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ANNUAL TECHNICAL REPORT 211(d) PROJECT

AID/csd-2459

Title: Optimum Utilization of Water for Agriculture
With Emphasis on "On-Farm Water Management."

Grantee: Utah State University

Director: H. B. Peterson

AID SPONSORING OFFICE: TAB/AGR

Statistical Summary:

Period of Grant: May 23, 1969 to June 30, 1977
Amount of Grant: $945,000
Expenditures for Reported Year: $141,335.74
Accumulated: $704,349.01
Anticipated for next year: $131,351.00

Logan, Utah

August 1975

TABLE OF CONTENTS

LIST OF TABLES

Table

NARRATIVE SUMMARY

Reporting Year

A comprehensive review of the grant resulted in a greater emphasis on utilization of the competence as a means of assisting the developing countries. Our On-Farm Water Management library has been maintained and expanded. A coordinated effort through CID has been made to develop an information storage and retrieval system network of varied library resources of the individual universities.

Graduate courses were taught on campus in Spanish by five members of the Agricultural and Irrigation Engineering Department. Eight staff members participated in out-of-country seminars and delivered lectures in Spanish. A special course comprised of 16 foreign graduate students, was taught.

A manuscript for a third edition of Irrigation Systems Evaluation and Improvement has been completed and G. E. Stringham's manual Irrigation Fundamentals was published. Two leaflets for use in short course training were also printed along with eight other additional publications.

Cooperation between Utah State University and Colorado State resulted in the development of an International Symposium on Global Water Law Systems.

During the year, thirteen Water Management Staff have responded to thirty-five requests for assistance ranging in duration from a few days to more than one year.

A model developed under the grant to optimize soil and water research programs, to identify research needs, and to insure maximum transferability of information was further developed, and arrangements were made for its use by the soils consortium.

Finally, a committee of Grant Directors of CID universities functioned as coordinators to direct activities at the various universities.

Life of Grant

An On-Farm Water Management Library has been developed along with a computerized bibliographic tape and printout having 13,000 titles covering the United States and 60 foreign countries. A "flier" was prepared describing the holdings and invitings its utilization. Plans are developing to include this material in a CID network for information retrieval.

Twenty of our staff are able to lecture in Spanish, and lectures are being given in Spanish here on campus as well as in host countries.

A graduate program has been approved that will enable students to come to campus and be instructed in Spanish by our professors and then conduct research on the problems of importance to their country.

Ten new staff members, supported in part by the grant, have been added. These and others have responded to 132 requests for assistance.

Ten new courses have been added for foreign students or U. S. students interested in working in foreign countries.

Finally, a close linkage has been developed between members of CID, the Soils Consortium, AID, FAO, The Centers, as well as among members of CID.

DETAILED REPORT

General Background and Description of the Problem

There was ample evidence that in developing countries there was urgent need for more food and better nutrition. Food production is closely linked to the water available for transpiration by the growing crop and the water availability is related to On-farm Water Management. In most LDC's there is a lack of trained people for transfer of the water management knowledge available in developed countries. The lack of technology and information was a deterrent to expanded production and restricted the effectiveness of AID and other donors in solving critical food problems common to many LDC's.

It was common knowledge that inferior and indifferent water management in LDC's, was depriving the countries of needed production and wasting the water resources. Water logging and salinity were often related problems. Poor on-farm water management was often practiced under irrigation systems which might otherwise be considered to be technically sophisticated. Land was not being properly prepared for irrigation and drainage. The problems of on-farm water management are pervasive, affecting agricultural land everywhere but are more crucial in the developing countries. Scheduling and applying the proper amount of water in an efficient manner was a goal which has in general not been reached anywhere regardless of the type of conveyance system bringing water to the farm. The problem was considered acute concerning farmers with small holdings because of the complicated distribution, lack of credit, etc.

It was reasoned that by making highly qualified and experienced professionals available from centers of competence at Universities, AID could develop and disseminate technologies that would be more effective than those being used in many countries. Through utilization of the technologies transferred, the LDC's could accelerate the rate of production expansion. By establishing strong linkages and networks among developed and developing country institutions and agencies, an even greater quantity and quality of capability could be directed toward improving the food supply.

At the time the grant was awarded, the Department of Agricultural Engineering and related departments such as Soils and Civil Engineering had many graduate students from foreign countries. The staff and course offerings were not adequate to teach and direct the research of these students.

Utah State University had considerable competence in the areas of irrigation and water management at the time the grant was approved. It was expected that the expanded full-time professional staff, courses of study, library information, and research would enable the University to respond much more adequately than heretofore to requests concerning agricultural related water management problems from such entities as: USAID/Washington, USAID Missions, other state and federal agencies.

The proposal for a 211(d) grant to Utah State University to utilize its competence in the general area of on-farm water management was one of three submitted by universities who are members of the Council of United States Universities for Soil and Water Development in Arid and Sub-Humid Areas. This consortium would coordinate the AID sponsored research and institutional improvement of these universities. Other universities include the University of Arizona emphasizing "watershed management," and Colorado State University specializing in "water delivery and removal systems and relevant institutional development." The Grant Project was expected to have built-in research, training and advisory components. It was expected that by the creation of special capability in a particular area of knowledge it would include the relevant technology and the capacity to pass it on to others.

Purpose of the Grant

The Institutional Grant Program had for its purpose the development of the competence and expertise of U.S. research and educational institutions to deal with critical problems of less developed countries. There are certain identifiable shortages of properly trained personnel and gaps in knowledge and skills that restrict AID's efforts to carry out its programs of assistance in these countries. The Institutional Grants Program is designed to overcome these deficiencies. Individual projects are designed to serve the program needs of AID without a requirement for providing specific services. Institutional Grants are thus to be used to strengthen "centers of competence" within educational and research institutions and to build long-range resources in depth rather than to procure services for AID for specific limited purposes.

The specific purpose of this Grant was to expand the competency of Utah State University as a center for world-wide training and research in irrigation and drainage. As the competence has been increased the purpose has gradually shifted toward sustaining and utilizing this competence in research, teaching, training, and consulting. The Grant has now been extended and revised. The purpose of this revision and extension is to focus and sustain, within a utilization framework, an institutional response capability at Utah State University in on-farm water management with emphasis on small farms.

It is one of three 211(d) water grant extensions providing a cooperative approach to assisting developing countries in solving their food and nutrition problems.

Primary emphasis will be given to the on-farm water problems as a means of improving the quality of life for the farmers in the lowest income brackets. A secondary focus of the grant extension is to permit involvement of the University in all phases of the water chain as appropriate, and in cooperation with CID. It is proposed that the competence will be used to identify water management problems in the LDC's and seek solutions to these problems through training, research, consulting, and preparation and dissemination of education materials.

The consortium will cooperate in identifying new problems, establishing priorities, and deciding on a division of labor and cooperation among the five universities in order to prevent duplication of efforts and to utilize the most qualified personnel.

Objectives of the Grant

Objectives Restated

The major objective of the initial Grant Program was to increase and expand the existing competence of Utah State University in the science and technology concerned with "on-farm water management" with emphasis on moisture environment on the farm as related to the special characteristics and problems of the less developed countries. Increased competence was to be developed in the teaching and research activities as follows:

1. Expand its full-time professional core staff which will focus its teaching and research activities on the technical disciplines which relate to maintenance of a proper moisture environment on the farm under less developed country conditions. These include irrigation and surface and subsurface drainage. Irrigation and drainage are complex arts requiring the application of the best knowledge of water, soil, climate, crop sciences, and engineering. Existing courses in this area will be reconstructed as appropriate new graduate courses. Special short courses and seminars will be developed as required.

2. Expand its research in less developed countries to increase the knowledge and understanding of subjects such as water requirements of crops, moisture-fertilizer-crop response, management of irrigated soils, drainage requirements, salinity water quality, movements of water in soils, methods of water application, management of irrigation water, and water-crop-soil system analysis.

3. Expand its total library holdings in irrigation and drainage and related disciplines, especially foreign and international publications, so as to become a center of information on world irrigation and drainage practices.

This increased interrelated teaching and research competence will include, but not be limited to, the following subjects as they relate to problems of the less developed countries:

1. Irrigation Practices. The theory and practice of maintaining the optimum moisture environment for plant growth by irrigation and drainage within the complex physical and institutional systems involved.

2. Drainage Theory and Practices. The investigation, design, and operation of drainage systems to assure the optimum soil-moisture environment and avoid or reduce flooding.

3. Water Resources Systems Simulation Engineering. Simulation of multi-purpose projects to provide adequate service for irrigation, drainage, flood prevention, and other purposes as related to on-farm water management.

4. Irrigation Science Research. The basics of consumptive use, infiltration, water physics, water quality, water-salt-soil interactions, within the framework of "on-farm water management" for maximum efficiency and economic returns.

5. Irrigation Economics. The economics of changing water management practices, costs, and economic efficiency of water utilization including the incremental value of water application and water application systems.

During the current year there has been a review of the Grant program and this specific Grant. As a result, the specific objectives or outputs for the future have been identified as:

1. Information capacity
2. Education and training
3. Expanded knowledge base
4. Advisory capacity
5. Linkages and networks

The general approach is to integrate a quality research, teaching, training, and consultive technological program into an effective means of information transfer to developing countries.

Review of Objectives

The objectives and areas of activities, as originally identified, were broad in scope and general in nature. There have been some gradual modifications until the review when the objectives were restated as above. In the plan for implementation of the program, it was anticipated that emphasis on activities would shift. Early emphasis was on identification of staff needs, selection of professors, and in language training. This was followed by a review of course content and revision and introduction of new courses. Emphasis was also placed on library improvement and expansion. As the goals in these areas have been reached, emphasis has shifted to teaching, conducting research, responding to requests for technical assistance and increasing accessibility of the library holdings. The results from the increase in language competence is becoming evident in the research and consulting accomplishments. There is a constant demand for the services of the staff having the language competence to teach short courses or provide technical assistance in LDC's. The demands have exceeded our competence.

In a proposal to extend the Grant, the purpose is to focus on utilization of the developed competence and there are more specific objectives with identified outputs, inputs, and verifications. There is also closer coordination of the programs with other members of CID.

Review of Critical Assumptions

In the original grant proposal most of the critical assumptions were not specified as such but were largely assumed. One assumption was that the University could increase its competence faster than the increase in demand for the assistance. This has not been the experience. It was assumed that the LDC's, AID, and Missions would cooperate with the University and a consortium in identifying problems, establishing priorities, and utilizing the capabilities. They have utilized the capabilities but have helped only in a limited way in identifying problems and establishing priorities. It is a difficult task to get the specific problems of the LDC farmer to the U.S.U. scientists for solution and then transfer the information back for utilization. We are sure AID is well aware of this but have limited opportunities to assist.

The altering by AID of their policies, objectives, and procedures have changed more than were originally announced by the Grantee.

ACCOMPLISHMENTS

During the year there was a comprehensive review of the Utah State University Grant and a general review of the Grant Programs in general. As a result there has been a change in emphasis from one of increasing competence to one of utilization of the developed competence. Late in the year the Grant was extended and five objective/outputs identified. In this report there is an attempt to present the accomplishments on the basis of these new objectives. For accomplishments in previous years, we have attempted to relate them in terms of the current objectives/outputs. This is somewhat awkward inasmuch as the early efforts were directed toward increasing competence rather than utilization. The estimated costs of the various outputs are shown in Table I. Other expenditures and expected expenditures are shown in Tables II-A and II-B.

Information Capacities

The general approach is to integrate a quality research, teaching, training, and consultive technological program into an effective means of information transfer to developing countries.

In order to develop an effective means of assistance in the transfer of knowledge, Utah State University has developed and maintains an up-to-date center of special competence in the broad areas containing the biologic, hydrologic, engineering, and socio-economic aspects of on-farm water management. Part of the center is an information system which links documents containing useful knowledge with users who are in need of this knowledge. A library of the more important documents has been developed and is being maintained.

For the past five years the Agricultural and Irrigation Engineering Department, in cooperation with Merrill Library, conducted an intensive program to expand the competence in the field of On-farm Water Management and related fields. To date the On-farm Water project has purchased some 1,900 books and developed a vertical file system comprising some 400 titles. All of these titles are in addition to the already existing holdings of the Merrill Library. The project has searched the holdings of other centers of information located on campus. This search for pertinent titles has yielded: 1,634 titles from the Utah Water Resources Research Laboratory; 450 titles from the Agricultural and Irrigation Engineering Department Microfilm Water Law Library; 1,700 titles taken from the Special Collections Sections of Merrill Library; 193 titles on Business Law from the College of Business; and 152 titles from the Government Document Section, Merrill Library. All of these titles have been combined in a bibliographic printout. These titles represent the best works, old and new, in the field of on-farm water and related areas. This collection covers the United States and some 60 foreign countries.

As a result of this program many of the Library's documents and archive holdings, which had never been properly indexed or cataloged, have now been correctly cataloged and the holdings are now being used.

The 13,000 titles have been keypunched (91,000 cards) for entry into a computerized bibliography. This bibliographic printout has been printed in book form and is available for distribution. The computerized tape is available for use in a consortium effort to make information more available.

A "flier" has been prepared which describes the library holdings and invites its utilization. Use of the book materials and publications is open to all students, staff, and the general public. Students and staff from other schools may obtain materials through interlibrary loans or visiting scholar permit procedures.

During the year several conferences were held with CID representatives in order to develop an information storage and retrieval system. A plan for establishing an information network is being developed by CID universities. In order to be realized, AID or some other organization will need to assist the universities in funding such an effort.

The program director and the editor participated in the AID Workshop Information Networking held October 24-25, 1974 in Washington, D. C. This was for the purpose of developing more effective means of communication among the producers and users of the information generated by the grants and contracts.

Throughout the year requests for publications are received and the material sent throughout the world.

Education and Training

Throughout the life of the Grant training program a total of 76 staff, wives, and graduate students received training in Spanish. Most completed the advanced courses. In the area of water management, 20 of the staff are capable of lecturing in the Spanish language and three of the staff have competence in Portuguese. This competence is especially valuable to the program and the staff assigned to Latin American countries for consulting, teaching short courses, or participating in seminars.

The staff in Agricultural and Irrigation Engineering are cooperating in offering a Masters degree program to be taught in LDC's and/or on campus. Most all of the courses will be taught in Spanish. Five graduate students from Guatemala are taking regular irrigation courses on campus, that are being taught in Spanish. After summer school, they will take a field trip of one month, and observe the irrigation development in Idaho, Arizona, Utah, and California. These students hope to take other courses in their own countries and then perhaps return to Utah State for additional training.

During the summer quarter 1974 we offered a special course entitled "Irrigation Water Requirements and Irrigation Scheduling." Dr. Marvin Jensen, Director of the Snake River Research Center at Kimberly, Idaho was the guest professor. In attendance there were 1 U.S. woman and 16 foreign students representing 11 countries. For a text the class used a very recent monograph published by the American Society of Civil Engineers entitled "Consumptive Use of Water and Irrigation Water Requirements." This contains the newest information on the subject. The course material was a product of a special committee of the American Society of Civil Engineers who had been working on this problem for some four or five years to get together all of the most recent information regarding the various methods of calculating and computing evapotranspiration. Dr. Jensen acted as chairman of this committee. We look at this as one of the highlights of the education experiences for our students at the graduate level in Irrigation Engineering. They were complimentary of the material of the course as well as the instructor's enthusiasm and knowledge of the subject.

