as the regional

programs are the same, just what group or agency sets up and operates each primary experiment is not the most critical question. Presumably a given continent, say Africa, might be divided into 3-5 regions, each of which will require 1 primary experiment site. If it is convenient for, say, a single university to operate all the experiments, that is fine, but more than one might be involved. Similarly one university might control experiments on more than one continent. At present, Colorado State University is concentrating quite a bit of effort in Pakistan, but it might be asked to set up all selected Asian plots, etc. The CUSUSWASH Consortium is designed to help deal with such matters.

Certain countries may be prepared to handle all the basic research themselves, given the field plans, in order that they might obtain the pay-offs from data swapping arrangements. In the end it might prove to be convenient to have more than one data bank when actual international knowledge transfer is at its peak -- this can be decided in due course. The program is fully compatible with the USAID sponsored soil test network and with the work of the new Rockefeller Centers in Colombia and Nigeria.

GOALS OF THE PROGRAM

Two general goals must be satisfied: appropriate irrigation and other on-farm management data must be generated; the generated data must be transferred (or be transferrable) to other sites and regions. These goals can be achieved in eight years or less (with world-wide coverage essentially completed) if the program is adopted by CUSUSWASH, TAB and other interested groups or agencies, with minimum loss in lead-time and if the resources necessary to establish the chosen number of primary experiments are available more or less immediately. If AID or other resources are inadequate, the work would have to be stretched out.

An outline chart of the research/technical assistance systems interactions of the proposed irrigation research program is shown inside the front fold-out. This is developed for a single region; the process is multiplied to any required number. Inside the back fold is a schematic relating the research and logistic sequences to expenditures for the probable required time period (Table 1, p. 15a).

PRIMARY EXPERIMENTS

The first requirement of the program is acceptance of a basic aim for all field research. That aim is to obtain crop yield response surfaces as a function of soil moisture/fertilizer interactions. Without such "production function" information it is impossible to be certain what technical and economic optimum yields are possible and what water or other management recommendations to make in areas where little is known of irrigation practices or technical potential.

Response surfaces are obtained from a large experimental plot where soil moisture will be controlled at four levels, there will be four fertilizer rates, two or three irrigation methods, and suitable replications. Each primary experiment will be conducted continuously through wet and dry seasons for three years. Soil testing and all experimental and field procedures are specified in advance in-so-far as possible. Professional, counterpart, and field labor requirements also can be estimated well in advance. The persons in charge of the field work at each primary experiment do not rotate; they have three-year assignments.

Resource requirements from AID's standpoint will be greatest during the first four years, since each primary experiment takes a minimum of three years to complete. However, most field research would cease at that point and costs would fall as the information transfer phase gathers momentum since most of the computer work could be concentrated in one or two locations.

Other subsidiary aims also may be accomplished depending on circumstances, but the interaction research is basic. Drainage investigation, nitrogen leaching tests and other tests are examples of such possibilities.

FIELD RESEARCH SITES

Having agreed upon the production function goal, plot locations need only be chosen according to the specific site characteristics desired in a given circumstance. The circumstances will be governed, of course, by the region in question. This means that whether or not any experimental site selected is in an irrigation or drainage "problem" area is incidental. Ordinarily the irrigation problems may exist in the selected areas, but this is not a pre-condition to effective research.

An important aspect of any experiment installation will be the control that can be exercised over the selected site. In general the irrigation plots will be positioned on experimental farms where the necessary logistic support, dependable irrigation supplies, etc., are available. All parties will have too much committed in a three-year program to run any risks of losing two or three years of work.

Data output from the primary experiments can be adapted and reported to local farmers beginning with the end of the first growing season. Simple analysis of variance techniques will be adequate to test whether production inputs are having significant impacts on crop yields.

ADAPTIVE RESEARCH

Countries or areas where primary plots are established obtain their most direct technical assistance spin-off in this phase of the program. (The program chart suggests several definite activities that can be grouped under research and training, as well as adaptive research).

