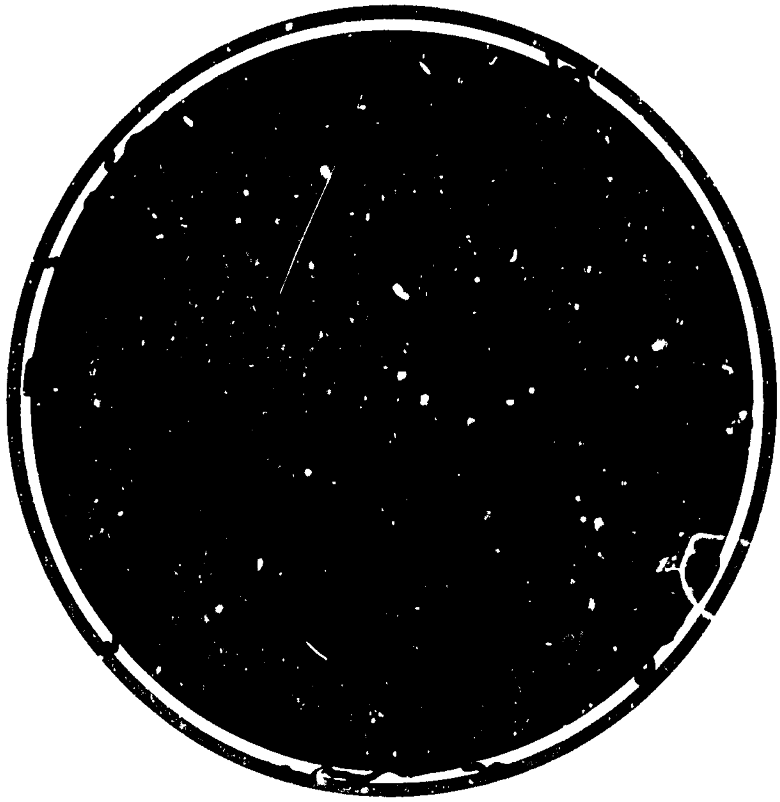

IRRIGATION DEVELOPMENT OPTIONS AND INVESTMENT STRATEGIES FOR THE 1980'S

GENERAL ASIAN OVERVIEW

USAID

WATER MANAGEMENT SYNTHESIS PROJECT

WMS REPORT 7

PN-AAP-146
9311007/62
ISN-33126

GENERAL ASIAN OVERVIEW OF IRRIGATION DEVELOPMENT OPTIONS AND INVESTMENT STRATEGIES FOR THE 1980'S

This study is an output of
Water Management Synthesis Project
under support of
United States Agency for International Development
Contract AID/DSAN-D-0058

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May 1982

WMS Report 7

PREFACE

This study was conducted as part of the Water Management Synthesis Project, a program funded and conducted by the United States Agency for International Development through the Consortium for International Development. Utah State University and Colorado State University serve as lead universities for the project.

The key project objective is to provide services in irrigated regions of the world for improving design and operation of existing and future irrigation projects and give guidance to USAID for selecting and implementing development options and investment strategies.

Contact the Water Management Synthesis Project for information about project support services or research findings.

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FOREWORD

The Asian Bureau of USAID requested that the Water Management Synthesis Project carry out a quick but systematic interdisciplinary field review of the irrigation sector in the Asian Region. The purpose of the review was to help delineate the Bureau's irrigation investment options and strategies for the Region.

As a point of departure for the WMS Team visits to selected Asian countries, Gilbert Levine developed the position paper, "Irrigation Development and Strategy Issues for the Asian Region." Each Mission in the Region was informed of the study and asked to express their interest and availability for the WMS Irrigation Sector Review Team visits. Due to interest and/or timeliness, the following five countries were selected for the initial study: Bangladesh, India, Nepal, Pakistan and Thailand.

Prior to the overseas activities the original WMS Review Team conducted an interdisciplinary appraisal of the Welton Mohawk Irrigation Project in Southwestern Arizona as a sort of "strategy and interdisciplinary development warm-up exercise." The original team visited Bangladesh, Nepal and Pakistan between July 4 and August 2, 1980. A second team visited India and Thailand between October 19 and November 22, 1980. The individual country summaries and recommendations developed by the Team from the visits are presented in Appendix A.

The Asian Bureau held an "Agricultural/Rural Development Conference" between January 11 and 16, 1981, in Jakarta, Indonesia, as part of their strategy for developing a comprehensive program for the Region. The conference covered the subject areas of: Agricultural Research, Irrigation and Integrated Rural Development with workshops in each of these areas. Appendix B contains summaries of: the entire conference proceedings and the irrigation group workshop comments and recommendations.

WMS Review Team members Jack Keller and Max K. Lowdermilk (who were on both teams) were asked to prepare review papers for the Jakarta conference. It was requested that these papers describe their impressions, lessons learned and recommendations based on their WMS Review Team activities. Revised versions of the papers they prepared and presented are included herein.

One final paper which is included in this document is "Canal Irrigation Management in India: Some Areas for Action, Analysis and Research" by Robert Chambers. This paper is included because it so nicely pinpoints the three pervasive themes for finding ways to achieve more of the potential of canal irrigation. These are:

first, raising the professional status and satisfaction of those who manage water distribution; second, encouraging all concerned to be more interdisciplinary; and third, field research on what actually happens to water, including who gets what, when, how, why and with what consequences.