Professors Stringham and Hargreaves from Utah State, in cooperation with professors from the University of Arizona and Colorado State University, presented a short course in Mexico. Professors Alfaro, James, and Hargreaves lectured at a workshop in El Salvador during the last spring season. Dr. Jack Keller taught a graduate course last summer at Colorado State University. The course covered agricultural and irrigation development. He contrasted the engineering requirements in developing and developed countries. As a text they used the proceedings of the Park City Seminar.

During the current year emphasis has been placed on the preparation of educational materials. John Merriam and Jack Keller completed the manuscript of the third edition of the handbook on "Irrigation System Evaluation and Improvements." This should be printed by January 1, 1976. Dr. Stringham completed the manuscript for the manual on "Irrigation Fundamentals," which was published during the year and is used primarily for instruction in short courses in the LDC's.

Instructions for making and using automatic syphons in LDC's, completed by Charles Burt, was printed and distributed during the year. Copies are in Spanish and are appended.

Expanded Knowledge Base

Emphasis has been placed on applicable research that will aid in solving problems of the very poor farmers in developing countries. To identify areas where existing as well as new technology and principles can be brought to bear on improving on-farm water management, state-of-the-art studies have been initiated for both humid and arid environments. These studies involve an analytical review of the knowledge accumulated by research and practice, setting forth the established principles, by how and where they can be used, and identifying the gaps in knowledge needing research for establishment of better principles and practices.

During the last couple of years a state-of-the-art study on water management of heavy soils has been underway. A large volume of information has been condensed into a draft report which is being reviewed and revised. We have found that such a broad topic is difficult to treat in a single publication.

During the year several planning sessions with CID university representatives and members of the Soil Consortium were held to coordinate and cooperate on the development of several state-of-the-art reports to be prepared during the coming year.

A trip to CIAT and CYMMIT was made to collect data for the state-of-the-art on water-oriented food production technology transfer.

The work plan for the current year indicated several manuscripts would be prepared and published during the year. Those published or prepared for publication during the year are:

Irrigation Fundamentals

Energy Inputs to Irrigation

Line Source Sprinkler Plot Irrigator for Continuous Variable Water and Fertilizer Studies on Small Areas

Predicting Soybean Growth as Affected by Water Management

Reference Climate Sites for Agricultural Technology Transfer

Irrigation System Evaluation and Improvement

Irrigation and Water Distribution Infrastructure Amplication and Optimization

Trickle Irrigation Design Parameters

An Agricultural Technology Transfer System

El Sifon Automatico

On-farm Water Distribution Structures

A major effort has been directed toward the preparation of a text on sprinkler and trickle irrigation. Draft copies have been completed and the material is being tested in the current courses.

One of the results from the Costa Rica Seminar was recommendation for research on problems of Central America. A specific suggestion was for research on the design of an irrigation system that would function on relatively steep land. The need is for a distribution system that can also provide for surface drainage with minimum erosion during intense rain storms. David Fisher, a graduate student, went to Guatemala to work on this problem during the summer of 1974. His report has not yet been completed but preliminary information indicates the problems of this nature may be largely site specific.

Advisory Capacity

The grant has enabled the University to provide flexibility in responding quickly and adequately to requests for technical assistance to LDC's. The University has faculty members available from a variety of disciplines (See Table III-A). The grant has used a minimal amount of funds for consulting time in emergency situations where individuals are needed on very short notice and when other instruments cannot be used without causing unacceptable delay. AID frequently requests the services of Dr. Bishop for a few days at a time.

An advisory capacity has been maintained for the whole chain of water systems, in addition to capability in on-farm water management.

As the number of staff members has been increased the demands for their services have also increased. Some responses have been for a few days and in the case of Ken Bach it was for a two year period. Dr. Alfaro was "on loan" for nine months during the year. The number and nature of the responses are indicated in the section of the report on utilization.

Linkages and Networks

Close relationships with a network of domestic and multilateral organizations has been developed for the purpose of collaborating in a joint problem-solving approach, developing cooperative research, and becoming involved in information exchange and dissemination.

This collaborative and professional relationship is being strengthened with AID missions and the Regional and Technical Assistance Bureaus in achieving information transfer.

Principal domestic linkages developed include CID Universities and the Tropical Soils Consortium. The USU Grant Program Director is the systems leader within CID for on-farm water management and linkages between that and dryland farming, watershed management, water delivery, and removal/drainage systems. The grant has provided some funding for support of the newly assigned leadership and coordination role of CID.

Close linkage with the tropical soils consortium has been developed in order to carry out the state-of-the-art reports which will be produced on the subject of soil and water management for erosion control, water management for heavy soils, and intercropping.

A close linkage with the University of Hawaii and University of Puerto Rica has been developed while working on the project for agricultural technology transfer to developing countries. Close ties with CIAT and CIMMYT are being developed for the same purpose.

Through a graduate student from the Philippines a closer tie with the East-West Center is being developed. The student will take course work at Logan and conduct his research in the Philippines under sponsorship of the East-West Center.

Utah State University cooperated with Colorado State University in an important linkage when developing plans for an International Symposium on Global Water Law Systems which was held in Valencia, Spain, September, 1975. The planning effort took more than a year and involved people and organizations involved with Water Law from throughout the world.

Conferences were held during the year and plans developed to initiate an information network within the CID universities. With this network, the library holdings of each university will be available to others. There will also be a cooperative effort in developing and distributing publications.

Many of the responses for assistance came as the result of linkages with the CID Universities. In many instances a team composed of individuals from several of the Universities responded to requests.

Table I. Distribution of 211(d) Grant Funds and contributions from other sources of funding.*
Reporting Period July 1, 1974 to June 30, 1975.

Grant Objectives/Outputs	Review Period	Cumulative	Projected next year	Projected to end	Non-211(d) University
Information Capacity	$ 8,500.00	$105,500.00	$ 8,000.00	$ 7,000.00	$ 16,500.00
Education and Training	21,101.00	140,101.00	24,000.00	16,000.00	20,500.00
Expanded Knowledge Base	63,500.00	210,450.30	53,700.00	46,300.00	25,600.00
Advisory Capacity	26,233.74	185,500.00	23,650.99	22,000.00	10,000.00
Linkages and Networks	22,000.71	62,797.71	22,000.00	18,000.00	5,000.00
Totals	$141,335.45	$704,349.01	$131,350.99	$109,300.00	$ 77,600.00

*These are best estimates

Table II-A. Actual and anticipated expenditures under Institutional Grant AID/csd-2459
Review period July 1, 1974 to June 30, 1975.

	Year #6 Period Under Review	Cumulative Total	Year #7 Projected Expenditures	Year #8 Projected Expenditures	Totals
Salaries, Wages and Consultants	$ 96,006.21	$412,140.32	$ 95,700.00	$ 78,000.00	$585,840.32
Travel					
(a) Foreign (7)	9,079.11	39,776.90	6,600.00	6,000.00	52,376.90
(b) Domestic (31)	6,067.86	22,824.67	4,400.00	4,000.00	31,224.67
Equipment	422.75	7,608.70	-0-	-0-	7,608.70
Stipends, Tuition and Fees	14,855.00	128,605.67	9,650.99	8,800.00	147,056.66
Supplies and Computer Use	3,915.17	33,343.21	3,000.00	1,500.00	37,843.21
Publications	2,754.35	19,708.38	2,000.00	1,000.00	22,708.38
CUSUSWASH - CID	8,235.00	40,341.16	10,000.00	10,000.00	60,341.16
Totals	$141,335.45	$704,349.01	$131,350.99	$109,300.00	$945,000.00

Table II-B. 211(d) Expenditure Report.
Reporting Year Detail Under Institutional Grant AID/csd-2460
Reporting Period May 23, 1974 to June 30, 1975

I. A. Professional	Man Months	Salaries
H. B. Peterson	3.25	$ 8,930.00
Alvin Southerland	0.5	856.00
Byron C. Palmer	5.5	10,628.00
Jack Keller	6.0	14,062.00
Jose Alfaro	0.44	763.00
Cleve Milligan	2.0	4,420.00
Robert W. Hill	7.5	11,376.67
Lester Leininger	9.0	22,000.00
Total Professional		73,035.67
B. Clerical		
Library		
Other nonprofessional		4,032.48
C. Fringe Benefits - Retirement only		13,112.30
D. Wages (payroll)		4,680.30
		$94,860.75

II. Student Support	Country	Amount
Charles Burt	USA	$ 3,303.00
Ronald Fischer	USA	4,153.00
Donald Burgess	USA	1,202.00
Kent Ryan	USA	3,153.00
Nancy Adams	USA	2,102.00
Peter Canessa	USA	942.00

III. A. Consultants	1,145.46
B. Guest Lecturers	
IV. Travel	
A. Domestic (31)	6,067.86
B. Foreign (7)	9,079.11

Table II-B (Continued)

V.	Equipment	422.75
VI.	Library Acquisitions Thesis and Dissertations, Reports, Papers, etc.	2,754.35
VII.	Other	
	Telephone Postage Computer Miscellaneous	3,915.17
	CID support	8,235.00
	Grand Total	$141,335.45

IMPACT OF GRANT SUPPORTED ACTIVITIES

The original objectives, simply stated, were to improve the University's competence for teaching, research, and to provide greater resources from which to draw for consulting and technical assistance particularly in LDC's. As a result of the Grant we now have an excellent library for students and faculty and also have a staff with experience and technical competence as well as capability in the use of the Spanish language for utilization in LDC's. Several of the staff working on AID/ta-c-1103 research contract were trained on the 211(d) program or were brought to the University with Grant funds.

In the early development of the program, emphasis was placed on the preparation of irrigation texts and manuals. These writings have universal use. Spanish versions of the manuals are being prepared for special use in Latin America.

As portions of the first objectives were realized, the emphasis has shifted more to utilization. This is in keeping with the directives received from AID. The library, manuals, language competence, etc., are being utilized in the numerous responses by the staff and in the teaching and training of students from the LDC's.

The Grant has had a direct beneficial effect on the program to recruit and hold highly qualified scientists supported by other funds. For example the Dean of Engineering was recruited on staff with Grant funds. These people appreciate the value of association with a viable center. Although they are not receiving grant money, they are available for teaching, directing the research of LDC graduate students, and responding to requests for short-term assistance in LDC's.

The idea to use sprinklers for evaporative cooling to retard early tree development as a means of avoiding frost damage to fruit trees came from staff members in the Department of Agricultural and Irrigation Engineering supported by the Grant. This idea has many beneficial ramifications in relation to flower, tree, and shrub management. It is of particular value to Utah and much of the U.S. It is a bonus or spinoff that cost the Grant or the State very little or nothing.

OTHER RESOURCES FOR GRANT-RELATED ACTIVITIES

The program is carried out in cooperation with the Utah Water Research Laboratory, the Departments of Agricultural and Irrigation Engineering, Civil and Environmental Engineering, Soils, and Biometeorology and Economics. Other units of the University such as the Agricultural Experiment Station and the Merrill Library make their facilities available. The experimental drainage farm, and the river laboratory are utilized by the staff and students supported by the Grant. A dollar value for such resources was not included in Table 1.

The program made it possible to employ new faculty members, and cooperating units have provided funds for portions of the salaries so that at present the percentage of salary from the Grant varies from about 10 to 60 percent. The University provides the overhead monies for the salaries paid from the Grant. During the life of the project a major contribution by the University has been the laboratory facilities and administrative supervisors. Dr. D. F. Peterson, Vice President for Research, has not only given administrative assistance, but has been active in developing the ideas for research and the information transfer model being used. He and the University have contributed some of his time in response for assistance as indicated in Table III-A.

The research conducted in Latin America by the graduate students is done in cooperation with AID and the host countries. Private companies in host countries and in the U.S. provide such assistance as equipment, office space, and some travel.

The University maintains an office for the foreign student advisor and an office and staff for the International Program. These both assist foreign students.

UTILIZATION OF INSTITUTIONAL RESPONSE CAPABILITIES IN DEVELOPMENT PROGRAMS

The information recorded in Tables III-A and III-B represent the best we can recall in that exact records are not maintained. Some of the requests are received via telephone, word of mouth, etc. And often requests we are not able to fill are referred to other CID member institutions. The information indicates considerable activity and a major effort to make the capability of the university available for a variety of activities and often for extended periods of time.

As reported elsewhere, we have five engineers from Guatemala for a summer session. They are taking irrigation courses for credit and instructors are lecturing in Spanish. A one-month tour will be taken to observe irrigation projects in Utah and other Western States. This is one specific use of our language capability. These students can now take classes in their own country taught by our staff and eventually obtain M.S. degrees.

A tabulation of foreign graduate students from developing countries is given in Table IV. Foreign graduates of programs in the Departments of Civil, Agricultural and Irrigation Engineering, and Soils have played significant roles in the development of their native countries. In almost all cases students have returned to fill responsible positions in developing countries. In Table V is listed, where known, recent graduate students in Irrigation Engineering indicating positions presently occupied and areas of service.

In addition, graduates of our programs with U.S. citizenship have accepted employment with consulting firms and, in some cases, governmental organizations whose working scope is international and have been stationed in various LDC countries.

We have not maintained a record of visitors to our center, however, we have recalled that 26 have visited us during the year. During the last year these have included ministers and other high administrators from Bolivia, Brazil, Malawi, Morocco, Iran, USSR and Taiwan. Few weeks pass that someone is not seeking our assistance or wanting to learn about our activities. There have been exchange of visits with the East and West

Center and CIDIAT in an attempt to better coordinate our activities and to take advantages of the materials each have provided. The Utah Director visited the East-West Center. Scientists from FAO consulted with us during the year. We regularly exchange publications.

A by-product of the Park City Symposium on Research Needs for On-farm Water Management and the Washington Workshop was the establishing of connections for linkage development. The Directors of the Grants at Arizona, California, Colorado, Oregon, and Utah serve as a committee of the Water Consortium to coordinate the activities. The universities have provided members of teams who have responded to requests from LDC's, cooperated in preparing educational material, and participated in seminars in LDC's. Attempts are being made to strengthen the linkages with the various crop centers. Visits were made to Colombia and Mexico Centers. The water consortium members also work directly with the soil consortium members. The CID program serves as a strong influence in developing and maintaining linkages and networking programs in. .ving foundations, development banks, host country universities, and government agencies. The cooperative effort of the Grant Directors of CID universities is particularly strong and keeps in close touch with TAB.

Table III-A. Requests for assistance received during reporting period July 1, 1974 to June 30, 1975.