Extension agents will be assisted in establishing approximately 10 satellite trial plots in any given year. These will be planned with cooperating farmers and will be more than casual field trials. Extension agents will be encouraged to take the lead in adapting complex results to farmer capabilities. This process will enable the smaller farmers especially to create a system of irrigation methods that will approximate the research results obtained with expensive and sophisticated techniques.

Field research counterparts can play as great a role in adaptive research as they are inclined. For example, they might coordinate training of younger Ministry of Agricultural Research technicians or agricultural university students. Experimental data can be made available for classroom use along with requests for students to solve actual field problems to create better cultivation equipment and practices.

An important feature of the Adaptation Phase is to obtain on-farm irrigation cost data. This can be accomplished by short-term agricultural engineer assignments to host countries. What is required is design of enough actual farm and field irrigation layouts, under diverse conditions, so that some engineering cost rules-of-thumb are available to agricultural economists who must make some judgements of the net economic benefits of

private investment in irrigation facilities.

A carefully laid-out program of actual farm water system designs under field conditions, should generate enough data to create a simplified handbook for specially trained extension agents or Ministry of Agriculture junior technicians to use when counseling farmers about the most suitable choices for private investment.*

The adaptive phase can be as research or training oriented as the host country desires and has resources to support. The thrust of the program can be tailored to a selected target group of farmers, say, small and medium sized operators who own their own land. Naturally, the results and data from the satellite plots will also feed back to the main experiment and will influence the information available for regional transfer.

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* It may be noted that once the system has been chosen, the second part of the "handbook" will provide irrigation and farm management recommendations for the crops that are likely to be grown.

EVALUATION - (HOST COUNTRY)

There will be some economic evaluation of experimental results within the host country. The level of this evaluation can be governed by the situation. Benefits and costs of the alternative irrigation methods might be a minimum activity. Another level would be determination of acreage and crop allocations within an irrigation project, by means of linear programming.

As shown on the program chart, any evaluation work in the host country requires some level of statistical, social and physical resource information. These site specific economic evaluations will lead to results and recommendations that have direct applicability to target and other producer groups within the host country.

Within the host country other groups may have economic and social evaluations underway. For example, agricultural sector studies are in vogue. The output of the main experiments, in the form of crop production functions would form a very important input into all the models used for sector analysis. The same is true, to a lesser extent, for the irrigation cost and benefit analysis work. Indeed, all data generated in any host country, on the basis of the primary satellite and cost experiments would be potentially useable by the Ministry of Agriculture and other planning groups and agencies in host countries.

KNOWLEDGE TRANSFER

The enormous amount of data that will be generated by each primary experiment will be evaluated in a model simulating a physical irrigation system. This model will be developed initially on a theoretical basis (as shown in the program chart) and will be verified using United States data that is now in the process of being generated.

Even before the primary experiments have run through their planned three-year programs, the master model will have been perfected and will have generated a lot of expectations about the most sensitive data areas of real world irrigation systems. These sensitive areas will be identified in two main ways: a) those data requiring especially precise measurement and; b) those data that probably must be site specific. This information will permit some modifications to be introduced into the three-year experiments.

When the three year experiments have run their course, the master simulation model will be re-verified utilizing the primary and satellite data in each host country. Each "adapted" model will become the "regional model" by which international irrigation knowledge will be transferred. Since the regional models will also indicate the most sensitive data areas, the irrigation agencies of adjacent nations can be told just what data will have to be collected on a site specific basis before the regional model will be able to grind out fertilizer, irrigation methods, and other recommendations for any particular farming regions.*

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* It is anticipated that the whole three years of the primary experiments, and time for re-verification of the master model will not have to elapse before irrigation agencies throughout the region can be warned about what data will have to be site specific and of the levels of needed accuracy.

The physical simulation model will have an economic (probably linear programming) interface built in each time the master model is "regionalized". Effects of various parametric adjustments of constraints and objective function on the sensitivity of the physical model can be noted and vice-versa. (However, the degree to which this option might be exercised in any region or country, would depend on local economic "needs", resources and economic research capabilities.)