GENERAL ASIAN OVERVIEW OF

IRRIGATION DEVELOPMENT OPTIONS AND

INVESTMENT STRATEGIES FOR THE 1980'S

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AN OVERVIEW OF USAID'S IRRIGATION INVESTMENT OPTIONS AND STRATEGIES FOR ASIA[1]

by

Jack Keller[2]

The purpose of this paper is to set the stage for further discussion concerning AID's assistance to the irrigation sector in the Asian Bureau countries during the decade of the 1980's. The options presented herein are based on the reports and recommendations developed by multidisciplinary study teams for Bangladesh, Northwest India, Pakistan and Northeast Thailand. The key recommendations presented in Appendix A were discussed during debriefing sessions with each Mission and to the extent possible reflect their concerns and inputs.

One study team visited Bangladesh and then Pakistan between July 11 and August 2, 1980. Members of this team were:

Jack Keller - Team Leader and Agricultural Engineer
A. Alvin Bishop - Civil and Irrigation Engineer
Max K. Lowdermilk - Water Management Extension Specialist
Howard B. Peterson - Agronomist
Thomas F. Weaver - Agricultural Economist

A second study team visited Thailand and then India between October 19 and November 22, 1980. Members of this team were:

Jack Keller - Team Leader and Civil & Irrigation Engineer
Wayne Clyma - Agricultural Engineer
Matthew Drosdoff - Tropical Soils Scientist
Max K. Lowdermilk - Water Management Extension Specialist
David Seckler - Agricultural Economist

The teams studied numerous documents; had discussions with many host Government and Mission officials and personnel; and inspected a number of irrigation projects (especially at the farm level) in each country.

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[1]Prepared for presentation at USAID/Asia Bureau Agricultural/ Rural Development Conference, January 11-16, 1981, at Jakarta, Indonesia. Revised May 1, 1981. (I am grateful to Wayne Clyma for his thoughtful comments on the initial version of this paper.)

[2]Co-Director of the Water Management Synthesis Project (Contract AID/DSAN-D-0058), Professor and Chairman, Agricultural and Irrigation Engineering Department, Utah State University, Logan, Utah.

Failure of Irrigation Projects

A common failure of most all donor funded irrigation projects is ineffective distribution of water to the individual farmer's fields. The water distribution is often unpredictable and ineffective both in terms of conveyance efficiency and equity. The next common problem is poor distribution to the crops growing on the individual fields. But it makes little sense to concentrate on application before a dependable and equitable water supply is at least reasonably available to the individual fields in the command area.

Irrigation system. The main components of a surface irrigation project which are of primary interest for our purposes are depicted in Figure 1. On larger systems there may be two or three levels of canals such as main, minor and distributaries, which deliver water through the headgates serving each unit command area. Where the water is supplied in whole or in part from wells, the groundwater reservoir serves as the overall distribution system and the wells usually discharge directly into the watercourses serving each unit command area. The individual fields are irrigated from field ditches which in turn are served from turnouts along the watercourses within the unit command areas.

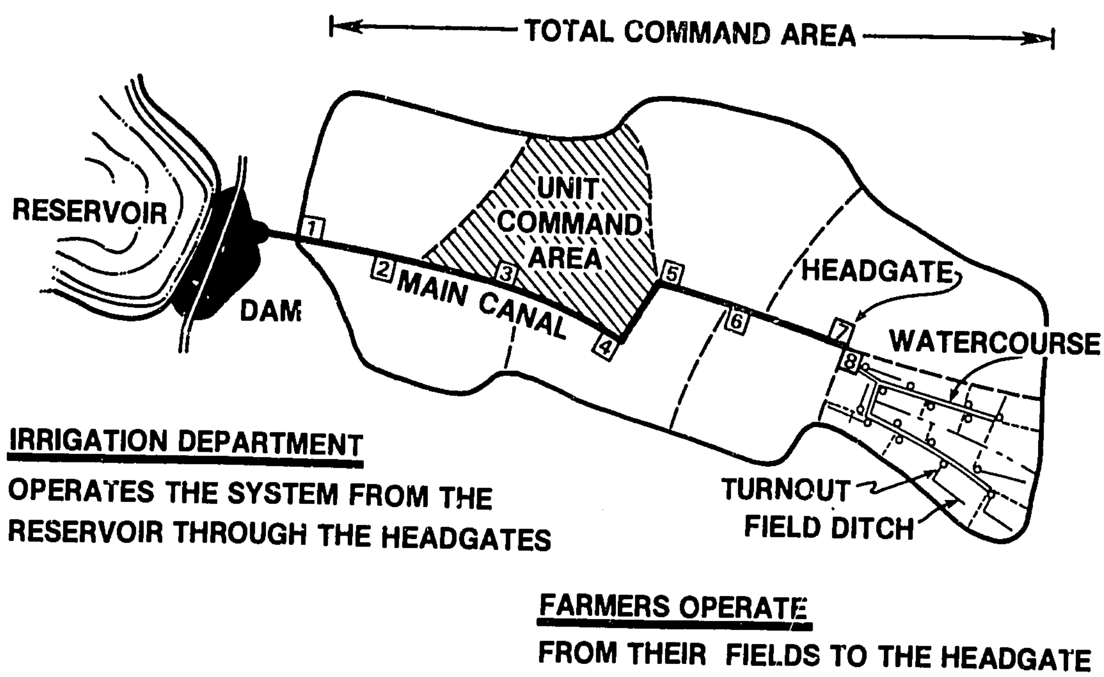

Figure 1. Typical surface irrigation components.

Most often the Irrigation Department operates and maintains the system from the reservoir to deliver water through the headgates; or in the case of wells the Department provides repair services and fuel for the pumping plants. Often the management philosophy is from the top (reservoir) down (through the headgates) with insufficient concern for crop irrigation requirements. Occasionally farmers operate the headgates, but more typically they maintain and operate the system from their fields up to the headgates. Their management focus is obviously from the bottom (crop in the field) up with major concern for crop water requirements.