Requests Attended

Description of Request for Assistance	Whom did you Assist?	Who Requested Assistance	Who Funded Assistance	Size of Effort Dollars	Size of Effort Man Days	Results of Assistance
Alfaro, Jose Sprinkler irrigation training to professional engineers from Venezuela	CIDIAT	CIDIAT	CIDIAT	3,000	10	About 30 participants received training
Coordinator of consultant group and irrigation planning consultant, to assist government division to improve planning, development and operation and management of irrigation areas.	Govt. of Guat.	Guatemalan Interamerican Development Bank (IDB)	IDB	23,000	9 mo.	Training, progress reports and final report were submitted
Field training course in El Salvador; farm, topography, drainage	Mission USU/AID contract	Mission and USU Res. Team	USAID		5	Completed course - 35 trained technicians
Graduate student training and field trip (taught in Spanish at Logan)	Guatemala and BID	IDB	IDB	12,500	4 mo.	In progress
Bach, Ken Project identification & development for West Africa Rice Development Assoc., Monrovia, Liberia	WARDA	WARDA	WARDA		2 yr.	Completed Project March, 1975

Table III-A. Continued

Requests Attended

Description of Request for Assistance	Whom did you Assist?	Who Requested Assistance	Who Funded Assistance	Size of Effort Dollars	Man Days	Results of Assistance
Bagley, Jay M.						
To participate in Sahel water data network assessment and evaluate WMO/ClLSS proposal for strengthening network and operation in Sahel	Nat'l Oceanic and Atmosphere Administration	NDAA	NDAA under Contract with AID	5,000	25	Final report to AID will be submitted on September 1, 1975
Bishop, A. A.						
Irrigation Consultant	AID/Egypt	TAB	AID/UAR	4,000	14	Report of irrigation development in Egypt
Irrigation Consultant	AID/Washington	TAB	AID/csd-1103	2,000	7	Washington Water Management Workshop
Irrigation Consultant	AID/Washington	TAB	TAB	4,000	10	Followup on Proceedings and report of AID Water Management Workshop
Water Management Assistance	ROCAP/ Guatemala	ROCAP/ Fiester	ROCAP	800	3	Developing Program for ROCAP
Burt, Charles						
Probable use of sprinklers and trickle systems	CSU Pakistan	Mission and CSU	AID		25	Prepared recommendations

Table III-A. Continued

Requests Attended

Description of Request for Assistance	Whom did you Assist?	Who Requested Assistance	Who Funded Assistance	Size of Effort Dollars	Man Days	Results of Assistance
Hargreaves, G.H.						
A Water Management Workshop in Brazil	EMBRAPA & SUDENE & Brazilian Technicians	EMBRAPA (GOB) & US/AID Brazil	GOB & AID		50 est	Improved knowledge of water requirements and water yield relationships. A climatic zoning for agriculture was produced.
Participate in watershed conservation program in Saltillo, Mexico	Univ. of Ariz.	Mexico	AID & USU		14	Presentation of part of a week-long program in Saltillo
Field training course in El Salvador; farm, topography, drainage	Mission USU/AID Contract	Mission and USU Res. Team	USAID		5	Completed course - 35 trained technicians
Evaluation of water development for National Range and Research development project	Kenya & Mission	Mission	USAID		45	Completed report
International Programs						
Horticulture, Farm management, Dry-land Crop production, Irrigated Crop Production, Machinery, Irrigation Methods, and Livestock Production	Mehday Nawaby	Iran	Iran	6,379		18 completed short course

Table III-A. Continued.

Requests Attended Description of Request for Assistance	Whom did you Assist?	Who Requested Assistance	Who Funded Assistance	Size of Effort Dollars	 Man Days	Results of Assistance
Keller, Jack Study of the feasibility, and economic practicality of trickle and sprinkle irrigation within the country of Pakistan	CSU mission in Pakistan USAID/Pakistan Ministry of Agriculture/ Pakistan	Ministry of Agriculture through USAID through CSU mission	USAID	10,000	65	Developed a report on trickle and sprinkle irrigation for the fringe and other special irrigated areas in Pakistan
LeBaron, Allan Adapt farm survey questionnaires, enumerator training, and coding manuals to be suitable for proposed Bolivian study	Sector, Analysis Div. LADR, Wash.	LADR	AID/PASSA with USDA		40	
Obtain social and economic background information on landless poor for inclusion in C.A.P. (El Salvador)(This required a 4 man team)	RDO, USAID El Salvador	AID Mission	USOM, El Salvador		170	(Still in progress)
Olsen, E. C., III Engineers to evaluate irrigation and drainage systems	Govt. of Ecuador and Mission	Mission	AID	5,000	30	Report. Spanish and English versions March, 1975.

Table III-A. Continued.

Requests Attended

Description of Request for Assistance	Whom did you Assist?	Who Requested Assistance	Who Funded Assistance	Size of Effort Dollars	Size of Effort Man Days	Results of Assistance
Peterson, D. F.						
Review of Research projects and programs	AID/res. advisory committee	AID	AID	5,000 incl. trav. & per diem	19	Advice on centrally funded research program
Review of AID program in Sahel, Africa	National Academy of Sciences	NAS	NAS travel & Exp. only	1,000	6*	NAS report on Sahel to African Bureau of AID
Review of Water Resources and irrigation-Peoples Republic of China	National Academy of Sciences	NAS, Comm. on Scholarly Exchange, PRC	"	1,000	3*	NAS report on PRC Agriculture
Inspection of Water Resources and Irrigation-Peoples Republic of China	Ad hoc	Ad hoc	Ford NSF-Travel	7,500	30**	Scientific and cultural exchange
Soil and Water Workshop	AID/TA/AG	AID/TA/AG	AID	1,300	6	Report to AID
Review of Departments research program in agriculture, Chairman of Resources Panel	USDA	USDA/NASALUGG	USU	1,000	3*	Working papers for user's review
Value of global weather models to agricultural	Dept. of Meteorology Mass. Inst. of Techn.	MIT	MIT(travel only)	1,000	3**	Report on value of weather prediction to agriculture

* USU Contribution of time

** Personal Contribution of time

Table III-A. Continued

Requests Attended

Description of Request for Assistance	Whom did you Assist?	Who Requested Assistance	Who Funded Assistance	Size of Effort Dollars	Man Days	Results of Assistance
Peterson, D. F. (cont.)						
Innovations for saving water in arid lands. Panel Chairman	National Acad. of Sciences	NAS	NAS (travel only)		1*	Completed bulletin "More Water for Arid Lands" This was a continuation from last year.
Procedure for implementation of the International Hydrological Program. Panel Chairman	National Acad. of Sciences Int'l Hydro-Decade	NAS	NAS (travel only)	150	1*	Completed NAS report. continuation from last year
Final summary report on the International Hydrological Decade. Committee Chairman	National Acad. of Sciences Int'l Hydro-Decade	NAS	NAS (travel only)	1,500	2* 4**	Draft report
Program and symposia on arid lands	American Assoc. for Adv.of Sci.	AAAS	AAAS (travel only	900	2* 2**	Program plans
Editing of Monograph on present and future of Colorado River	American Assoc. for Adv.of Sci.	AAAS	USU Personal	1,000 3,000	7* 20**	Manuscript for mono-

Table III-A. Continued

Requests Attended

Description of Request for Assistance	Whom did you Assist?	Who Requested Assistance	Who Funded Assistance	Size of Effort Dollars	Man Days	Results of Assistance
<u>Stringham, Glen E.</u> Participate in watershed conservation program in Saltillo, Mexico	Univ of Ariz.	Mexico	AID & USU		14	Presentation of part of a week-long program in Saltillo
Wadi Dawasir Study Team - Saudi Arabia	Ministry of Agriculture	US Joint Commission Economic Research Service	Saudi Arabia through the U.S. Joint Commission	24,000	75	Visit to Saudi Arabia (6 weeks) and a "plan of action" report to the Ministry of Agriculture for irrigation development in Wadi Dawasir
<u>Willardson, L. S.</u> Request to evaluate use of subsurface buried drains to replace open drains	United Brands, Inc., Gölfito,C.R.	Wm. Wade Chief Engr.	United Brands	3,000	6	A pilot program is being designed for field evaluation

Table III-B. Requests for assistance received during reporting period July 1, 1974 to June 30, 1975.

B. Requests not Fulfilled

Description of Request for Assistance	Whom did you Assist?	Who Requested Assistance	Who Funded Assistance	Size of Effort Dollars	Size of Effort Man Days	Why not met?
Jose F. Alfaro						
Irrigation consultant for training and advising on-farm water management (small farmers in Ecuador)		FAO	FAO		3 mo.	Just returned from another assignment
Study irrigation possibilities in Guatemala. Preinvestment studies. Part of AID, World Bank, and IBD studies in Central America		Inter-American Development Bank (IBD)	IBD		2 mo.	Involved in another assignment
Assisting in the planning and implementation of the activities of the Secretariat of the Technical Advisory Committee	FAO	FAO	FAO		3 yr.	Pending
A. A. Bishop						
Water Management Course Development		India	Ford-Found.	20,000	90	Pending - 1976
Water Management Assistance	ROCAP Guatemala	Don Fiester	AID/ta-c-1103			Negotiating
Water Management Research		Chile				

Table III-B. Continued

B. Requests not fulfilled.

Description of Request for Assistance	Whom did you Assist?	Who Requested Assistance	Who Funded Assistance	Size of Effort Dollars	Size of Effort Man Days	Why not met?
D. F. Peterson						
Coordination International Hydrological Program-UNESCO	UNESCO	Geological Survey	Dept. of State	4,500	23	Schedule conflict
Planning, U.S. International Hydrological Program	US Geological Survey	Geological Survey	U.S. Geological Survey	850		Schedule conflict
Komain Unhanand						
Irrigation specialist to develop graduate program of Irrig. Engrg., Kasetsart Univ., Thailand		Kasetsart Univ. Thailand	World Bank		180	Time conflict with other assignment
Off Offered to serve as irrigation specialist to plan and administer irrigation and drainage works of Guatemalan Government		BID	Inter-American Development		9 mo.	Time conflict with other assignment
L. S. Willardson						
Government of Iraq about visiting to review drainage problems		Mohamed Al-Kubaisi, Pres State Org. of Soils and Land Reclamation	Iraq			Reply has not been received to the positive response of their letter

Table IV. Graduate Students from Developing Countries 1974-1975.

Country	No.	Country	No.
Afghanistan	1	Lebanon	1
Bolivia	3	Libya	2
Brazil	1	Nepal	1
China-Taiwan	37	Nigeria	4
Costa Rica	1	Pakistan	3
Ghana	1	Peru	1
Guatemala	2	Philippines	4
India	14	Rhodesia	1
Indonesia	1	Saudi Arabia	23
Iran	37	South Viet Nam	1
Iraq	3	Sudan	4
Jordan	2	Thailand	28
Kenya	1	Venezuela	8
Korea	3	Turkey	3

Table V. Graduate Students from the U.S. and Foreign Countries who were supported by or received benefits from the Grant Program

STUDENT	COUNTRY	PRESENT STATUS AND/OR LOCATION
Craig Anderson	U.S.	Presently negotiating employment with USAID Contract, Ecuador
Jose Aquize-Carpio	Colombia	Director, CIDIAT, Bogota, Colombia
Russ Backus	U.S.	Engineer, CH_2M Hill, Consulting Engineers, California
Lee Bailey	U.S.	Land Bank, California
Salassier Bernardo	Brazil	Universidade Federal de Vicona in Brazil
Ronald Bliesner	U.S.	Superior Farms, Bakersfield, California
Bruce Brown	U.S.	Bureau of Reclamation, Lakewood, Colorado
Richard Chase	U.S.	Coordinator, International Programs, Oregon State University Research in El Salvador.
Adolfo Correa Charris	Colombia	National University of Colombia in Palmira, Valle, Colombia
Allen Dedrick	U.S.	Agricultural Research Service, Arizona
Melke Denekew	Ethiopia	Department of Water Resources, Ethiopia
Yehia El-Shafei	United Arab Republic	College of Agriculture, Soil Department, Alexandria
Morgan Ely	U.S.	Private consulting
Ronald Fischer	U.S.	Engineer, Hawaiian Agronomics International
Jose Antonio Forero	Colombia	Works for ICA in Bogota, Colombia
Massood Ghavami	Iran	Private consulting in Iran
Gary Glenn	U.S.	Purdue University, Lafayette, Indiana
Omar Guitierrez	Venezuela	Head, Agric. Eng. Dept., Shell Foundation, Cagua, Venezuela
Steve Hammond	U.S.	
Grant Hansen	U.S.	Engineer, Rain Bird Sprinkler Co.

Table V. Continued

STUDENT	COUNTRY	PRESENT STATUS AND/OR LOCATION
James Hardee	U.S.	Engineer, Harza Consulting Engineers, 2 yr. assign. in Iran, presently in Colombia
Somnuk Indratanee	Thailand	
Abdollah S. Jenab	Iran	Private Engineering in Tehran
Rustu Kasap	Turkey	Regional Directorate, Bursa, Turkey
Abdol Khosravi	Iran	Head, Experiment Station for Soil Institute of Iran
Henry Kurwahn	Honduras	Director, Dept. Irrig. and Ministry of Natural Resources, Honduras
Ghazi Mahmoud	Jordan	Amman, Jordan
Christos Marcoullis	Cyprus	Water Development Dept., Nicosia, Cyprus
Jeshaiahu David Melamed	Israel	Representative for Tahal, an Israel based consulting company
Roberto Michel	El Salvador	Director, Irrig. & Drainage, Ministry of Agriculture El Salvador
Hossein Mirnezami	Iran	Dept. of Agriculture, Soil Institute of Iran
Ken Mitchell	U.S.	
Antonio Moncada	Honduras	Engineer, Consulting Engineer Firm, Dominican Republic
Michael Moynahan	U.S.	Area Manager, East Division, Rain Bird Sprinkler Co., Australia, Japan, New Zealand
Abdolhossein Nozzehzadeh-Tabrizi	Iran	Working on his Ph.D. at Utah State University
Benjamin Olsen	U.S.	Engineer, Superior Farms, Consulting Eng., California
Herbert Paul	U.S.	Engineer, CH_2M Hill, Consulting Engineers, California

Table V. Continued

STUDENT	COUNTRY	PRESENT STATUS AND/OR LOCATION
Khalid Pervez	West Pakistan	West Pakistan Agricultural College, Lyallpur, Pakistan
Kitcha Polparsi	Thailand	Royal Irrigation Dept., Bangkok, Thailand
Morgan Powell	U.S.	Engineer, CH_2M Hill, Consulting Engineers, California
Matias Prieto	Peru	Engineer, International Development Bank, Guatemala
Lanny Ptacek	U.S.	Engineer, Hawaiian Agronomics, Inc., Stationed in Iran
Luis Ramirez	Venezuela	Engineer, MOP, Caracas, Venezuela
Alfonso Ramirez-Lavin	Mexico	Engineer, Sec. de Recoursos Hidraulicos, Mexico City
Freddy Rondon	Venezuela	Staff, Universidad de Oriente, Managas, Venezuela
William Rubink	U.S.	Colorado State University, working on Ph.D.
Supojana Rujirakul	Thailand	Engineer, Royal Irrigation Dept., Bangkok, Thailand
Mohammed Rassol Sahibzadah	Afghanistan	Professor, University of Kabul
Alfonso Silva	Venezuela	Works for the Ministry of Public Works in Venezuela
Kern Stutler	U.S.	Research Engineer, USAID Contract ta-c-1103, El Salvador
Dung-Hai Thai	Vietnam	Taiwan Cheng Kung Univ., Tainan, Taiwan, China
Kovit Thuamsangiem	Thailand	Dept. of Vocational Educ., Ministry of Educ., Bangkok
Praving Titavunno	Thailand	Electricity Generating Authority of Thailand, Bangkok
Juan Tosso	Chile	Director of Irrig. Division, Ministry of Agric., Santiago
Phil Tscheschke	U.S.	Research Engineer, Okokele Sugar Company, Hawaii

Table V. Continued

STUDENT	COUNTRY	PRESENT STATUS AND/OR LOCATION
Duong Van Duc	Vietnam	Resettled in U.S.
Thomas White	U.S.	Alexandria, Virginia
Shih Chen Yen	Taiwan	Brown and Root, Houston, Texas
Thomas Young	U.S.	Engineer, Private Work

WORK PLAN AND ANTICIPATED EXPENDITURES

The detailed work plan and budget for the period of the Grant extension are shown in Appendix A. The anticipated expenditures are shown in Tables I and II-A of this report.