COSTS AND FURTHER DETAILS

Certain aspects of the research program outlined are as follows: The whole program is centralized in purpose and planning, yet execution of the field research can be spread into many areas and can be flexible for situations encountered. A heavy interdisciplinary emphasis is clear, especially in the organization and execution of the evaluation phase. For example, plant physicists and chemists as well as agricultural engineers, economists or systems analysists will have to create the master simulation model. And even the most simple model will have to have climatic, soils, fertility and engineering features.

It may be noted that nothing has been said about research components or phases dealing directly with social institutions having direct bearing on water availability, allocation and management. Water laws are a case in point. Sociology and political science studies are not mentioned. Probably such features can be accomodated in certain situations. The evaluation phase may be flexible enough. But there appears to be little reason to program in specific actions in these areas as a general part of the total program frame.

The economics aspect would have to be somewhat flexible as well. Except for the input in the simulation models for each region, only fairly simple host country studies would be pre-scheduled. Such studies would be designed and coordinated with the agricultural engineering (irrigation cost estimations) to be obtained in each primary experiment country.*

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* Any expansion above this level might be at mission or host country expense on the grounds that the site specific aspects will impart a heavy technical assistance bias to the effort. However, this all can be forseen and programmed in advance for each situation or primary experiment.

The program chart inside the front cover is for a single primary experiment. Two men (at least one experienced in heavy field work) would form the nucleus of each in-country team. They would be supported by others responsible for design of the experiment and international transfer of the result. This "back-up" would be the equivalent of 1.3 full-time professionals and .7 technicians and sub-professionals.**

Costs can be conveniently estimated on the basis of individual regional programs (table 1). Allowing for 2 experts per primary experiment, plus the necessary agronomic and evaluation phase back-up, this would be about 112,000 to 127,000 per year, with the total reaching 357,000 for the required three-year period of the major primary experiment.***

Transferring the basic data throughout the region of each primary experiment would require short-term travel, publication and communication costs, but overseas personnel would be reduced. The costs of this phase cannot be ascertained accurately until tests of the evaluation model suggest the required site specific data throughout the region. For the present we estimate that the cost per region won't rise above 100,000/per year. This probably will be fairly accurate if sites throughout a given region are evaluated within a second three-year period.

Thus we arrive at an estimate of about 660,000 per region for six years. If allowance is made for start-up lags and time for wind-up, the

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** Every four primary plots would require 5 full-time equivalent professionals and 3 equivalent sub-professionals, plus 1.5 full-time equivalent secretarial and 8 M.S. or 4 Ph.D. graduate students.

*** This total assumes that part of the back-up costs are averaged over 4 primary plots; if there are fewer plots the back-up costs will be higher per plot.

whole program could run eight years and raise average regional costs somewhat. Suppose this totals $800,000 per region; the total cost for a 16-region world program would be about $12,800,000 spread over eight years. This would average 1.6 million per year. It is possible that the 16 regions are not enough, but that number allows four in Latin America, four in Africa, two in the Middle East and six in Asia. In addition, it can be assumed that some additional sites can be operated at little or no cost through cooperative arrangements with certain countries that have the need and the resources.

These costs are exclusive of overhead and do not include every item that might be construed as a back-up requirement (or an over-seas cost.)****

**** Overheads are often open to negotiation, especially where long-term arrangements are contemplated.

Table 1: Summarized Field Research Direct Cost Estimates for Each Regional Program (constant 1973) Prices