Optimizing crop production per unit of water or unit of land requires that water be available on demand when needed by the crops and disposed of (through drains) when in excess. Where a demand system is not provided or practical, water deliveries should at least be equitable, reliable and predictable. Where farms are large, such as in the USA (40 ha or more), a single farmer (or at most, two or three farmers) owns and farms all the land in a given unit command area. Thus, a single owner-operator is responsible for maintaining and operating all the irrigation facilities served from a headgate. In fact, a very large individual farm may be served by several headgates, in which case the project canal system is in effect part of the irrigation infrastructure on the farm. When serving large farms, the irrigation, extension and service groups communicate with relatively few farmers. Each farmer in turn operates and manages his or her own land, including consolidating fields, building watercourses and acquiring all needed farm inputs.

In countries such as India where farms are small (typically 1 or 2 ha) it has heretofore been deemed impractical for the project to control and operate canal systems to subdivide and deliver water to each farm. Typically, the unit command areas range from 8 ha to over 100 ha, thus each headgate or well serves a number of farmers. The farmers must work together to manage water deliveries plus maintain the watercourses, turnouts, field roads and drains within their command areas. Often the watercourses with adequate turnouts, field roads and drains are not provided with the project; thus, the farmers must depend on paddy to paddy or field to field flow or organize to finance and construct the needed watercourses for the unit command area.

Hypothetically, so-called "water users associations" made up of the community of farmers holding land within each unit command area are set up. In turn, these associations may be charged with the construction, maintenance, management and operation of their unit command area infrastructure. This is a formidable task which I believe is too often well beyond the current political, financial, managerial, and/or technical capabilities of most communities of farmers. Consequent failures of the water users associations inevitably result in inequitable distribution and inefficient water use.

Membrane concept. In order to better visualize the problem at hand, I like to think of the physical objective of an irrigation project as being to stretch the water like a membrane uniformly over the intended command area. The irrigation project canals, farm watercourses and field ditches form the rigid framework or skeleton needed for extending the membrane over the command area. Unfortunately, the membrane must be pushed out from the source because users cannot pull it out and stretch it across their fields unless the water reaches them. Therefore, an adequate irrigation system and effective management of it are essential to extend, stretch and hold the membrane in place. A uniform membrane over the entire command area represents an efficient and equitable system, as depicted in Figure 2.

If the membrane is not extended, stretched out and held in place, it merely remains in globs at "head-enders" scattered throughout the project, as depicted in Figure 3. Irrigators in these areas usually apply excessive amounts of water, much of which is lost to deep percolation, and this, along with seepage losses from the conveyance and drainage system, enters and fills the groundwater reservoir. Fortunately, in many surface projects the groundwater system acts as a great equalizer -- relaxing tensions in the system and providing each individual field with a potential supply of water. Unfortunately, to utilize this supply requires capital for wells and pumpsets and a continuous supply of costly energy; and these are resources which are in short supply -- especially for small farmers.

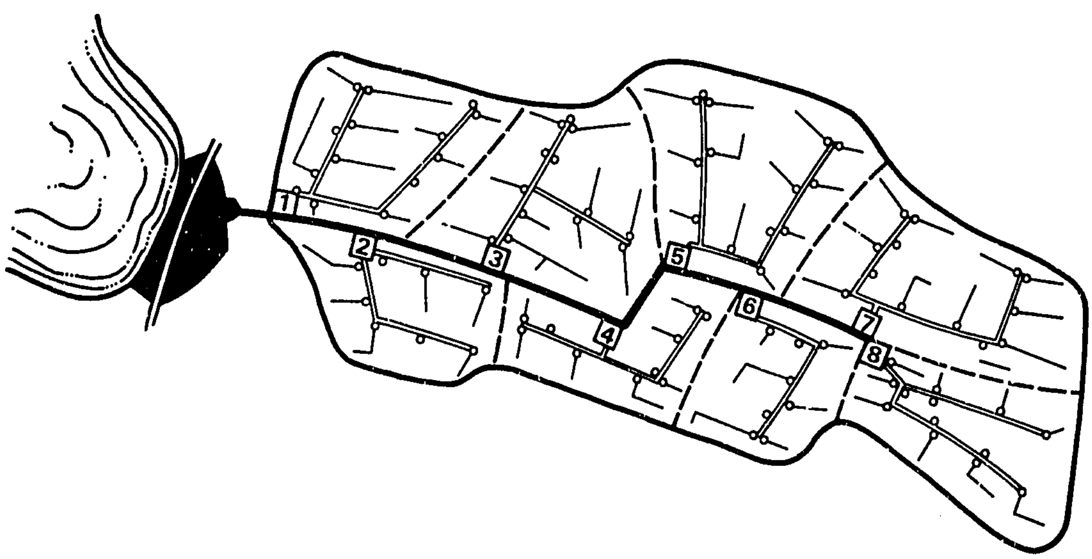

Figure 2. Adequate irrigation system with effective management "stretching" the water like a uniform membrane over the entire command area.

The excess water and seepage from projects on relatively steep topography typically reappears as return flow in lower lying areas. While these return flow waters may eventually be effectively utilized in the lower lying areas, this does not relieve the tension or solve the equity issues in the original project command area.

Various types of distribution problems are depicted in Figure 3. The situation in each of the eight unit command areas which make up the total command area is:

1. This unit has no distribution system and the farmers have control of the headgate so they practice paddy to paddy irrigation continuously taking water and all farms are potentially over-irrigated.

2. This unit has a watercourse, but no field ditches. Being high on the system the farmers get somewhat more than their share of water. Paddy to paddy irrigation is practiced beyond the watercourse turnouts and all farmers get an adequate supply of water, but the farmers closest to the watercourse are over-irrigated.