As noted in the Work Plan some of the detailed plans are to be developed in cooperation with other CID universities during the year.

INVOLVEMENT OF MINORITY PERSONNEL AND WOMEN

Through the assistance of the Grant, two minority professional staff members were recruited. Those included are: Dr. Komain Unhanand, Associate Professor of Agricultural and Irrigation Engineering who is actively involved in teaching and developing a State-of-the-Art on water management of heavy soils. During the year he was in Brazil as a consultant for the research contract. Dr. Jose Alfaro, Associate Professor of Agricultural and Irrigation Engineering, has taught several irrigation classes in Spanish and has undertaken numerous consulting assignments including attendance at a Seminar in Costa Rica on irrigation and drainage at the farm level for Central American countries and Panama. In 1974-1975 he spent nine months consulting for the International Development Bank in Guatemala where he was coordinating a program to assist Guatemala in implementing a plan of work for irrigated agriculture. Dr. Alfaro has also authored and co-authored the following publications: "Medias De Aguas En Canales Por Media Del Aforado 'Sin Cuello'," and "Irrigation System Evaluation and Improvement." He is actively doing Spanish language versions of many of our Grant supported publications.

Nancy Adams has been employed by the Grant on a part-time basis as an undergraduate to conduct research dealing with information transfer. Ms. Adams is a student in the Department of Agricultural and Irrigation Engineering and entered our graduate program in midyear. Ms. Dorothy McCarty and Ms. Linda Rammell, technicians supported by the grant, have been instrumental in collecting data, assembling reports, and editing publications initiated by the staff members. They also cooperated in the distribution of publications. During the year they moved from the area and Ms. Thompson was employed.

Past efforts in recruiting minority students and staff have met with limited success. There are few women involved in the field of water management research and very few minority males. There is competition for competent minority males as well as females and efforts to locate qualified people have often failed however, efforts to attract and encourage minorities are continuing. Nancy Adams has been actively involved in a program to promote women in Engineering. A Chinese student, Ms. Hwei-Tzi Chu has recently enrolled in a MS program in Agricultural and Irrigation Engineering.

APPENDICES

A. Work Plan

B. List of Publications and Reports, 1974-1975

C. Abstracts

D. El Sifon Automatico

E. On-Farm Distribution Structures

F. Irrigation and Water Distribution Infrastructure Amplification and Optimization

APPENDIX A
WORK PLAN

July 1, 1975 to June 30, 1977

This plan of work is structured to conform with recent instructions issued by the TA/PFU Grants Coordinator and indicates the specific programs, man months of staff time, scheduled events/targets, expected results and costs by program category.

I. Information Capacity

A. On-farm Water Management Documents Procurement Center

To the already substantial library holdings at U.S.U. in the biologic, hydrologic, engineering and socio-economic aspects of on-farm water management, new documents, as they become available, will be added to the collection and recorded on the magnetic tape on which the current holdings are recorded

Sources of these documents, especially from developing countries will be expanded. This will include foreign language publications.

Staff to be involved

One man month of a professional time and one man month of technician time will be paid from the grant.

Scheduled Target

Acquisitions are expected to increase by June 30, 1977, from the present holdings of 1300 documents by 10%.

Expected Results

The new materials plus documents currently on hand will provide the inputs for the cataloging and distribution programs to be described subsequently. This, together with companion documents held by the other CID universities, can provide the most complete accessible library of on-farm water management documents in existance. U.S.U. will cooperate with CID universities in developing a means for making the holdings available to more users.

Estimated Costs

Salaries and fringes	$2,400
Acquisitions	2,000
Supplies	200
Other Direct Costs	400
Total	$5,000

B. Computerized Information Storage Retrieval and Transmittal System.

In cooperation with CID, the current documents plus those required under program I-A above will be considered for indexing for easier computer access under such categories as arid, semi-arid, sub-humid, and humid environments. Special emphasis will be placed on acquiring and indexing documents on erosion control on small farms.

Accessibility by user location and category will also be investigated to determine how land managers, students, planners, researchers, and others throughout the world could access the documents, especially by requests for searches on specific topics. The feasibility of providing an abstract of the documents will also be investigated.

The U.S.U. system will be considered for integration with those at other CID universities and with agency document centers such as those of AID, FAO, and other major related tecnical libraries.

Staff to be Involved

Four man months of time are required. Professor Palmer and Bonnie Thompson will represent U.S.U. in the development of the cooperative program.

Scheduled Events

Linda White from Arizona will visit each of the CID universities during June of 1975. She will make preliminary arrangements for participation in a conference to be held at Tucson in September 1975.

Palmer, Peterson and Thompson are scheduled to participate. At this workshop other meetings will be scheduled to improve the network.

By June 1976 the initial programming proposal will be completed. By June 1977, in cooperation with CID, a detailed plan for access to the documents should be finalized.

The grant period will be used to build the design for an inter-university and inter-agency acquisition, storage and retrieval system. Concurrently, strategies will be developed to secure sources of operating funds to carry on the program after the grant has terminated.

Expected Results

The system will be designed whereas when functioning, all the documents are accessible and subject bibliographies can be printed out immediately on demand. Depending on the results of the abstracting feasibility study, a detailed program for this service will be ready for implementation by the end of the grant period.

Estimated Costs

Salaries and fringes	$2,400
Travel	1,500
Other Direct Costs	1,100
Total	$5,000

C. Client Education Program

In order to maximize utilization of the On-Farm Water Management Document Center, careful coordination with CID and the other linkages already mentioned must prevail. In addition, a major effort is needed to identify and educate potential users. This will be programmed through the cooperative development of brochures, journal articles, professional meeting presentations, and workshops.

Staff to be Involved

Three man months

Scheduled Events

CID liaison by October 1975.

Other agency liaison by February 1976

Brochure design by July 1976

Newsletter feasibility study August 1976

Workshop August 1976

Expected Results

It is difficult at this time to forecast the client user rate for the system. By June 1977 an estimate will be available. A long term education program will by June 1977 also have been developed.

Estimated Costs

Salaries and fringes	$2,400
Travel	500
Direct Costs	2,100
Total	$5,000

II. Education and Training

A. Regular Course Augmentation

The increasing demand by foreign as well as American students for courses on the most effective technologies to plan and operate irrigation systems has indicated the need to add two new courses to the curriculum of the Department of Agricultural and Irrigation Engineering. These are "Irrigation Project Planning," and "Trickle and Subsurface Irrigation." Both courses will meet urgent needs in the many areas where irrigation projects, especially those with limited water supplies are planned. The first course will include topics on economics, system planning, operation, and management. The second will include emitter characteristics, filtration, layout and design, and operation and maintenance. They will be offered at the graduate level.

Staff to be Involved

Drs. Alfaro and Keller will develop and teach these courses. These will be offered annually for one quarter each. Seven man months will be required for development and presentation time.

Expected Results

The presentation of two cycles of these courses will add significantly to the technological capabilities of about 30 foreign students plus a number of Americans.

Estimated Costs

Salaries and fringes	$14,000
Direct cost	1,000
Total	$15,000

B. Short Courses

In collaboration with other CID universities, U.S.U. will organize and direct the presentation of a short course on the practical aspects of on-farm water management. This will be designed to help decision makers and the technicians who are responsible for resource planning, development and application to understand how water is managed on the farm, and how it relates to agricultural production by the small farmer. From July 1, 1975, until January 1, 1976, a review of existing courses taught by CIDIAT, the East-West Center, etc., will be made.

Staff to be Involved

Seven man months of professional staff time will be used to develop the courses, make the necessary liaison and advertising contacts, and present them. Professors Alfaro, Peterson, and Stringham will be primary developers of the course.

Scheduled Events

Staff assigned July 1, 1975

Course materials developed, March 1976

Programming completed, July 1976

During the period August 1976-June 1977 the courses will be presented. The number depending on the demands and funding available.

Expected Results

The primary objective of this course is to sensitize planners and other technical personnel to the needs and problems of the farmer in operating an irrigated farm. It will also show what irrigation projects need from decision makers in order to successfully serve the farmer. Initial results will be measured in terms of number of course participants. The potential impact of the course on small farmer operations will be evaluated by regular course evaluations by the participants. Later, followups evaluation will depend on availability of funding after June 1977.

Estimated Cost

Salaries and fringes	$13,000
Travel	2,000
Total	$15,000

C. Collaboration with Colorado State University and the University of Arizona.

U.S.U. will participate in the courses proposed by the other CID universities, specifically the short course on Irrigation Water Delivery and Removal Systems by Colorado State University and two short courses in watershed management by the University of Arizona.

Staff

Three man months of professional time will be allocated to this activity.

Scheduled Events

As described in the work plans of the sister universities, the materials for the Water Delivery and Removal Systems course will be ready by Spring, 1976, with presentation to follow as scheduled by C.S.U. An Arizona initiated watershed management course is scheduled for presentation in the Philippines or Pakistan before the end of the grant period. The course pilot tested by Arizona in cooperation with C.S.U. and U.S.U., should be ready for additional use by December 1976.

Expected Results

As in the U.S.U. initiated short course, results will be in terms of personnel trained and their initial evaluation of course effectiveness with any followup evaluation dependent on subsequent funding.

Estimated Costs

Salaries and fringes	$5,000
Travel	1,000
Total	$6,000

D. Ongoing Training on Campus

There are presently 15 M.S. and 4 Ph.D. students from LDC's engaged in water management studies. Enrollment is expected to continue at about this level. These students require a great deal of extra effort from faculty in supervision, especially since U.S.U. attempts to have their research topics relate to problems of their own countries.

Staff Involved

The difference between staff supervision for Americans and foreigners is estimated at two man months over the period of the grant. The professors involved will depend on the choice of advisors by the students.

Costs

Salaries and fringes	$4,000

III. Extended Knowledge Base and Research Capability

A. State-of-the-art reports.

A major effect will be devoted to development of these reports. A number of state-of-the-art reports, oriented largely toward the needs of very poor farmers will be developed in cooperation with the other CID universities. U.S.U. will provide leadership in developing reports on intercropping, water management of heavy soils, methods of irrigation and water oriented food production technology. U.S.U. will participate in the reports proposed by Colorado State University and the University of Arizona, namely waterlogging and salinity control, water delivery, rules and procedures, pumping systems, and erosion control.

Staff Requirements

22 man months of professional

20 man months of technologist, secretarial and graduate student

Scheduled Events

These state-of-the-arts studies will be done by literature reviews, consultations with LDC, AID, international organizations, and sister universities. These reviews and consultations will help define knowledge gaps and additional research needs. During the period from July 1, 1975, to October 1, 1975, schedules will be worked out with the cooperating CID universities. Three committees will meet during August 1975 at Logan to develop schedule details. At that time the information developed at the workshop in Hawaii should be available for use in making the schedules.

Much of the data collection will take place before June 1976. At that time it will be possible to determine the costs for completion of the studies and determine the support available so schedules for completion can be made.

Expected Results

The documents will be widely distributed. The primary objective is to provide professionals who deal with poor farmers with simple, easily transferable, and useful information. This will counteract the tendency of professionals to talk over the heads of the advisors to farmers.

It is expected that some of the documents will be finished sufficiently before the end of the grant period to field test and report on them.

Estimated Costs

Salaries and fringes	$76,300
Travel	8,000
Consultants	5,000
Supplies	4,000
Other direct costs	6,700
Total	$100,000

IV. Advisory Capacity

A. Release Time

Additional staff will be funded in order to provide release time flexibility to respond to requests for technical assistance from LDC's. A variety of disciplines are represented among the staff who can be made available. (See Appendix A). This release time capability is an essential requirement for AID to secure access to staff whose normal commitments could not otherwise be met. These faculty members will also teach, perform application oriented research, related to problems in developing nations, and participate in the state-of-the-art studies.

Eight man months of released time will be allocated at an estimated cost of $16,000. The faculty members will be funded in the programs as their services are required.

B. Short-Notice Consulting Time

In emergencies, when individuals are needed on very short notice and when other instruments cannot be used without causing unacceptable delay, a nominal portion of the grant has been budgeted to cover this contingency.

Staff Involved

Three man months have been included in the budget.

Estimated Cost

Salaries and fringes	$ 6,000
Travel	3,500
Direct costs	500
Total	$10,000

C. Consortium and Other Institutional Advisory Capacity

In order to optimize U.S.U.'s potential contribution to LDC development in both on-farm water management and other related areas, especially those being stressed by the other CID members and the soils consortium, a secondary advisory capacity will be maintained. This secondary capacity provides an expanded range of talent for cooperative efforts with these institutions. This will include but not be limited to providing expertise in problem identification and analysis, and project design and evaluation, functions which AID anticipates will become increasingly important.

Staff to be Involved

U.S.U. will identify faculty members and their specialties for inclusion in a talent bank to be developed by CID. The Grant Program Director will become the CID "systems manager" for that portion of the talent bank dealing with on-farm water management expertise. The type of information recorded for each individual is shown in Appendix B.

Ten man months have been allocated for this activity.

Estimated Costs

Grant funds will be used for short-term consulting, for release time of faculty members, for staff training and for the development, and improvement of the talent bank.

Salaries and fringes	$15,000
Consulting	2,000
Travel	2,000
Total	$19,000

V. Linkages and Networks

Relationships with a network of domestic and multinational organizations will be maintained for the purpose of collaborating in a joint problem-solving approach, developing cooperative research, and becoming involved in information exchange and dissemination.

A close collaborative and professional relationship will be maintained with AID missions and the Regional and Technical Assistance Bureaus in achieving the purpose of the grant.

Principal domestic linkages include CID and the Tropical Soils Consortium. The U.S.U. Grant Program Director will become the systems leader within CID for on-farm water management and linkages between that and dryland farming, watershed management, water delivery, and removal/drainage systems. The grant will provide some funding for support of the newly assigned leadership and coordination role of CID.

Close linkage with the tropical soils consortium will be required to carry out the state-of-the-art reports which will be produced on the subject of soil and water management for erosion control and water management for heavy soils.

Linkages with several world-wide and regional organizations will be necessary to meet the condition of this grant. Of these, the primary multilateral organization contact will with FAO so as to determine the avaiability to CID and this grantee of water management specialists.

Linkages supporting U.S.U.'s state-of-the-art study on water management as an integrating factor in crop production will be sought with two regional organizations (CIMMYT and CIAT) to provide data from different climatic areas.

Funds under this grant will provide seven man months of faculty time and travel for linkages involving CID, the Tropical Soils Consortium, FAO, and regional organizations.