ITEM	SOURCE	YEAR 1	YEAR 2	YEAR 3	SUB-TOTAL	YEAR 4	YEAR 5	YEAR 6	SUB-TOTAL	LOST LEAD TIME	PHASE-OUT	TOTAL
Salaries & allowances	TAB	80,000	70,000	80,000	230,000							
Operating budget	TAB	10,000	10,000	10,000	30,000							
Agronomic back-up (per diem, salaries, travel)	TAB	10,000	7,500	7,500	25,000							
Fertilizer, seed, labor, water & site costs	HOST	8,000-12,000	8,000-12,000	8,000-12,000	24,000-36,000							
One-time costs vehicles	TAB	8,000			8,000					72,000	72,000	144,000
Irrigation equipment	MISSION	18,000			18,000							
Evaluation phase back-up	TAB		7,500	4,000	11,500							
Ag. Engineering & economics (in-country)						100,000	100,000	100,000	300,000			
Computer	TAB	500	700	1,300	2,500							
Ag. Engineering* simulation-Econ (in USA)	TAB	5,500	4,000	4,000	13,500							
Climatological* (in USA plus in-travel)	TAB	10,000	8,000	8,000	26,000							
Secretarial* & other	TAB	2,000	2,000	2,000	6,000							
Publications etc.*	TAB	500	1,000	1,500	3,000							
Domestic travel	TAB	600	600	600	1,800							
TOTALS	TAB	127,100	111,300	118,900	357,300				657,000			801,000
	HOST	8-12,000	8-12,000	8-12,000	24-36,000				24-36,000			24-36,000
	MISSION	18,000	0	0	18,000+	6,000	6,000	6,000	36,000		4,000	40,000

*Apportioned on basis of servicing at least 4 primary plots.

CONCLUSION

The irrigation research program as outlined will generate the knowledge required for international transfer.

The program can be in more than one country (region) or more than one continent simultaneously. (It needs no testing, and the only reason for not setting up all necessary primary plots at once would be a lack of necessary resources).

Over-all size of the program to accomplish a world-wide task can be estimated quite readily through expert consultation.

The program builds directly on the experiences already obtained in the early years of the TAB supported program in water management.

The program integrates procedures and research approaches but there is no requirement for a fantastic effort at integrating world-wide results. Results need integration only up to a regional recommendation level.

Over-all goals and field research aims are easy to understand and appreciate, yet, the field research program especially is not absolutely rigid.

During the field research phase, direct host country benefits are considerable, acceptable, and should generate ample local (mission) support.

Necessary resource and logistic support can be planned well in advance. It will not be necessary to have two highly trained (and paid) U.S. professionals at every primary experiment; one may do if he is supported by a good junior university staff member or technician.*

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* M.S. trainees who have benefited from 211-D scholarships could be recruited.