3. This unit has a watercourse, but no field distribution system. There is sufficient water to adequately irrigate all of the unit command area, however because paddy to paddy

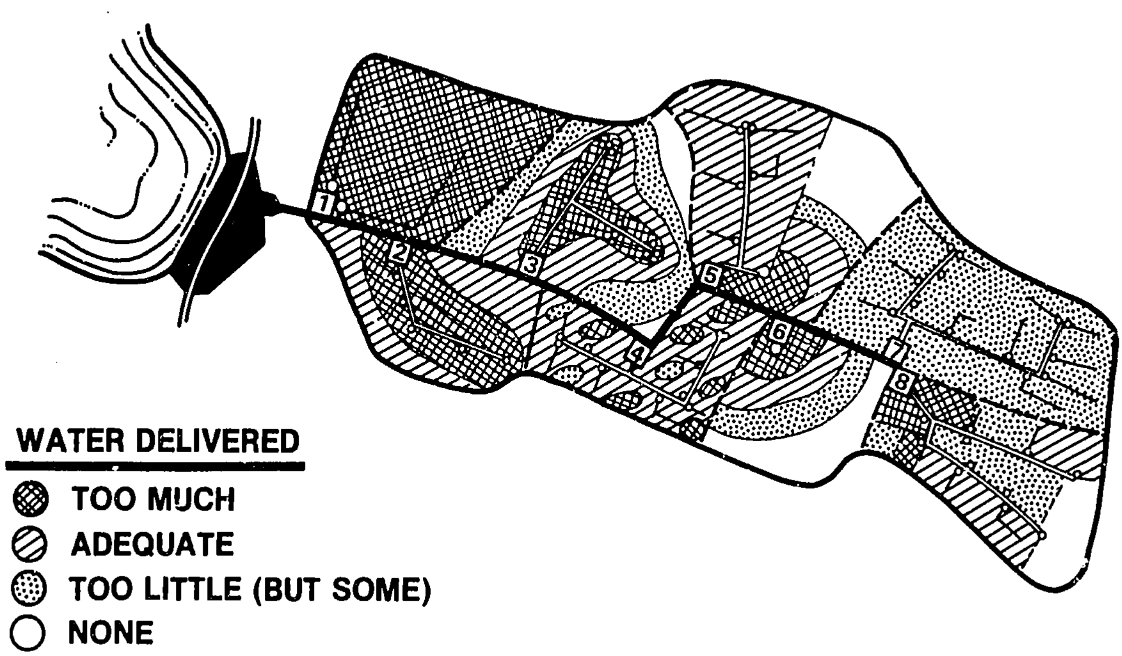

Figure 3. Command area with various types of water distribution problems.

irrigation is practiced, the areas nearest the watercourse are over-irrigated at the expense of insufficient water elsewhere.

4. This unit has an adequate watercourse and field distribution system along with adequate water and equitable management. But the fields are not leveled; therefore, high spots are under-irrigated and low spots over-irrigated.

5. The watercourses on this unit are incomplete and only serve half the unit. Field ditches are used in this half and the farmers have leveled their fields and they are effectively irrigated, but the other half relies on paddy to paddy irrigation and only farms near the turnout receive water.

6. There are no watercourses in this unit and being near the end of the canal system and with no politically powerful farmers it receives less than its share of water. Thus, only a small portion of the area is irrigated with those farms nearest the headgate getting all the available water.

7. This unit which is at the end of the canal system receives less than its share of water, but it has a very effective, well managed distribution system and the farmers have leveled their fields; therefore, all farmers receive a fair share of the water delivered at the headgate and irrigate all of their land. But all fields are inadequately irrigated.

8. This unit has adequate watercourses and field ditches and the farmers who can depend on receiving water have leveled their fields. Furthermore, like Unit 7, the unit receives less than its share of water. However, the few head end, larger, and/or more politically powerful farmers in the community take most of the water, leaving some fields inadequately or non-irrigated.

During our field visits in the various countries we found practically all of the unit command area water distribution problems depicted in Figure 3 as described above. The net result is that for many projects we visited the irrigated land is less than 50 percent of the land that could potentially be irrigated with the available water supply. Obviously, when one considers the very large civil works investments which have already been made in these projects, more attention must be directed toward water management at the farm level. Furthermore, a concept of overall project management from the farmers' fields up through the whole system must also be initiated.

Membrane Tension

Planners design projects with different concepts of the desirable stretch of the farm water supply per unit area of land for a given set of soils and topography plus climatic and crop program conditions. I like to think of this as a measure of the tension designed into the system where:

Tension = function of (design delivery flow rate/unit area, soil, topography, climate, cropping programs)

Using a reference crop and local weather data, an estimate can be made of the basic flow rate per unit area which is needed to satisfy peak crop water requirements (after accounting for rain and soil water storage) assuming 100 percent on-farm irrigation conveyance and application efficiency. Dividing the "design flow rate per unit area" by this "basic flow rate per unit area" gives a ratio which I refer to as project water density. (This ratio has also been referred to as the relative water supply.) A density of 1.0 means that farmers could produce optimum crop yields per unit of area only if they achieved 100 percent on-farm efficiency.

Most field crops will produce about 90 percent of potential yield when only supplied with about 75 percent of peak water requirements. For individual irrigations where water is in short supply, resulting in significant under-irrigation, the highest practically attainable on-farm irrigation conveyance and application efficiencies with adequate systems and good management, are in the neighborhood of 75 percent. (Here, water application efficiency is defined as the ratio of the quantity of water effectively put into the crop root zone and utilized by growing crops to the quantity delivered to the unit command area, the efficiency being expressed as a percentage.) Therefore, a reliable project water delivery density in the neighborhood of 1.0 can give optimum production per unit of water while still enticing farmers to use high yielding varieties and the needed inputs for high yields.