Estimated Costs

Salary and fringes	$14,000
Travel	6,000
CID Administration	20,000
Total	$40,000

APPENDIX A

Professional Staff at Utah State University Having Competency in On-Farm Water Management and Related Fields

Name	Speciality	Functions*
Alfaro, J. F.	Irrigation Engineering	1, 4
Anderson, B.	Engineering/Water management	1, 4
Bach, W. K.	Engineering	3BC
Bagley, J. M.	Water Resources Hydrology	1, 2, 3
Bishop, A. A.	Irrigation Engineering	1, 2, 3, 4
Bishop, A. B.	Water Resource Systems	1, 2
Christiansen, J. E.	Irrigation Engineering - General	1, 3, 4
Daines, D. R.	Water Law and Institutions	1, 3
Daines, S. H.	Agricultural Engineering	3
Fullerton, T. M.	Irrigation Engineering-Drainage	3
Gardner, B. D.	Resource Economics	1, 3, 4
Griffen, R. E.	Water Management/Extension	1, 3
Hanks, R. J.	Soils Physics - Water Plant	3
Hargreaves, G.	Engineer/Hydrologist	1
Hill, R. W.	Irrigation Systems Analysis	3
Huber, A. L.	Systems Modeling and Design	3
James, D. W.	Crop Water Requirement	1, 3
Kidman, D. C.	Agronomist	3
Keller, J. O.	Irrigation Trickle & Sprinkler	2, 3, 4
LeBaron, A.	Agricultural Economics	1, 3, 4
Middlebrooks, E. J.	Water Quality	3, 4
Nielsen, R. F.	Crop and Water Management	3, 4
Olsen, E. C.	Irrigation Engineering	1, 3
Palmer, B. C.	Engineering Water Management	1, 2
Peterson, D. F.	Water Resources Engineering	1, 3, 4
Peterson, H. B.	Water Chemistry and Salinity	1, 3, 4
Riley, J. P.	Hydrology Resources Systems	2
Smith, R. L.	Fertilizer/Water Management	1
Stringham, G. E.	Agricultural Engineering-Surface	3
Stutler, R. K.	Irrigation Engineering - General	1, 3
Thorne, W.	Agronomy and Water Management	3, 4
Unhanand, K.	Hydraulic Engineering	1
Watters, G. Z.	Fluid Mechanics/Hydraulic Trans.	3
Wennergren, E. B.	Agricultural Economics	1, 3, 4
Willardson, L. S.	Irrigation Engineering/Drainage	1, 3, 4

*The functions are designed into the following categories:

1. Problem identification and analysis
2. Program and project design.
3. Operations: A - Research, B - Teaching, C - Consulting and Professional Backstopping.
4. Evaluation.

Utah State University

Specialists On-Farm-Water-Management

1. Name ____________ 2. Department ____________ College ____________ Business Phone ________ Home Phone ______	Do not use

3. Training:

Institution	Degree Conferred	Year

4. Specialty

5. Foreign Experience

Date	Description

6. Availability for Foreign Work

Short term (2-6 weeks) _____
Medium term (6 weeks-6 mo) _____
Long term (over 6 months) _____

7. Language Competence:

____
____
____

____________ Date

____________ Submitted by

APPENDIX B

Publications and Reports
1974-1975

An Investigation of Resources Management Options in Bolivian Agriculture by Allen LeBaron and Bruce Brown with Darwin Nielsen and Stephen Hammond.

Irrigation Fundamentals by Glen Stringham

Energy Inputs to Irrigation by J. C. Batty, Safa N. Hamad, and Jack Keller.

Line Source Sprinkler Plot Irrigator for Continuous Variable Water and Fertilizer Studies on Small Areas by R. J. Hanks, J. Keller, and J. W. Bauder.

Predicting Soybean Growth as Affected by Water Management by R. W. Hill, K. H. Ryan, and D. R. Johnson.

Reference Climate Sites for Agricultural Technology Transfer by R. H. Shaw and R. W. Hill.

Irrigation System Evaluation and Improvement by John L. Merrian and Jack Keller.

Irrigation and Water Distribution Infrastructure Amplification and Optimization by A. Alvin Bishop.

Trickle Irrigation Design Parameters by Jack Keller and David Karmeli.

An Agricultural Technology Transfer System by Jack Keller and L. N. Leininger.

El Sifon Automatico by Charles Burt.

On-Farm Water Distribution Structures by Komain Unhanand and H. B. Peterson

APPENDIX C
ABSTRACTS

An Investigation of Resources Management Options in Bolivian Agriculture

by

Allen LeBaron and Bruce Brown

With Darwin Nielsen and Stephen Hammond

Linear programming is employed to: (a) study the efficiency of agricultural resources use among 10 ecological zones; and (b) estimate the minimum costs of achieving specified 1985 food production targets. The potential role of modern technologies, principally irrigation, is emphasized.

The most traditional areas appear to have activity levels very comparable to those generated by the L. P. Analysis. This is not true for the developing Santa Cruz zone. The marginal value for Santa Cruz labor is substantially higher than elsewhere; this suggests agricultural output for the entire economy would increase if labor were completely mobile.

For some crops and zones, traditional technology is the most productive for resource input. Sugar cane, pineapple, coffee, peanuts and oranges, are examples.

Initial indications are that capital intensive irrigation is practical in many regions. Returns to ordinary irrigation methods on common crops are generally under 15%, whereas, better methods generally return 20% and over within the target ranges studied. Major benefits from irrigation could be easily obtained in reaching rice, wheat, and potato production goals. The optimum cost program calls for 65 to 100 percent of these crops to be irrigated.

The range over which crop outputs (and therefore target goals) may be varied without affecting the least cost solutions are also tested. Generally, the most sensitive crops are coffee, tobacco, coca leaf, pineapple, and cotton.

Irrigation Fundamentals

by

Glen Stringham

Irrigation Fundamentals has been written to be used as a guide for those involved in teaching the fundamental concepts of irrigation to water users. It discusses the concept of using the soil as a reservoir to store water for plant use and discusses principles which must be considered in the reservoir management. Eight laboratory and field demonstrations are presented which help in the visualization of the principles discussed. These demonstrations are presented with complete lists of equipment needed and photographs showing how it is to be assembled and used. Comments are also given on the interpretation of phenomena observed during the demonstration and cautions about some of the pitfalls which may be encountered.

This publication is well adapted for the use of extension personnel and officers of rural development organizations who are charged with introducing and improving irrigation skills of water users in new or existing irrigation projects.

Available from the Office of International Programs, Utah State University, Logan, Utah. Price $3.50.

Energy Inputs to Irrigation

by

J. C. Batty, Safa N. Hamad, and Jack Keller

Energy inputs to irrigation are dramatically increasing as irrigated agriculture expands to meet world food demands and more sophisticated technologies are developed to increase water use efficiency. In this study nine irrigation systems, designed for a specific land area, are analyzed and the total energy inputs computed for each system. The analysis includes energy inputs to manufactured components and installation as well as operation and maintenance. The expected life of each system and the energy value of salvagable materials are also taken into account. It is concluded that a practical balance must be established between maximizing water use efficiency and minimizing energy inputs to the irrigation system.

Line Source Sprinkler Plot Irrigator for Continuous Variable Water and Fertilizer Studies on Small Areas

by

R. J. Hanks, J. Keller, and J. W. Bauder

The design details and a sample set of field test results for a line source sprinkler plot irrigation system are presented. The system produces a water application pattern which is uniform along the length of the plot and continuously but uniformly variable across the plot.

By applying a fertility variable along a plot (at right angles to the water variable) planted in some test crop, the system offers a convenient means for developing crop production function data. The system test area and water supply are both small. However, the application of the system may be limited by wind, and all water application levels must be applied at the same irrigation frequency. Describes an excellent tool for use in demonstrating the interactions of water levels and fertility variables.

Publication CID 211(d)-7, Utah State University, Logan, Utah.

Predicting Soybean Growth as Affected by Water Management

by

R. W. Hill, K. H. Ryan, and D. R. Johnson

A computer program is presented which illustrates a strategy for relating soybean growth and production at specific site locations as influenced by water management. The application of the program can be demonstrated by a model based on phenology equations and on soil and climatic characteristics whi-' predict crop growth.

The program requires the amount of soil water in storage at the beginning of the season, available soil water storage in the root zones, and daily values of rainfall, irrigation, and maximum and minimum temperatures. In addition, specific parameters relating phenology to weather data for each variety must be provided. The example presented utilizes three sites, three soybean varieties, and five years of data. From a series of preselected planting dates the program predicts yield from the relative transpiration during each stage of growth, i.e. with end points at: emergence, flowering, pod fill, end of flowering, and maturity.

Determination of required depth and timing of irrigation water for any planting date is accomplished by application of supplemental water in incremental amounts. The resultant irrigation scheduling is indicated when a pre-selected yield level has been obtained.

Paper presented at the World Soybean Research Conference, Champaign, Urbana, Illinois, August 3-8, 1975.

Publication CID 211(d) - 12, Utah State University, Logan, Utah.

Reference Climate Sites for Agricultural Technology Transfer

by

R. H. Shaw and R. W. Hill

A systematic identification of major agricultural climatic zones in the world is presented. The idea is to select locations throughout the world with significant variations, yet also provide some common factors in such a manner as to permit the determination of major climatic influences on crop growth. These sites would then be identified as reference climates.

A minimum of eight stations have been selected to provide a range of temperature, day length, and precipitation factors which would provide an adequate range of climatic conditions for an information transfer project. These eight would be (1) tropical rainy; (2) tropical wet and dry; (3) low latitude, high elevation; (4) Steppe, dry, relatively low latitude; (5) humid subtropical; (6) subhumid, temperature, hot summer; (7) dry, temperature, cool summer; and (8) subhumid, temperate, cool summer.

The paper demonstrates that this surprisingly small number of such strategically located sites can provide the basis for crop-production-technology transfer, if the appropriate crop varieties are grown at all of the sites, and the proper sets of soils and weather data are simultaneously collected. The minimum weather data and daily values of maximum and minimum temperature, precipitation, pan evaporation, solar radiation are suggested.

The greatest plant-growth research-data void which exists at the present is in the extensive area of plant-environment interactions. This paper identifies part of a rationale for eliminating the void with a minimum of expenditure and in a relatively short time. Such organization of research effort must take place if the world's food needs are to be met in the coming years. The application of climate classification can help identify needed modifications in research programs for increased effectiveness towards adaptive transfer. Data collected at reference climate sites will aid in determining the climate interactions with crop variety and management regions. Once these interactions are known and understood, performance information can be transferred even to an area of dissimilar climates, aided by the classification of this climate.

Publication CID 211(d)-11, Utah State University, Logan, Utah.

Irrigation System Evaluation and Improvement

by

John L. Merriam and Jack Keller

This third edition of the manual has been expanded to include detailed procedures for the field evaluations of orchard, center pivot, and traveling sprinkler systems, trickle (or drip) systems, and basin irrigation systems in addition to the fixed grid sprinklers, furrow, and border irrigation system evaluations contained in the earlier editions. Complete instructions are given for each evaluation covering such items as a list of equipment needed; step by step instructions for carrying out the field work; sample forms for recording and organizing the field data; and sample studies demonstrating the entire process. It also includes an analysis and recommendations for the actual case studies used.

The introduction deals with the general uniformity, efficiency, and management concepts employed in the evaluation of each system. The fixed grid sprinkler, furrow, and border irrigation sections have been extended to include both simple and full evaluation procedures.

The second edition is out of print and the third should be available about January 1, 1976.

Irrigation and Water Distribution Infrastructure Amplification and Optimization

by

A. Alvin Bishop

Discussed in this paper are some of the problems of water distribution with emphasis on infrastructure. Irrigation is essentially a manipulation or management of the soil moisture environment for agriculture. Thus, water management is usually oriented towards increased agricultural production. The focus therefore must be on management of water on the farm which is not a simple process.

The many facets of the irrigation situation suggests that the infrastructure should not be limited to the physical elements alone, but should include other components as well. There are two basic infrastructure requirements. These are the physical infrastructure and the institutional infrastructure. The physical infrastructure includes the dams, canals, and appurtenances that have been and still are the concern of the engineer. The institutional infrastructure includes research, extension, markets, financing, water rights, legislation and societal organizations. The institutional infrastructure has generally been overlooked and neglected in irrigation development.

Until very recently, the priorities of development for irrigation have highlighted the physical infrastructure, and unfortunately this has been largely confined to the major works, the dams, canals, and the distribution system. The important physical infrastructure requirements for utilizing the water on the farm have been left to the farmer who has neither the capital nor the technical resources required to do the job.

Publication CID 211(d)-9. Utah State University

Trickle Irrigation Design Parameters

by

Jack Keller and David Karmeli

Trickle irrigation is a system for supplying filtered water (and fertilizer) directly on or into the soil. Spraying is eliminated and water is allowed to dissipate under low pressure in an exact predetermined pattern.

In trickle irrigation the objective is to provide each plant with a continuous readily available supply of soil moisture which is sufficient to meet transpiration demands. Trickle irrigation offers unique agronomical, agrotechnical, and economical advantages for the efficient use of water. The main disadvantages of trickle irrigation systems are sensitivity to clogging, salinity build up, and poor soil moisture distribution.

Unfortunately most of the current information and design procedures are quite general and/or incomplete. Therefore this paper provides an outline and sufficient detail for trickler system design using the limited knowledge currently available. The following topics are further elaborated on with equations, charts, and other design criteria presented:

1. Irrigation depth and interval
2. System capacity
3. Emitter flow characteristics and uniformity
4. Hydraulic design considerations
5. System design.

An Agricultural Technology Transfer System

by

Jack Keller and L. N. Leininger

An efficient system for rapidly improving world food production is through the innovative transfer of crop production technology found in temperate zones to developing non-termperate regions where major food deficits exist. Successful transfer of such technology depends upon a predictive system and adequate data sets for describing crop response under various environmental conditions. Such complete and consistent data sets are not now available in either the non-termperate or temperate zones. Application of these concepts to agricultural research in non-temperate (and temperate) zones will provide valuable direction towards a highly efficient and selective data collection program. Then sufficient data can be systematically integrated into an organized model based on water - crop - soil - climate interaction; and transferability and dissemination of information can be greatly improved and adaptive site-specific research needs substantially reduced.

This proposed system will provide a basis for the linkage and coordination of the various international crop centers and other research activities in water and soil management. This will be accomplished through extension of a predictive system using an existing crop production technology transfer (CROPIT) model which is based on both physical theory and access to collected data on crop responses to stress and the interactions between water, management inputs, and the local environment.

Publication CID 211(d)-10. Utah State University

APPENDIX D

EL SIFON AUTOMATICO

INTRODUCCION

Un sifón es un tubo que se utiliza para conducir agua desde un canal de riego a un surco o una parcela de tierra. El propósito principal del presente boletín es informar al agricultor acerca de las ventajas y el diseño de un nuevo tipo de sifón. Las ventajas que adelante se mencionan indican que este sifón es muy apropiado donde existen ciertas condiciones que requieren especial control del agua de riego.

FUNCIONAMIENTO

Como todo sifón el Sifón Automático debe cebarse para poder ser puesto en funcionamiento. Sin embargo, a diferencia del sifón corriente, el Sifón Automático se mantiene lleno de agua y listo para funcionar aún cuando este vacío el canal de riego, a menos que ocurra una evaporación excesiva del agua en los depósitos.