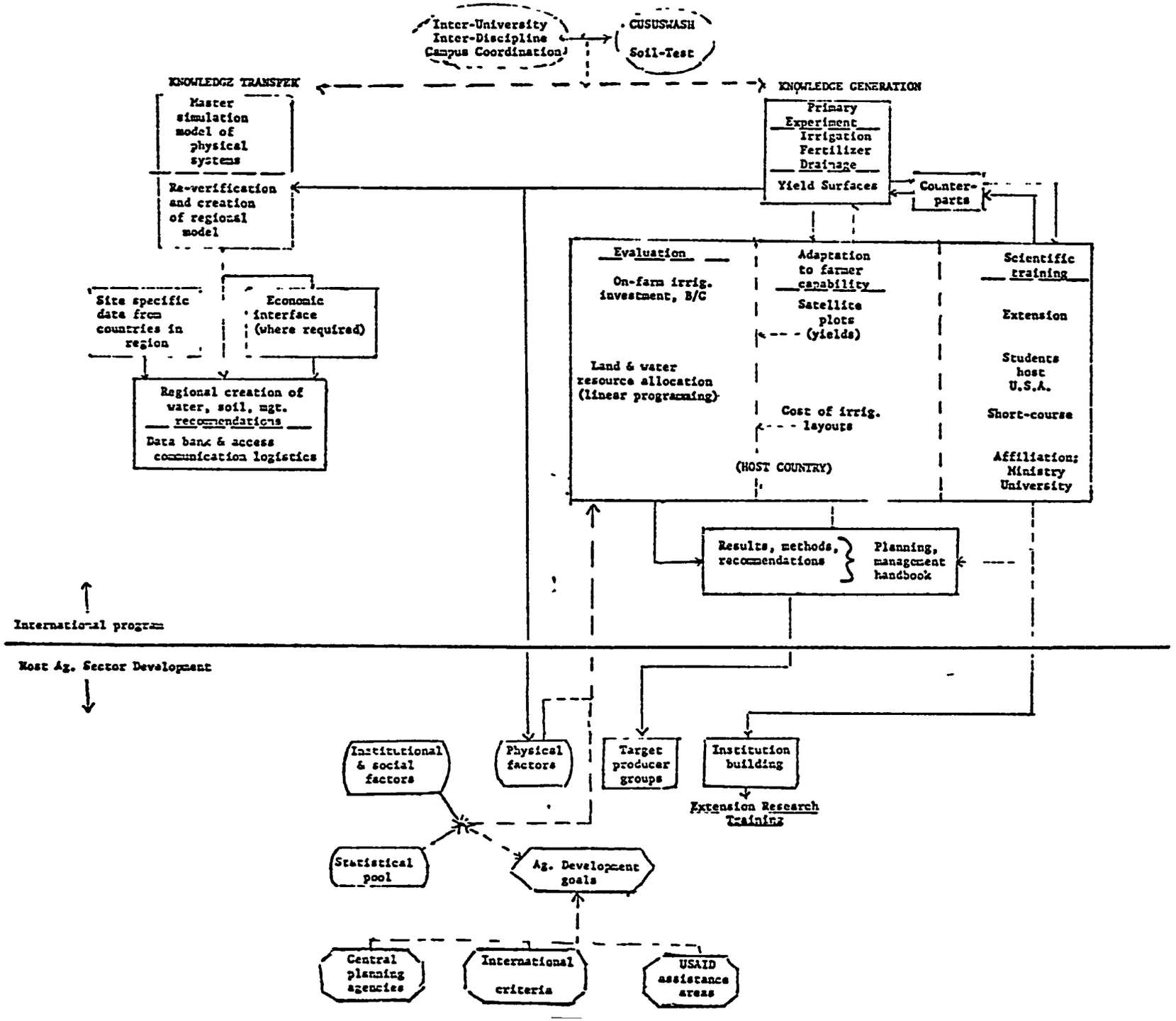
All funds and resources are expended with clear-cut reasons to achieve purposes that all parties are in agreement on.

The immediate need is for a global estimate of the returns that could reasonably be expected from extension of irrigated agriculture into suitable resource and economic structures. However, in the absence of such estimates, we must continue to assume that the benefits will easily justify the research resources and effort.

The next most immediate need is for a handbook of instructions for laying out the primary experiments along with field plot techniques to be employed.

Another need is for a general plan of work that will guide agricultural engineers on short-term assignment to collect and estimate on-farm water system costs for alternative irrigation methods and situations. In association with this is a need for a work plan covering the basic economic evaluations that will be made of benefits of alternative on-farm investments in irrigation systems and structures.

The work plans cited are necessary for organization, execution and back-up of the field research. The centralized evaluation work, leading to creation of an appropriate physical systems simulation model, must be planned and organized as well. However, this inter-disciplinary activity will require one or two years to reach fruition.


Inter-University
Inter-Discipline
Campus Coordination
CUSUSWASH
Soil-Test
KNOWLEDGE TRANSFER
KNOWLEDGE GENERATION
Master simulation model of physical systems
Re-verification and creation of regional model
Primary Experiment
Irrigation
Fertilizer
Drainage
Yield Surfaces
Counter-parts
Site specific data from countries in region
Economic interface (where required)
Regional creation of water, soil, mgt. recommendations
Data bank & access communication logistics
Evaluation
On-farm irrig. investment, B/C
Land & water resource allocation (linear programming)
Adaptation to farmer capability
Satellite plots (yields)
Cost of irrig. layouts
(HOST COUNTRY)
Scientific training
Extension
Students host U.S.A.
Short-course
Affiliation: Ministry University
Results, methods, recommendations
Planning, management handbook
International program
Host Ag. Sector Development
Institutional & social factors
Physical factors
Target producer groups
Institution building
Extension Research Training
Statistical pool
Ag. Development goals
Central planning agencies
International criteria
USAID assistance areas