A system with a water density of 1.0 is a high tension system and usually if the design density is below 1.0 the farmers will elect to irrigate less than all the land under the command. For example, with a density of 0.5, farmers will elect to irrigate only about 50 percent of their land at a given time, providing the system is very efficient (or perhaps only 25 percent if their systems are very inefficient due to soils and topography). In either case, farmers with more water could produce more from their individual holdings. It is not too difficult to visualize the very high tensions, and thus the quality of the water delivery system and managemet discipline needed to achieve equitable distribution when providing each farmer with only enough water to irrigate 50 percent of his or her land.

It is my opinion the farmers served by a high tension system which provides reliable water deliveries will strive to efficiently irrigate their lands. However, they normally need technical assistance for on-farm water management plus credit for land leveling and constructing field channels. On the other hand, farmers served by low tension systems (2.0 density) will tend to rely on inefficient practices.

Planned tension. We found a great deal of variation in the level of tension which planners in the various countries were designing into the systems. The level of tension selected appears to be a product of the physical, social and political environment.

In India and Pakistan high tension systems are common. For example, a river run project we visited in the state of Haryana in India provided 1 cfs every other week to 400 acres (1 cfs continuous flow for 800 acres) during the rabi wheat season. This gives a water density of about one-third; and as expected, only about one-third of the command was irrigated during rabi. The project had lined watercourses and effective delivery management using the warabundi system (rotational delivery). Thus, as might be expected, there was a high degree of equity and farmers had done a commendable job of leveling their land for efficient irrigation.

Planning in Bangladesh and Thailand is for low tension systems. For example, in the Northeast Small Scale Irrigation Project in Thailand the project water delivery density is 1.7. This will allow farmers to meet peak water demands of all crops while maintaining an irrigation efficiency of 60 percent.

With densities over 2.0 there may be little trouble with equity within the project command providing the water conveyance system in the unit command area is sufficient and reliable and fields have been reasonably well leveled and there is at least some management input. What happens in high tension systems without adequate management is that the "head-enders" opt for low tension (plenty of water) and the "tail-enders" get no water at all.

I would suggest that a density function of less than 1.0 for single cropping programs, or 0.5 for double cropping programs, be reviewed with caution. This is because the economic and management costs of such projects too often exceed potential benefits, even when taking into account theoretical and political equity issues. In fact, water densities of 1.2 (and 0.6) would appear more appropriate. Even here, caution is needed in considering density on an average seasonal vs. a peak use period basis after allowing for conjunctive use possibilities.

Structure of Irrigation Projects

All irrigation projects (other than hand pumps) serving farmers with small individual holdings should have well managed and adequate farm distribution and field application systems. This is essential in order to have high water use efficiencies and equitable distribution of water within the command area. Gravity projects and lift projects of over a few hundred hectares must also have reliable and well managed main distribution systems. Small lift and well projects must have reliable pump sets including a maintenance program for them plus availability of fuel for power. In any event, the first order of business is to have a reliable, predictable and equitable water supply delivered to each farm watercourse in the command area.

In government projects, the main distribution systems down to the farm turnouts and/or the pumpsets are managed by some project authority. The question arises as to what is the largest unit command area that can be adequately served from each project controlled turnout or pumpset. This is because the project costs appear to be less where larger turnouts are used since the group of farmers are expected to cooperate in getting the water to their individual fields. This would be true if efficiency and equity were achieved; but in most cases, where the unit command areas have many farmers and the on-farm distribution system is the responsibility of the farmers, the area actually irrigated is much smaller than project goals. Thus, project costs per unit area actually served may be higher than where smaller unit command areas are used and more of the distribution system is the responsibility of the project.

In general, the larger the group of farmers who must cooperate below the project turnout or pumpset, the more difficult will be the job of achieving equitable and efficient distribution of irrigation water. Furthermore, the lower the anticipated project water delivery density, the greater the physical facilities per unit area irrigated and more rigid the management system must be.

Studies of traditional small scale irrigation systems which have been community developed and operated and recent development work with participatory management by water users are encouraging. It appears that with sufficient assistance and guidelines that rather large groups of farmers can take on the responsibility of organizing and managing rather large unit command areas or even groups of command areas.

Project formulation. Projects can be formulated by endless combinations of the following:

- Water delivery density
- Capital (invested and for maintenance)

- Management (irrigation department, extension, water users associations and individual farmers)
- Laborer (farmers)
- Energy

The assemblage and expected output from any given project formulation is dependent on the distribution and social circumstances and the degree of cooperation which can be expected between agencies and farmers.

An important paradox is that low density projects which are usually designed to maximize output and equity in terms of numbers of individual farmers served are expensive per unit of irrigated area. This is because the high tension inherent in such projects necessitates intensive as well as extensive distribution systems, and strong project management all the way from the individual farms to the water source.

To be effective on larger projects, the management authority for the total command area must have control over the main system and either controls or cooperates closely with the farmer management of the unit command area distribution systems. Furthermore, the management philosophy and understanding must be able to visualize the project from the bottom (crop water needs) up, as well as from the top (water supply) down. In addition, many other inputs such as extension advice, high yielding seed, fertilizer and credit, to name a few, must be provided, along with timely applications of water to reap the essential crop production benefits for success.

A total command area management concept requires both a new way of thinking and of training. This is necessary to establish dedicated cadres of operating and management personnel who know how to maintain, monitor and control irrigation systems to optimize crop production while providing equitable inputs and assistance to the farmers.