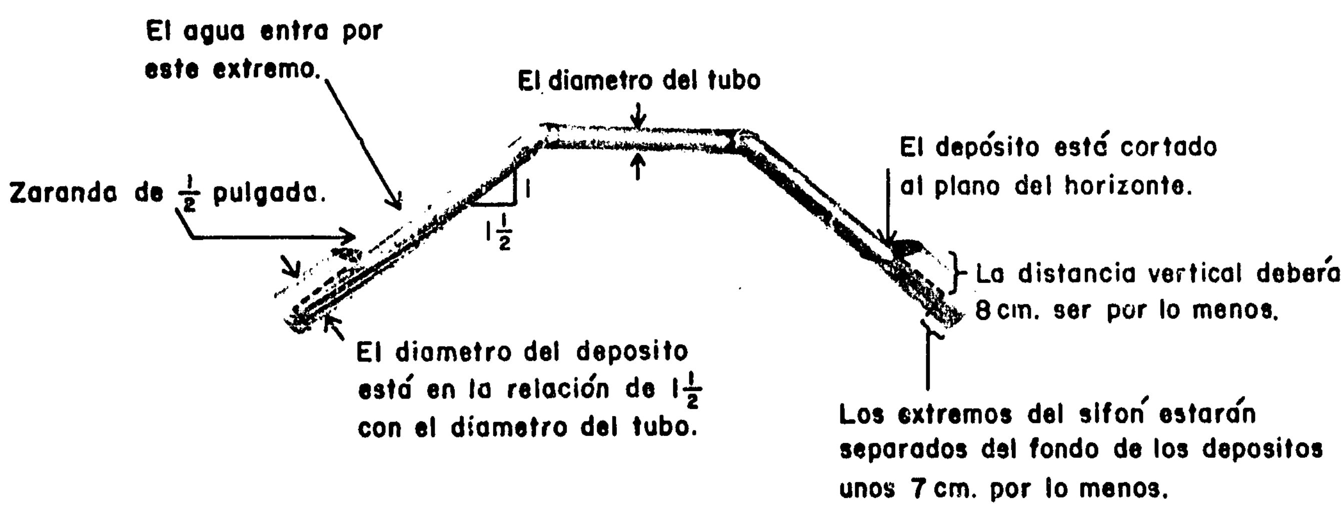
VENTAJAS

Las siguientes son las ventajas comunes a todo tipo de sifón:

1. Almacenaje fácil.
2. Liviano y fácil de llevar e instalar.
3. El caudal de agua del sifón puede regularse fácilmente subiendo o bajando uno de los extremos. El aumento en el caudal puede efectuarse utilizando un diámetro mayor o simplemente colocando 2 sifones por surco de acuerdo con los requerimientos de riego.

El Sifón Automático presenta además las siquientes ventajas:

1. No necesita ser cebado antes de cada riego. Esto representa disponibilidad de tiempo para otras labores tales como regulación del caudal en el canal, cierre de escapes en el canal, surcos, etc.



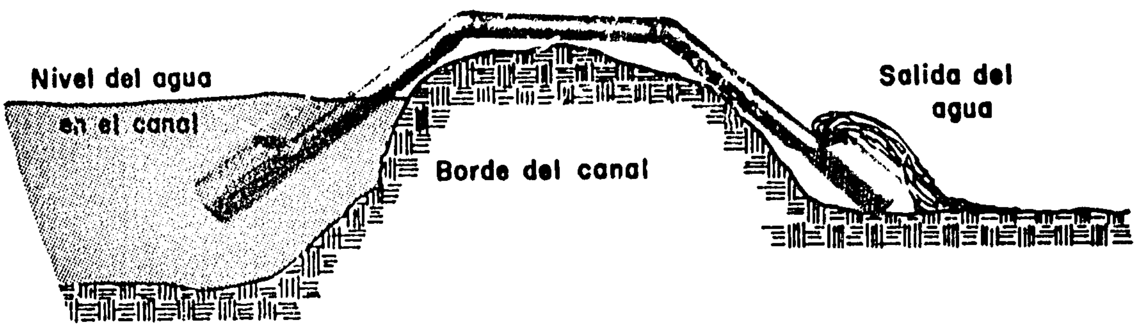
2. En algunas circunstancias tales como falla temporal en el sistema de bombeo, presencia de fugas en el canal principal, etc., el caudal de agua en el canal de riego se disminuye siendo necesario cebar de nuevo los sifones una vez que el caudal se haya restablecido, en el caso de los sifones corrientes. Ante este tipo de circunstancias, el Sifón Automático presenta la gran ventaja de que permanece lleno y listo para ser usado nuevamente.
3. Hay menos erosión debido a que la presión del caudal se amortigua a través del depósito.

CONSTRUCCION

El Sifón Automático se construye con tres tubos de lámina galvanizada N°28, soldadas de tal manera que tomen la forma de un trapecio para acomodarlo a la forma del borde del canal. En cada extremo deberá soldarse un depósito cilíndrico cuyo diámetro esté en relación de 1 1/2 con el diámetro del tubo. El extremo del sifón estará separado del fondo del depósito unos 7 cm, y la superficie libre del agua en el depósito deberá estar por los menos 8 cm arriba de dicho extremo. Esto último para evitar que la evaporación en determinado momento ocasione el vaciado del sifón. El depósito de la entrada llevará una zarada de 1/2 pulgada para evitar la entrada de basura. Este sifón puede ser hecho por cualquier hojalatero. El material necesario para construir un sifón de 1 1/2 a 2 pulgadas de diámetro, es de aproximadamente 3 a 4 piés cuadradros de lámina.

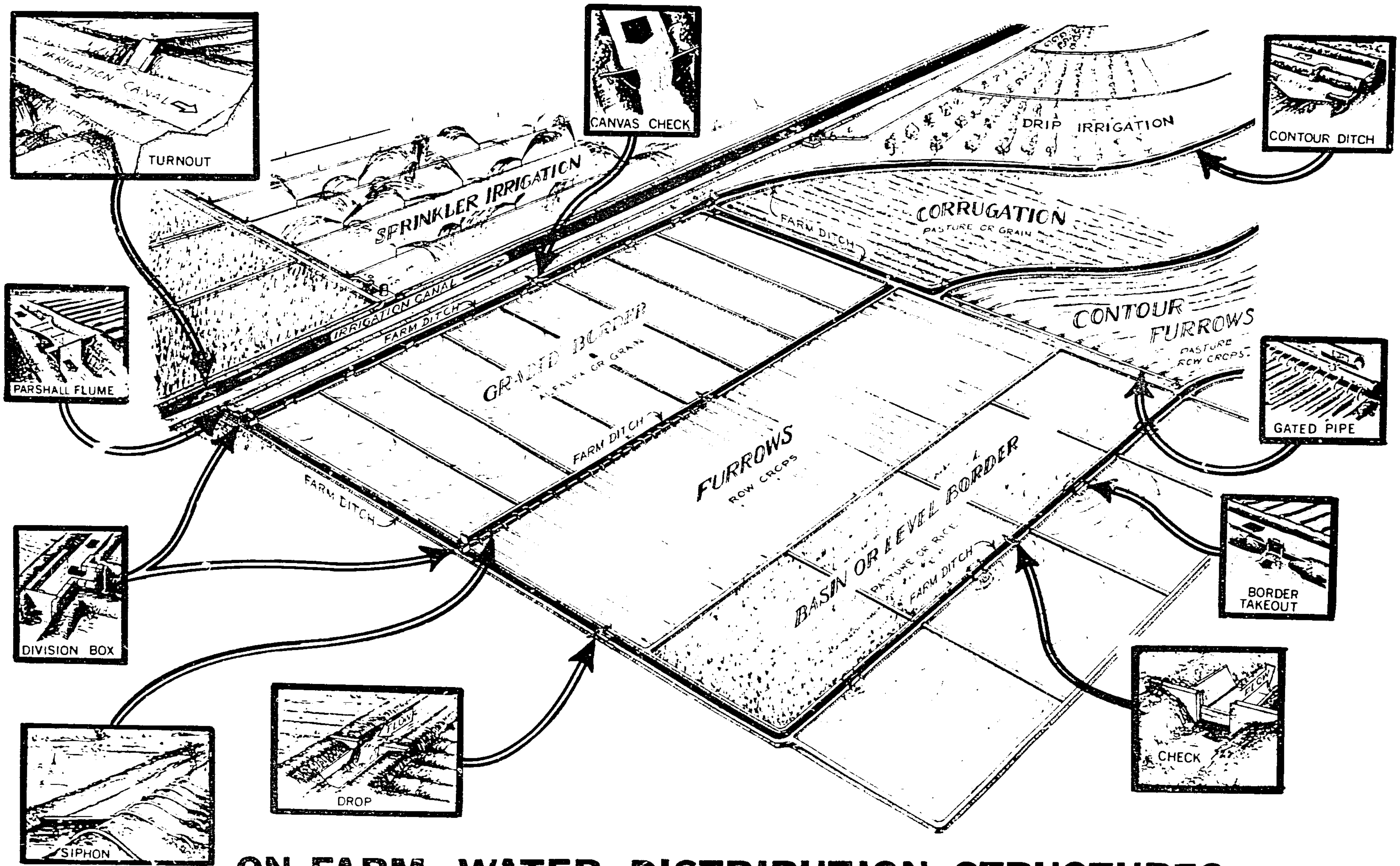
Ing. Charles M. Burt – Utah State University, E.E.U.U.
Ing. Gregorio Benjamin Vides López – Depto. de Ingenería Agricola-CENTA
Ing. Jaime Antonio Cea – DGORD

El costo de este boletín fue contribución bajo contrato USAID/csd-2459 con USU. Las recomendaciones son de los autores



APPENDIX E

ON-FARM WATER DISTRIBUTION STRUCTURES



ON-FARM WATER DISTRIBUTION STRUCTURES

K UNHANAND AND H B PETERSON

DEPARTMENT OF AGRICULTURAL AND IRRIGATION ENGINEERING

UTAH STATE UNIVERSITY LOGAN UTAH

What is a good water-distribution system?

A good water-distribution system should perform the following functions:

- . Deliver water to any portion of the farm when needed.
- . Deliver water in the amount required to meet crop demands.
- . Divide water into the required amount for use in different fields.
- . Measure the amount of water delivered to the farm.
- . Re-use the water as much as possible.
- . Dispose of waste water.
- . Allow free movement of farm equipment.

In addition the operation should be simple, efficient, and need little maintenance.

Why do we need a good water-distribution system?

We need a good distribution system because:

- . Less water is wasted.
- . More land can be served with the amount of water saved.
- . Less work for the irrigator and operation time is saved.
- . Less cost of operation and maintenance.

How to get a good water-distribution system?

A good water-distribution system must be well planned from the beginning. The planning consists of the following considerations:

- . Land levelling
- . Irrigation methods
- . Size, location, and types of structures
- . Soil types
- . Crops to be grown
- . Water requirement
- . Rainfall
- . Land topography
- . Operation preference

What are typical structures needed in a good water-distribution system?

a. From irrigation lateral to farm ditch:

Structure	Function
Turnout	Delivers water from irrigation canal to the on-farm distribution system.
Measuring structure	Measures the amount of water delivered to the farm system from the irrigation canal.
Division box	Divides water in the amounts required for different branches of the farm ditch system.
Check	Raises the water level in the farm ditch to the desired elevation for delivery into the field or branches of the farm ditch system.
Drop	Usually the longitudinal slope of the farm ditch is rather flat to avoid high flow velocities which may cause erosion. If the land slope along the ditch line is too steep, a drop is required in order to maintain the ditch bottom in the original soil.

b. Structures or devices for delivery of water from farm ditch to field.

Structure or device	Function
Siphon	Delivers water from farm ditch to furrows, borders, basins, or corrugations.
Spile, gated outlet, furrow turnout	Delivers water to furrows, corrugations.
Gated pipe	Delivers water to furrows, corrugations.
Take-out	Delivers water to borders or basins. Sometimes it delivers water to a secondary ditch which supplies water to furrows or corrugations.

Material for Construction

Structures for farm water distribution systems may be built with concrete, steel, wood, masonry, plastic, or asbestos cement. Some factors to consider in making the choice of material are the desired permanency of the structures, the available funds for the project, the time available for construction, and the availability of local material.

Concrete, steel, and masonry are normally more expensive than wood but they are more permanent. Built-in-place concrete and masonry are time consuming. Wood structures can be built more easily, inexpensively, faster, and may be removed to facilitate ditch cleaning or for use elsewhere. They could last for many years if constructed with creosoted wood or hardwood using galvanized nails. Masonry could be economical if sand and stones are locally available and labor is not expensive.

Precast concrete or steel structures are easy and fast to install if proper handling equipment is available. For larger installations, structures consisting of prefabricated sections of concrete or steel could be very economical, simple, and fast to cons ruct.

Consideration should be given to the type of foundation soil. Massive concrete and masonry structures may settle excessively in time when constructed on a soft clay foundation.

General precaution in installation of structures

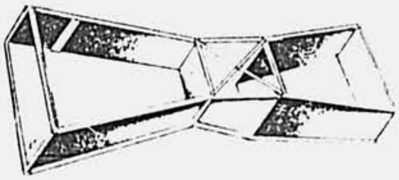
- . The structure must be in good contact with the foundation soil and the soil must be well compacted around the structure. Otherwise, water may find its way under or around the structure. This action endangers the structure and may prevent it from performing the intended function.
- . Silty soils are less resistive to the erosive power of flowing water than are cohesive soils. Some extra protection with a gravel or stone blanket in the erosive region, such as downstream from the structure, may be necessary.
- . Measuring structures should be installed according to instructions, or they may not function accurately.

Typical Designs: (All dimensions are in meters, unless otherwise shown).