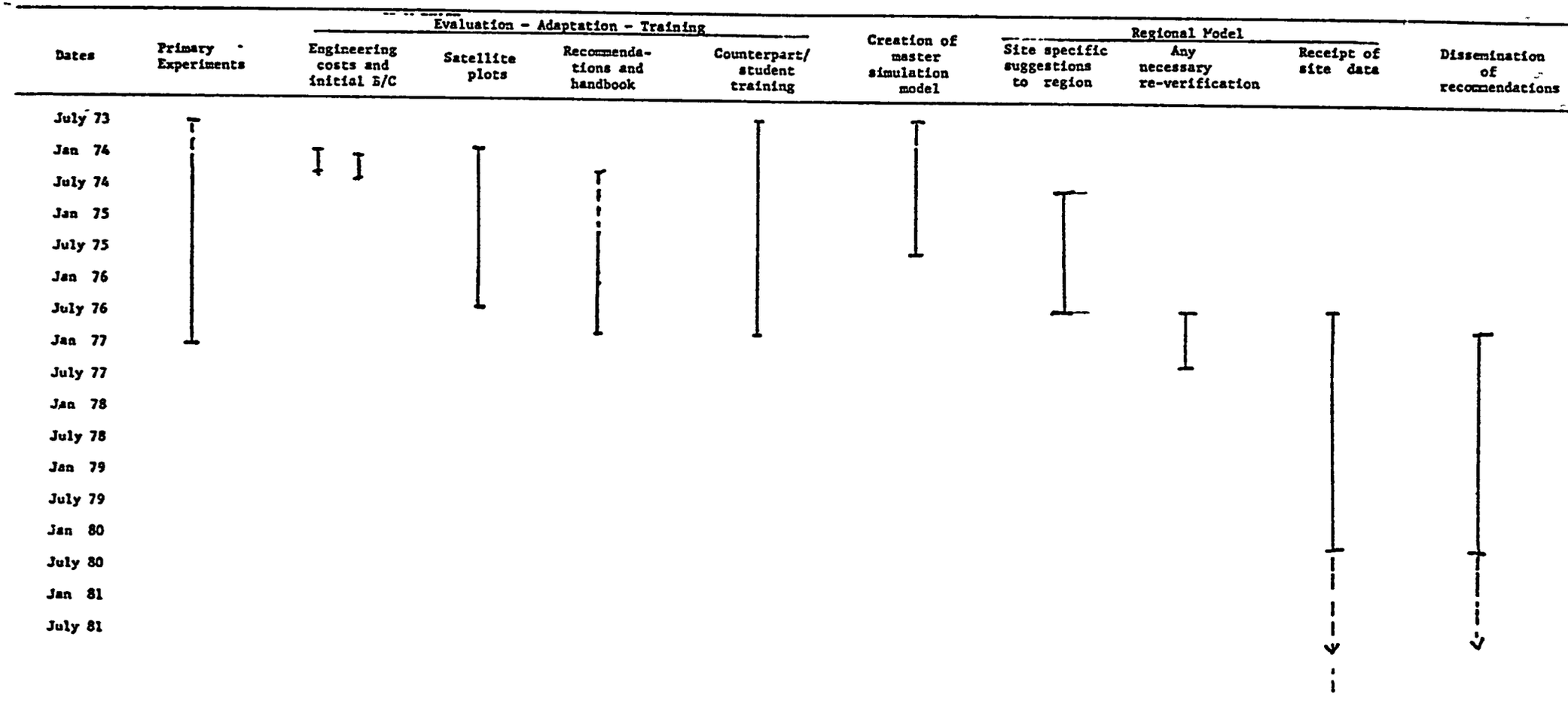



Figure 2. Research Activities and Time Frame for Regional Program