Other inputs. As a single input, even good irrigation may give disappointing results. The basic problem is illustrated in Figure 4. With wet season supplemental irrigation in Northeast Thailand, but no additional inputs such as high yielding seeds, fertilizers, extension services, etc., ("other inputs"), the increase in rice yield may only be from the present level of 200-300 kg/rai to 300-400 kg/rai or about 100 kg per rai (6.25 rai = 1.0 ha). On the other hand, with no irrigation but with the "other inputs" the yield may increase from zero to 200 kg/rai or an average of 100 kg/rai as well. It is only when both irrigation and other inputs are applied intensively that yields may be expected to increase to the 400-800 kg/rai level (2.5 to 5.0 ton/ha) which is necessary to justify projects in economic terms.

The problem is that improvements of existing irrigation facilities is very expensive, while increasing the use of in "other inputs" requires very little intensive management effort and organization at least over the short run while the farmers are learning by doing.

The cost of improved irrigation, including distribution systems, land consolidation, leveling, ditches, drains and access roads is now running from $1250 to $2500 per ha in Northwest Thailand. If yields increase by only 100 kg/rai, or roughly $100 per ha in the wet season, the present value of the benefits (at a 10 percent discount over 30 years) is only about $875 per ha. Thus, the benefit cost ratio of wet season irrigation activity is only about 0.5. These figures are, of course, only rough estimates, which may vary from place to place and are subject to further refinement, but the essential message is the same.

Without the basic irrigation input, as shown in Figure 4, an area such as Northeast Thailand will inevitably be tied to a low level of production, even with intensive application of other inputs. The only reasonable conclusion is that an appropriate organizational and management structure must be created to assure intensive utilization of both irrigation and other inputs.

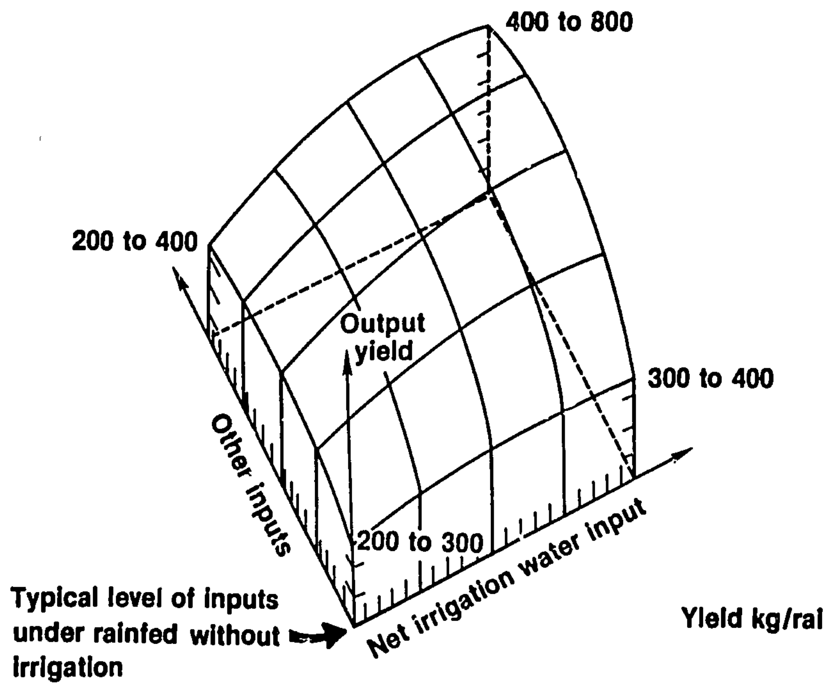

Figure 4. Illustrative rice yield surface (based on farmer interviews and literature) for paddy production on Roi-Et soils during the wet season in Northeast Thailand.

Common Recommendations

An individual "Irrigation Development Options and Investment Strategies for the 1980's" report was written for each of the four countries visited. Each of these reports contain a Summary and Recommendation section, and in addition to the above comments, the following recommendations were generally applicable.

1. If AID stays involved in irrigation projects it should organize and hire more technical staff or consultants so that a consistent systematic program can be developed and carried out.

2. AID should insist that a monitoring system be built into each project it sponsors (and in some cases, even if there is no project).

3. AID should insist that (in its sponsored projects) success in irrigation projects be measured in units of agricultural production output gains.

4. AID sponsored projects should either make the farmer management units as small as practical with the ideal being delivery of water to each individual farm or provide sufficient assistance to farmer organizations to ensure the level of farmer participation in system management necessary for timely and equitable water deliveries to each farm unit.

5. AID should sponsor projects using new and innovative appropriate technologies such as pipe where applicable.

6. In developing projects, AID must be cognizant of the fact that in almost all cases the Ministry in charge of building and managing irrigation systems is not the Agricultural Ministry. Thus, special efforts are needed to develop a comprehensive approach to managing irrigation systems to efficiently and equitably serve farm needs plus bring together the other necessary inputs required to justify the high expense of irrigated agriculture. This suggests that AID develop and sponsor model command area development and management systems.

7. AID should assist countries in identification and qualification of water resources.

8. AID should assist in developing methodologies and training for system diagnostics, monitoring and design. In this regard, AID should greatly increase its emphasis on training at various levels. This suggests that AID should organize

and sponsor in-service training programs. These should be set up to develop the ability to continue with in-country training programs.

9. The role of women and the potential for developing kitchen gardens should be considered on all AID sponsored projects.

10. Pre-project and post-project diagnostic and/or evaluation studies should be conducted on all AID sponsored projects.

11. AID should avoid sponsoring pump irrigation unless the project can be assured of a long range firm power supply. In this regard, AID should assist in developing energy resources (especially electrification) where the power is to be used for irrigation pumping.