Measuring structures

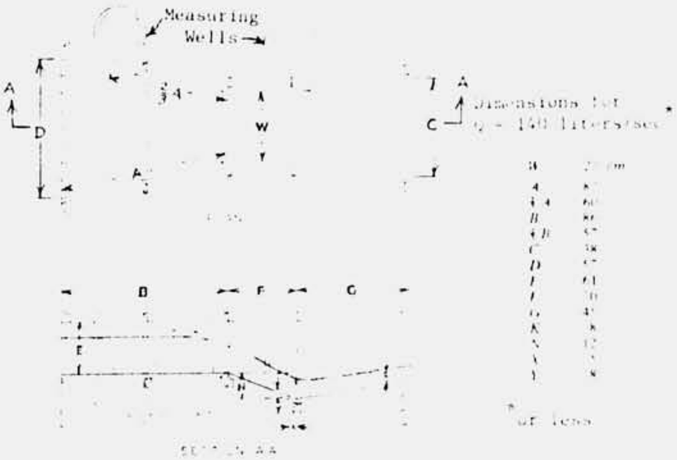
Parshall flume:

a. Steel

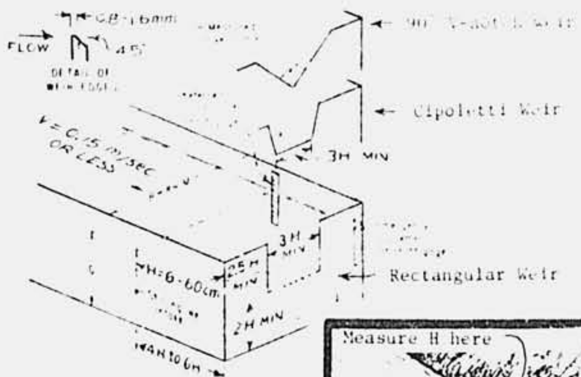


b. Concrete (Could also be built with masonry)

b. Wood

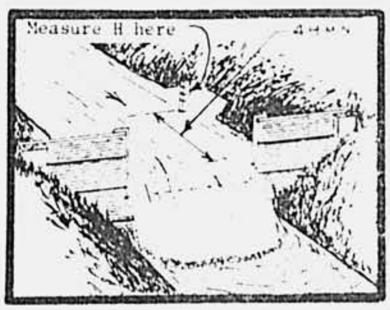


Weir

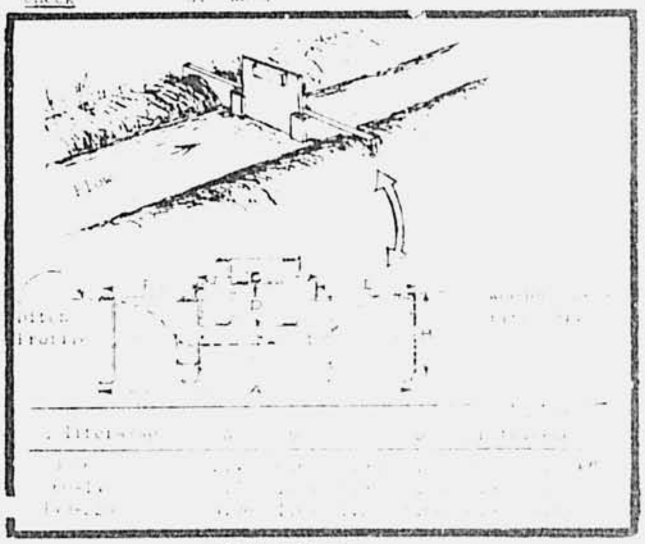


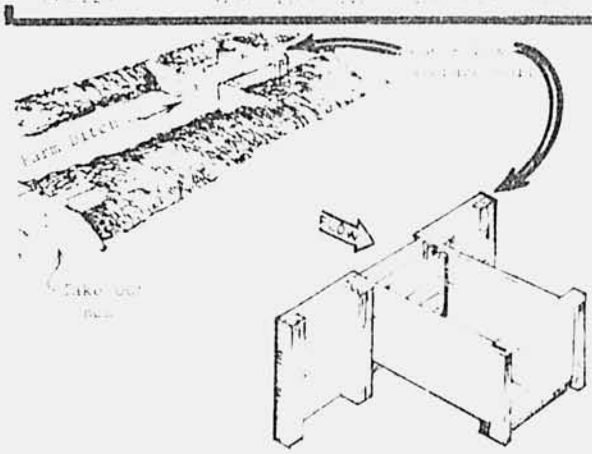
Weir Setting
Rectangular, Cipoletti
90° V-notch

Wooden Rectangular Weir



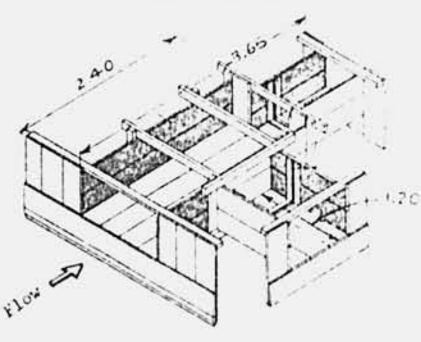
Check a. Wood



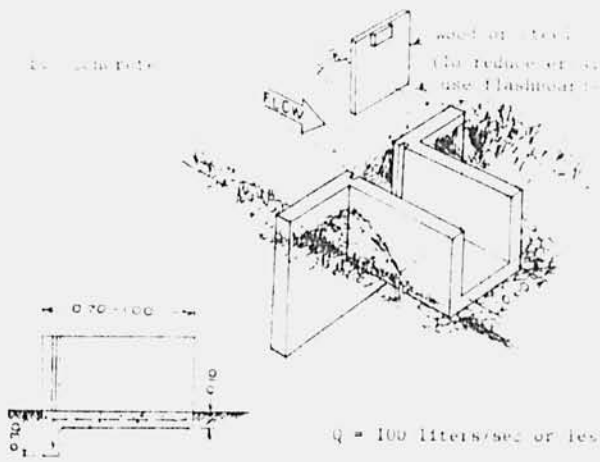


Division box:

a. Wood

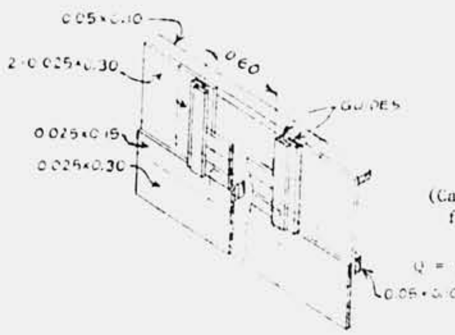


b. Concrete



Q = 100 liters/sec or less

c. Canvas Check (see cover)

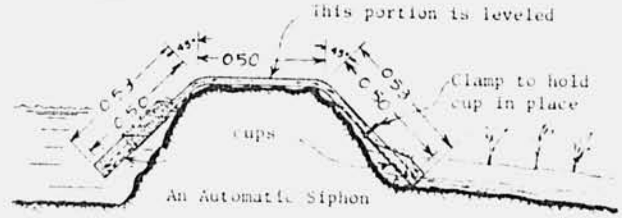


Basin or Border Take-out

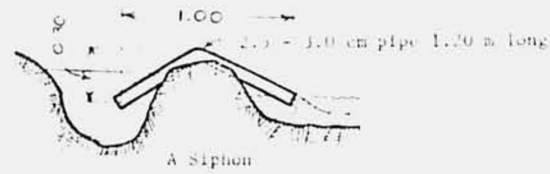
(Can be used as check for firm soil)

Q = 85 liters/sec or less

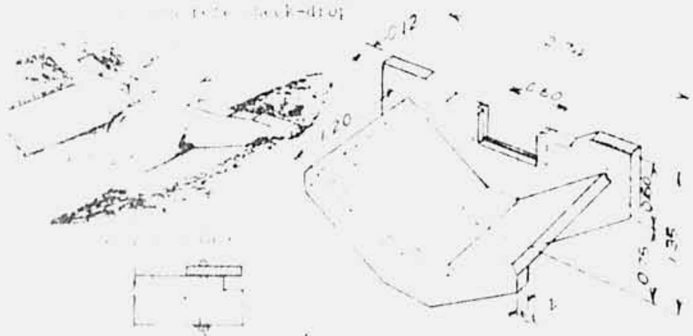
Siphon

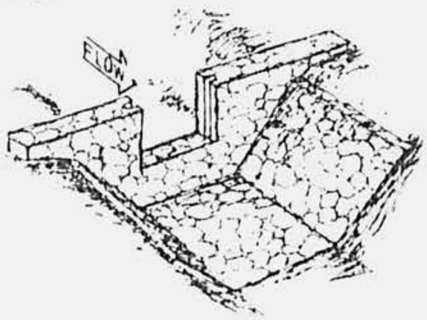


An Automatic Siphon



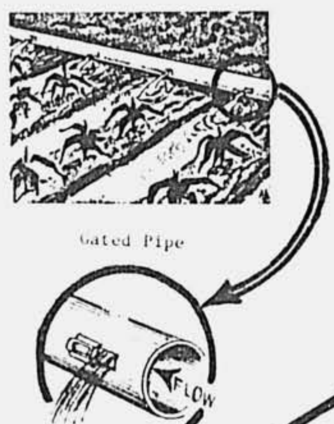
A Siphon





Masonry check-drop

Gated Pipe



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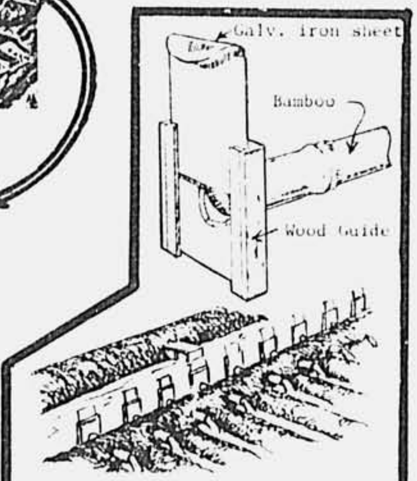
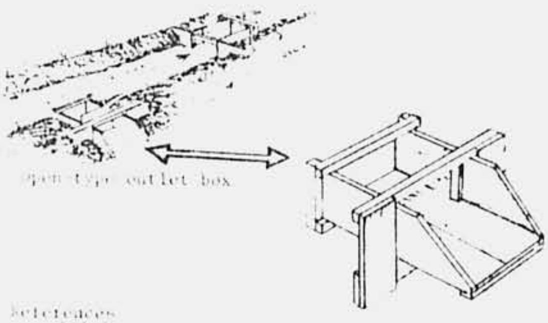


Bamboo Tubes used as Furrow Turnouts



Open type outlet box

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APPENDIX F

Appendix F

IRRIGATION AND WATER DISTRIBUTION INFRASTRUCTURE AMPLIFICATION AND OPTIMIZATION

by

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This paper will discuss some of the problems of irrigation and water distribution as related to the conference theme, "Priorities in Development" with emphasis on the focus of this special session dealing with infrastructure amplification and optimization.

BACKGROUND

Irrigation is an old art but a relatively new science. The application of the basic principles of soil physics, plant physiology, water requirements of crops and other disciplines have been combined with the engineering hydraulics and fluid mechanics to make irrigation the rather complex science that it is today. Irrigation is essentially a manipulation or management of the soil moisture environment for agriculture and thus water management is usually oriented towards increased agricultural production. The focus therefore must be on management of water on the farm which is not a simple process. In an earlier paper,[1] the writer developed a concept for on-farm water management as follows:

> *"Modern 'On-Farm Water Management' is a complex combination of art and science requiring the application of our best knowledge of water, soil, climate and crops and their interactions, together with inputs of nutrients, pesticides, capital, power (energy) and management for agricultural production. It extends from the production of water as precipitation (either in the watershed or at the farm) to the disposal of the remnants after use. It gives emphasis to timely and sufficient delivery of water to the farm including the conjunctive use of surface water and groundwater and the re-use of irrigation return flow or the sequential use of waters reclaimed from industrial, municipal or other uses. It includes the preparation of the farm land to enhance its efficiency to receive and store water. It employs the necessary water removal systems (drainage works) to control the water table, provide leaching requirements and dispose of unwanted water whether coming from excessive precipitation, excess irrigation or otherwise. It involves the design and construction of devices and structures for the efficient application of water to the land such as field ditches, pipelines, furrows, borders, and sprinkler systems. It involves the design and construction of complicated engineering works such as dams, reservoirs, canals and appurtenances for control and modification of the space-time availability of natural water supplies so delivery and application to the farmland can be made on a timely basis. In modern society the need for proper concern for the environment, erosion, pollution, water quality and factors affecting the quality of life are also recognized. Apparent also is the knowledge of and need for institutions, organizations, legislation, laws and regulations providing for an orderly and acceptable development and use of the water resource to meet societal goals."*

This concept of on-farm water management emphasizes that an irrigation system is more than a hydraulic system. The many facets of the irrigation situation suggests that the infrastructure should not be limited to the physical elements alone, but should include other components as well. There are two basic infrastructure requirements. These are the physical infrastructure and the institutional infrastructure. The physical infrastructure includes the dams, canals, and appurtenances that have been and still are the concern of the engineer. The institutional infrastructure includes research, extension, markets, financing, water rights, legislation and societal organizations. The institutional infrastructure has generally been overlooked and neglected in irrigation development. Concern is growing, as the theme of this conference indicates, for better utilization of the world's resources by taking a critical look at the priorities of development.

THE PROBLEM

Until very recently, the priorities of development for irrigation have highlighted the physical infrastructure, and unfortunately this has been largely confined to the major works, the dams, canals, and the distribution system. It has been tacitly assumed by civil engineers that once these major works are completed the utilization of the water resource for agricultural production would automatically follow. The important physical infrastructure requirements for utilizing the water on the farm have been left to the farmer who has neither the capital nor the technical resources required to do the job.

Each element of the physical system is as important as any other. It is axiomatic that the benefits to be derived from irrigation cannot be realized until the <u>water reaches the land</u>. It is also a corollary that the full benefits from an irrigation project requires that water be available to satisfy the evapotranspiration requirements of the crop. The above precepts are well understood, yet the water resource development projects designed to provide irrrigation water for agriculture seldom provide the vital last step necessary to apply water to the land.

Among the reasons given for omitting the essential last step in getting water to the land are: (1) Major facilities such as diversion dams, canals, storage reservoirs, must all be built to control the resource before water can be available to the farmer; (2) The small terminal laterals and ditches can be built by the farmer with farm equipment; (3) The farm supply ditch and the on-farm distribution system is the responsibility of the cultivator; (4) The on-farm system is beyond the scope of the project authorization; (5) The investment will be reduced if the smaller ditches and farm laterals are left for the farmer to build.

Therefore, it seems evident that the physical infrastructure is incomplete. In addition the institutional infrastructural requirements at the farm level are often lacking. These are needed to insure credit, markets, extension activities and needed education. Likewise off-farm institutional infrastructures to provide needed research, system management, laws and legal support are essential.

CURRENT APPROACH TO THE PROBLEM

In light of the above, it seems appropriate to review current development philosophy as implied from projects of the World Bank, United States Bureau of Reclamation, the U.S. Soil Conservation Service, the U.S. Farmers' Home Administration, the Western United States, India Ministry of Irrigation and Power, and Asian Development Bank to determine whether the problems outlined above are being attacked.

The World Bank

The following quote is taken directly from World Bank Operations:[2/]

"Irrigation Development

Through the 1950's the Bank's lending for irrigation was primarily for the construction of dams and main distributary canals. Governments, farmers and local entrepreneurs were responsible for financing, without further Bank assistance, the complementary investments required to take advantage of the improved water supply. However, it was found that, in many cases, although progress on the major construction works was generally satisfactory, the complementary developments were delayed. The economic benefits of the capital-intensive works, therefore, were either not fully realized or were realized rather late. This was often attributable to a lack of coordination between various agencies involved in the development of irrigated agriculture and to a lack of appropriate financing.

In recent years, therefore, the Bank has given particular attention to these complementary developments during project preparation and appraisal. It has sought to ensure that the planning of agricultural and ancillary developments has been carried out, and that suitable arrangements have been made for implementation, including those required for proper coordination. In some cases, especially those where the construction and consequently the disbursement periods are long, the Bank has financed irrigation development in phases or, where appropriate, has financed only the major civil works.

But the trend is towards paying equal attention to all aspects of the development and use of water resources, and financing the agricultural and ancillary developments as well as the basic irrigation infrastructure. Some recent irrigation projects have thus provided for the construction of the complete distribution system down to the field level; the construction of roads and tracks; the strengthening of applied research, demonstration facilities and agricultural extension services; the provision of credit to entrepreneurs, cooperatives and farmers for input supply, on-farm investments and storage and processing facilities; and training of farmers as well as of operations personnel."

The above quote clearly indicates that until recently the World Bank concerned itself only with the major engineering works and assumed that the necessary on-farm works and supporting services would automatically follow. The inability of the farmers and local societies to provide for the completion of the project has postponed the realization of the benefits. It seems apparent that the Bank now recognizes the problem and is developing a philosophy which will exert a positive force on the loan policies.

U.S. Bureau of Reclamation

The water resource development philosophy of the Bureau of Reclamation has been concerned with physical control of the water resource. The emphasis has been the dams and major engineering works to alter the space-time availability of the resource. It is a stated policy of Bureau projects to provide delivery to the high point of the ownership. Bureau design manuals, policy statements and general concern have been toward providing the efficient hydraulic system to deliver water according to the project plans. This phase of project development involves primarily engineering considerations with related economic and political constraints. The neglected on-farm component with its agricultural considerations and farmer desires combined with the on-farm engineering problems presents a much more complex mix.