IRRIGATION ISSUES AND INVESTMENT STRATEGIES FOR THE 1980'S[1]

by

Max K. Lowdermilk[2]

The purpose of this presentation is to provide a general overview of the reports developed by the Asia Bureau Team visits to five countries. (See Tables 1 and 2 and Appendix A for Summaries and Recommendations of the Country Reports on India, Bangladesh, Pakistan, and Thailand.) I had the opportunity of being a member of both study teams.

Background of the Asian Bureau Study Tours

The purpose of the study tours was to define and make possible a long term endorsement of the Asia's Bureaus Irrigation Program. The Bureau requested the Water Management Synthesis Project of CID to put together a team of experts to assess irrigation issues and strategies for the 1980's. The Bureau, with a long record of involvement in Asian irrigation, is aware of present development and the magnitude of the task ahead. For example, to take one country (India) alone, there are estimated annual investments of about $3 billion in irrigation developments. India has projected plans to double her present irrigated acreage of about 53 million hectares by the year 2000. This is an extension of about 2.5 million hectares per year plus improvements of existing systems. Likewise Pakistan, Thailand, Philippines, Indonesia, Bangladesh and Sri Lanka are also deeply involved in costly long-term irrigation developments.

The purpose of the team visits was to engage Missions and host country officials in a serious dialogue to ascertain priority issues and strategies and to determine what role AID might play in future developments.

Twenty-four man-months were utilized by the teams in preparations, review of documents, visits and conversations with officials, project managers, and observations and discussions with farmers and those who work with farmers directly. Prior to the visits, Dr. Gilbert Levine prepared a general discussion paper of

[1]Prepared for presentation at USAID/Asia Bureau Agricultural/Rural Development Conference, January 11-16, 1981, at Jakarta, Indonesia.

[2] Water Management Advisor, ASIA/TR/ARD, Washington, D.C.

Table 1. Overview of Emphasis and Needs in Irrigation Development by Project Type and Size in Selected Asian Countries Visited by the WMS Study Teams in 1980.

PROJECTS	INDIA	PAKISTAN	BANGLADESH	NEPAL	THAILAND
New[1]					
• Large					
• Medium	x				x
• Small	x	x	x		x
• Very small	x		x	x	
REHABILITATION[1]					
• Large	x	x			
• Medium	x		x		x
• Small			x	x	x
GROUNDWATER[2]					
• Large	x	x	x		
• Small	x	x	x		
LIFT PUMP[3]					
• Large	x	x	x		x
• Small	x	x	x		x

[1]Project Size: Very small, up to 100 ha; small, 100-1,000 ha; medium, 1,000-10,000 ha; and large, over 10,000 ha. (The above values were used herein, however, project size is relative to different criteria in each country situation.)

[2]Groundwater: Small wells, less than 40 lps (1.4 c/s or 600 gpm) and large wells, over 40 lps.

[3]Lift Pump: Small pumping plant, less than 120 lps; and large plant, over 120 lps.

Table 2. Overview of Emphasis and Needs in Irrigation Development in Selected Asian Countries visited by the WMS Study Team in 1980.

EMPHASIS/NEEDS	INDIA	PAKISTAN	BANGLADESH	NEPAL	THAILAND
RESEARCH PROJECTS					
•Soils				x	x
•Crops				x	x
•Diagnostic analysis	x	x	x	x	x
•Technology testing	x	x	x	x	x
SOFTWARE					
•Formal training			x	x	x
•Hands-on training	x	x	x	x	x
•Information systems	x	x	x		x
•Operation-maintenance	x	x	x		x
•Monitoring/evaluation	x	x	x	x	x
•Organizational improvements	x	x	x		x
•Water user assocs.	x	x	x		x
•Water laws-codes	x	x	x		x
•Water mgmt advisory services		x	x		x
SUPPORT ACTIVITIES					
•Electricity	x	x	x	x	
•Fuel					
•Credit	x	x	x	x	x
•Extension	x	x	x	x	x
•Roads				x	x

potential issues and strategies to help Mission staff begin a dialogue prior to the team visits. (Levine's paper "Irrigation Development and Strategy Issues for the Asian Region" follows this paper.) All Mission staff involved were well prepared for the visits and facilitated our work in an outstanding manner.

Positive Aspects of the Team Visits

First, as already suggested, Mission personnel involved were candid, open, and cooperative in all meetings. The visits were well-planned and the staff involved had done their homework, a part of which was to bury the team in essential reports and documents which we reviewed. A special vote of thanks goes to Gerrit Argento and others in the Bureau for careful planning which made these study tours possible. Key contacts with officials and field units were well thought out. Each Mission also gave use additional work assignments to review special projects and documents in order to have the teams evaluations. This indicates a well-known need that Missions desire more assistance in this complex area of identifying, developing, and managing irrigation projects.

Secondly, we were impressed with both the frankness and openness of host country officials in the articulation of their needs, and to strengths and limitations of existing programs. Some of the Mission staff, as well as the teams, were surprised at the degree of candidness exhibited. It was the impression of the team that the visits opened up new areas for Mission staff and helped to establish better linkages and communications between Missions and host country officials and their needs. Our focus was on priority issues, strategies and potential roles perceived for AID's involvement within the context of long-range country plans.

Thirdly, team members gained much from the team visits and identified both technologies and strategies in most countries which may have transfer value to other countries in the region. As teams we evolved a process and procedures for quick and clean reconnaissance which can be effectively used by the Bureau in areas other than irrigation. It is our perception that an experienced team following a systematic process and procedures can yield useful and timely information which in some cases is more valuable than "long and complex research methods" which often seem to simply generate more research.