It should be pointed out that the cost of the on-farm development is taken into consideration in the feasibility studies and in computing the farmer's ability to repay project costs. The actual on-farm developments and supporting institutional systems are left to the farmer or to other agencies. In isolated cases the Bureau has been specifically authorized by the project legislation to develop the on-farm drainage works and other on-farm improvements.

Fortunately, in the United States there are services available to the farmer to assist him in the on-farm development problems. Agencies of the U. S. Department of Agriculture provide financing, farm planning, research and extension. The availability of these services is perhaps the major reason that the Bureau of Reclamation has not concerned itself with the on-farm problems. However, there has not always been sufficient support during the initial settlement of the project. Often the first generation of farmers go bankrupt before their farmland is in full production.

U.S. Soil Conservation Service

This agency of the U.S. Department of Agriculture created during the 1930's has responded to the on-farm water management problems both for irrigated lands and non-irrigated crop land. Engineering services specially designed for land preparation (leveling) were developed by the SCS. Problems of uniform application of water to irrigated land, methods of application, drainage and problems related to the management of irrigated land have become a major concern of the SCS. Through the institutional support of Soil Conservation Districts the agency now engages in farm planning and provides the farmer with the technical services required for remodeling the farmer-developed irrigation systems to evolve a better on-farm facility. Although the SCS work involves the intimate field knowledge of both the engineering and agronomic components of farming, the program is now reaching about one-half million acres each year for land leveling for irrigation alone. Private work by farmers and private contracting and other sources of technical and/or financing are also being used extensively.

Farmers Home Administration

This agency of the U. S. Department of Agriculture, also organized during the 1930's is involved in a credit program for low income farmers in the United States. One of the requirements for a loan under FHA is that the borrower cannot obtain credit elsewhere. The philosophy of the Farm Ownership Loans under FHA is that the borrower (farmer) have a livable and operable unit. This has been interpreted to include at least minimum housing, essential equipment and land development. Land development in irrigated areas includes farm ditches, control devices and land leveling. In essence the philosophy sets the farmer up as a producer, not a developer or builder. It assumes that he will be a better risk say with a $20,000 mortgage on a producing farm than he will be with a $5,000 mortgage on undeveloped land. Apparently this philosophy is sound, for after nearly 40 years of loan operations with low risk farmers, present policies still are geared to this philosophy.

Western United States Pioneer Development Philosophy

The general water resource development philosophy has been concerned with resource development rather than resource utilization. The underlying assumption being that once the resource has been harnessed the on-farm utilization would automatically take place. The exception in the United States are those projects built by the landowners themselves. In most Western irrigation projects built with private capital, the pioneer landowners organized themselves into irrigation districts or mutual irrigation companies and through the organization jointly built the facilities. Each landowner thus had an interest in the major works which served the group. The land development, however, remained the responsibility of the individual land owner. The pioneer philosophy of land development especially on irrigation projects seems to prevail even though modern irrigation requires more technology than most farmers command. The long time span required for the "do it yourself" trial and error land development typical of the early developments in the United States can now be materially shortened with application of the new science of irrigation and land development for irrigation. Nevertheless, many still hold onto the "do it yourself" philosophy because the project costs appear to be less and the on-farm design jobs are usually not fully understood by those concerned with developing the resource and designing the major works.

India - Ministry of Irrigation and Power

Some of the largest irrigation developments in the world are in India. Here, as elsewhere, the inclusion of the on-farm development problems have only recently been considered but not yet provided for as indicated in the following statement by the Indian Irrigation Commission,[3]

"Consideration of Ayacut Development and Conservation of Catchment

11.13 The cost estimates of irrigation projects cover all works up to outlets and include the cost of constructing water courses, and in some States, even field channels. But they do not include the cost of ayacut development, for which separate estimates are prepared. At present, in working out the benefit-cost ratio the investment on ayacut development is not taken into account. This, in our view, gives a distorted picture of the economic viability of a project. It is obvious that the full benefits, for which credit is taken in the benefit-cost ratio, can accrue only after land has been shaped, and field channels and field drains have been constructed.

11.14 In the U.S.A., the Sub-Committee on Evaluation Standards stated in its report to the Inter-Agency Committee on Water Resources in 1958 that, 'all costs of development and improvement of agricultural land and all production costs must be considered in project evaluation'. In 1964, the Gadgil Committee in its report on 'Criteria for Appraising the Feasibility of Irrigation Projects,' stated as under:

> *'When irrigation newly comes to a region, the lands used till then for dry irrigation have to be adapted and prepared for irrigated agriculture. This involves a capital cost for the preparation of land to receive water. This is in the nature of a capital investment on the part of the farmer and is to be treated on the same lines as an annual charge in the form of depreciation. The problem then becomes as to what should be the period over which this capital charge should be retired. We suggest that it should be ten years. The capital costs on this account will have to be estimated by the Project authorities and these can be easily done. In fact, as in the U.S.A., conventions may be adopted by which these costs should be included in the project costs.'"*

The responsibility for construction and maintenance of facilities in India is indicated in the definition of water courses and field channels taken from page 142 of the above-mentioned Commission Report:

"*Water Courses and Field Channels*

A water course has been defined by the Planning Commission as a channel, built at the Government expense, to convey water from an outlet to a 40 hectare block or as may be prescribed. The area for which a water course has to be constructed varies from State to State according to local conditions relating to topography and the cropping pattern. In 1958, the Planning Commission recommended that project authorities should be made responsible for the construction of water courses at project cost for chaks or blocks up to 40 hectares in area. Beyond this, field channels were required to be built by cultivators to serve the various fields within the blocks. The responsibility for the maintenance of both the water courses and the field channels was to be that of the beneficiaries. It was suggested by the Planning Commission that the State Government should have the power, through legislation, to construct field channels and to maintain water courses and field channels should the beneficiaries fail to do so themselves, and to recover the cost from the latter."

From these quotations it is evident that the present policies for public assistance on irrigation projects in India stop far short of the on-farm problems.

Asian Development Bank (ADB)

In an international symposium[4/] concerned with research needs for on-farm water management, Dr. Kunio Takasi, Irrigation Project manager, ADB, outlined the current philosophy of the Asian Development Bank as follows:

"In order to achieve production targets in a fully-fledged irrigation project most effectively, the Bank considers a three-stage approach essential and has applied it in most of the projects it has assisted. The three stages are: (1) The Experimental Farm; (2) the Pilot Scheme; and (3) the Pioneer Project.

1. The Experimental Farm deals with basic field investigations of agronomy, soil, crop, and water relationships. It aims at solving location-specific problems through research and usually covers an area of about 5 to 10 hectares.

2. The Pilot Scheme is essentially a trial demonstration of, and training in, water management and modern farming techniques on a practical scale. Usually undertaken by pilot farmers, this approach aims at solving mainly technical problems. It is on a limited scale, of between 100 and 200 hectares, but the physical layout has the same degree of complexity as that of a pioneer project.

3. The Pioneer Project is a model of a fully-fledged irrigation project under actual farm management. It should be large enough to be an economic unit of agricultural production and includes credit, processing, marketing, and institutional arrangements. Such projects aim to solve not only technical problems, but also marketing, economic, and organizational problems associated with a larger-scale operation. An area of from 1,000 to 30,000 hectares is involved depending on the purpose of the pioneer project."

The above quotations and discussions indicate that the current approach to the problem falls far short of the requirements of a completely operable system with the needed institutional support, although there is a trend towards more concern for the utilization of the water as opposed to the earlier philosophy where the development seemed to be the end in itself.

FUTURE PRIORITIES

In order to overcome the evident shortcomings, it seems that a philosophy regarding irrigation project formulation must be developed and policy guidelines for future projects must be established. The basic elements of irrigation project development philosophy that should be given high priority include the following:

1. The physical system must be complete

The construction of an irrigation project should not be considered complete until the water reaches the land producing the crop. This implies not only the construction of the dam, reservoirs and canals but also the construction of the terminal laterals serving the farm, the construction of on-farm distribution system and the preparation of the land for the irrigation method employed. In addition, the drainage or water removal facilities should be anticipated and provided for. The outlet drains should be located and constructed so the necessary field drainage can be installed when required. Construction plans and execution of the work should not fall short of this goal.

2. The system management must be secured

It is not only important to provide a physical system that insures water delivery to the crop, but also to manage and maintain the system so that deliveries are made and the crop water requirements are satisfied. The methods of water application employed such as furrow, flood, sprinkle and trickle demand flexibility in delivery methods. These range from continuous flow delivery for sprinkle and trickle systems to demand delivery to satisfy the short duration, high discharge requirements of border strip flooding. The physical limitations of the system in relation to the crop water requirements which depend upon climatological factors, stage of growth and type of crop must be considered. Management must also be closely integrated or in tune with the farmer and the social system of the locale. Management is highly site specific but the site specificity only emphasizes the necessity for careful planning and consideration for each new location. Too often the canals and laterals are managed as hydraulic systems serving the engineering concerns rather than the agricultural requirements and related human (farmer) concerns. The management component involves both the agro-socio-economic system and the engineering system. The agro-socio-economic system and the related human concerns may be even more site specific than the engineering system.

3. Innovations and adaptations must be anticipated

This implies that a research and demonstration area should be an integral part of the project. Every project, small or large, will have many individual characteristics not found on any other projects. The specific problems range from the nature and quality of the water supply to major and minor element nutrient deficiencies with crops, method of water application, soils, pests, etc., all presenting specific demands upon the project. The research and/or demonstration center is necessary to search out solutions and demonstrate the innovations and adaptations required in the science for the particular site specific problems. Adaptive research is perhaps the most neglected technical component of irrigation projects. It should be considered necessary to include this facet as an integral part of the project development plans.

4. Institutional support must be planned and organized

The mature irrigation project will produce a new segment of the society whose requirements must be understood, planned for and functional if the project is to be successful. Many integral societal functions must be provided. Extension, closely linked to the research activities mentioned above, provides the vehicle to bridge the gap between the researcher and the farmer. The complex package of practices combining seed, fertilizer, water and soil must be translated to the farmer in language and terms he can understand and afford. Other institutional services include markets, credit, transportation and other community services. Irrigation farming is a way of life, and the demands of irrigation farming will present many new and different opportunities and problems to cultivators not familiar with irrigation techniques.

5. Development time must be included

It is inconsistant to assume that an irrigation project can go into full production immediately upon completion of the physical works. The system must have its "test run." This requires time. Minor changes in both major works and on-farm facilities may be necessary. Five to ten years may be required. Certain farm crops, especially orchards, do not come into production for three to five years after planting and may not reach full production for ten years or more. Thus full production may not be possible for twenty years. Many irrigation projects do not reach maturity for forty to fifty years. It is essential to recognize and allow for the time period necessary for the "growing up" of the project.

The five components of irrigation development philosophy outlined above should be given priority consideration by development agencies and lending institutions undertaking or involved in water resource development. Too often it has been assumed that the on-farm development would automatically take place if the water was delivered to some high point near the land or within some distance from the field to be served by the project. The farmers' abilities and resources have usually been greatly overestimated even in the more developed countries. Likewise, the technical problems related dto the design and construction of the terminal laterals have been underrated. It also seems apparent that efficient on-farm irrigation design is not well understood by many irrigation development planners. For example, it is not generally realized that for most methods of water application the irrigated soil surface serves as part of the distribution system. All surface methods of irrigation use the soil to convey the water to other areas to be irrigated. The hydraulics of surface irrigation which involves the complicated problem of flow of water over a porous media having a variable infiltration rate and variable roughness components is much more complex than the hydraulics of the major distributory canals. As the soil moisture changes, the infiltration rate also changes, and as the crop grows, the surface roughness changes. Thus, a given point of a field seldom involves identical flow conditions from one irrigation to the next. This is more complicated than the flow of water in the canal system where the hydraulics remain essentially constant with time considering the roughness and other hydraulic characteristics.

These rather complex relationships that exist between good land preparation (leveling), size of stream, length of run and soil intake rates for surface irrigation are completely beyond the design and perhaps financial capabilities of the farmer. True, the farmer usually comes up with an application system that works, although it generally requires much more water and is less efficient than a scientifically-designed system. It is alsotrue that through the trial and error process the farmer may eventually evolve an efficient surface irrigation system, but this may require several generations. The same technicalities exist for sprinkle, trickle or subsurface methods of application.

The technicalities of design of the on-farm system are simply not within the farmers' capability. So it is easy to see why the completion of the unfinished system is not readily accomplished by the farmer.

Engineers and some planners are coming to the realization that resource development for the purpose of simply harnessing an idle resource does not create an irrigation project. More and more, the importance of on-farm water management is coming to the front.

In a seminar[5/] on Water Management and Control for Agriculture held October 2-14, 1972, in Tokyo, Japan, the Summary Report endorsed by the seminar stressed the importance of more concern for the on-farm considerations in irrigation projects. The following is taken directly from the Summary Report of the seminar:

"Basically, irrigation can be divided into two phases each dependent on the other for attaining meaningful results. The first is the harnessing and distribution of water, the second is the use and management of the water distributed. The first involves mostly engineering expertise, whilst the second entails an integration with agronomic aspects relating directly to farmers' activities. The planned development of these two phases and involvement of different disciplines in an integrated fashion in developing these phases are necessary in making irrigation schemes successful."

The seminar suggested that the following measures be taken relative to the second phase:

"1. *Provision of on-farm facilities*
2. *Operation and maintenance facilities*
3. *Applied research and dissemination of information obtained*
4. *Education and training*
5. *Creation of an awareness of the on-farm problems of water management."*

Each of these five points is discussed in the Summary Report of the seminar and was given detailed consideration during the seminar. It was pointed out by the Japanese delegates, that feasibility studies and project plans included both phases of irrigation projects mentioned above with on-farm development costs ranging from \$500/ha to \$1,000/ha and research-extension activities adding an additional \$250/ha to the capital costs.

The international symposium referred to above[4/] identified thirteen deficiencies in existing knowledge which in the writers opinion include many of the high priority considerations needed in planning future irrigation projects. These are:

"(1) Physiological responses of crops to environmental stresses; (2) optimal crop productivity relationships of water and other inputs; (3) methods for systematically transferring crop productivity functions geographically; (4) improved on-farm systems, including drainage, and measuring and control structures; (5) improved production systems and understanding of climatic variables for rainfed agriculture (6) improved prediction of quantity and quality of surface and subsurface water supplies and improved storage and distribution procedures for optimal on-farm water management; (7) methodology to identify critical technological innovations or systems; (8) improved 'systems' to facilitate or deliver appropriate water management technology; (9) farmer motivation; (10) methods for involving farmers in the planning and management of water distribution systems; (11) approaches to needed water rights legislation; (12) prediction of economic consequences of alternatives; and (13) techniques for predicting socio-economic problems."

SUMMARY

Priorities in future development for irrigation and water distribution should focus on the shortcomings of existing projects.

1. The physical system must be complete
2. The system management must be secured
3. Innovations and adaptations must be anticipated
4. Institutional support must be planned and organized
5. Development time must be included

"The successful irrigation project is not measured by the height of the dam nor by the efficiency of the canals for water delivery but by grain in the bin and fruit in the box. The late Dr. O. W. Israelsen summed it up nicely in the following statement, "The building of all these structures (reservoirs, dams, canals, etc.) constitutes only preparatory work. The real and ultimate task is using the irrigation water to produce food."

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