Fourthly, we identified from the experience and expertise in countries of the region many technologies, organizational procedures, and methods which have transfer value across all the countries of Asia. This raises a real issue and a definite need. Far too many countries know more about irrigation developments in Utah and

Colorado than in their neighboring countries. Is there some transfer of irrigation knowledge mechanism which could be developed in the region? I recall AID's involvement in the 1950's and until 1970 in the Irrigation Practices Workshops for South Asia and the Middle East. Let me provide only a few examples of technologies which have or can be transferred at low cost that were identified on these field visits:

1. The AID Irrigation Project in Pakistan has evolved new approaches to water management improvement which have influenced the World Bank, FAO, ASIAN Development Bank, developments in Egypt, Sri Lanka and many other countries. This was possible because AID had the wisdom to build into the Pakistan project a mechanism which motivated a university to devise ways and means to diffuse lessons learned around the world. The Water Management Synthesis Project is also another AID mechanism developed by Dr. Gill Corey to achieve this important end. Lessons learned in Pakistan have even been extended to Colorado State University where new courses are now taught to future foreign and domestic irrigation developers which grew out of the Pakistan experience. The diffusion process as a result of AID's vision in these two projects continues.

2. The Command Area Development Authority concept of India is being investigated by Thailand because our team served as a temporary knowledge transfer mechanism. In India they have experimented with the reduction in size of command areas down to 40 and 8 hectare units both to provide more water control, reliability of deliveries, and as a means to get more face to face cooperation between farmers. In India they also have experience with buried pipelines for conveyance systems which have many advantages. Also the GOI is considering the separation of design and construction from operation and maintenance in the Irrigation Departments. They intend to develop training in water management and a new organization structure where agronomists, agricultural engineers, economists and rural social scientists can have prestige and rewards for involvement in this new field. This is indeed far-reaching, as is the planned establishment of a national training and research center for water management.

3. In Thailand we found a far-reaching water code which delineates the structure and the role of formal water user organizations. This experience is greatly needed in Pakistan where possibly the weakest component of AID's project is the lack of formal Water User Associations for the maintenance of improved systems.

4. Another innovation in Northern India is the 100 year old <u>warabundi</u> dictability and discipline in on-farm deliveries of water.

5. A new concept has been evolved in India in the marginal hill track areas above the canal command system to provide watershed management, reduction of soil erosion, protective irrigation for small holders, dependable domestic and animal water supplies. When the proper technologies are combined with a workable management mode this approach provides an engine for rural development and also meets most of the new emphasis of AID in a unique new way. If this system can be made to work, it has application in all countries of Asia which could impact millions of farm families as well as the conservation of soil and water resources.

6. Finally, small pump technologies being developed in Bangladesh may have significant transfer value to other countries.

This is only a small sample of technologies and innovative procedures which the team identified. We were indeed a knowledge transfer mechanism but temporary. Is it possible to design innovative transfer mechanisms into new projects, develop ways and means where program officers and selected host country irrigation leaders can formally transfer ideas and experience?

Irrigation Role's in the Agriculture/ Rural Development Sectors

First, there is the clear realization that appropriate irrigation development can play a major role in accelerated food and fiber production, provide stability of production, create increased labor productivity, help general rural employment, and provide a means for improved income growth and distribution. In all successful irrigation projects client participation is a must if system improvements at the farm level are to be operated and maintained adequately.

The separation of agriculture and rural development may be useful to some but it is basically false. Improved irrigated agriculture should be viewed as an engine for broad based rural development. In the future all new irrigation projects must be evaluated in terms of increased production, income, employment generation, accelerated rural development, labor productivity, and resource conservation instead of the criteria so often used in the past.

The legs of a reliable irrigation stool are stable production increases, widely distributed income-employment generation, and greatly increased labor productivity. In order to achieve these interdependent and complementary goals, irrigation systems must be improved to be more efficient and deliver more relaible water supplies at the farm level. The farm level is the only productive unit of irrigation systems designed for agriculture. Unless there is improved water control for the end users we can hardly expect that the irrigation behavior of farmers will change significantly to achieve increased production.

Furthermore, each country and often different areas of a country have their own priorities in irrigation improvements. A recurring set of themes, however, have emerged from the team reconnaissance studies. These relate very directly to some of AID's past experience available expertise, and major thrusts in helping countries improve small, medium, and large commercial production possibilities. The themes lead to needs which fall under some form of software or human and institution building as follows:

1. The need for a more comprehensive understanding of the meaning of water management. The term is often misunderstood and has almost become a dangerous fad because many international agencies are now willing to invest in water management improvement projects. Water management is the process by which water is manipulated and used in the production of food and fiber. This includes the management of water in rainfed areas as well as water artificially provided for perennial irrigated areas. Water management is not water resources development, building dams and reservoirs to capture water, canals to convey water, codes, laws and institutions to allocate water, farmers organizations, or soils or cropping systems, but the way these skills and physical, biological, chemical and social resources are utilized to provide water for improved food and fiber production.

   There is, however, ferment and change in the minds and the approaches of engineers, agronomists, economists, and behavioral scientists about water. Nevertheless, it takes time to re-educate those who for too long have regarded water as simply a civil engineering domain. As Dr. Gilbert Levine has well stated in his paper which follows, in almost any country there are these rough overlapping stages in irrigation development. First, engineers are trained to capture and convey water, therefore the focus is on design and construction. Secondly, when problems of water logging, salinity and negative externalities emerge there is concern for soil-plant-water relationships which brings agronomists and economists on the scene. Thirdly, as population demands build-up new projects cannot be easily developed, there is an emphasis on improving the operation and management at the farm-level which by the nature of the complex system requires a systematic team effort rather than a single disciplinary focus. Several countries are at stage two, some are between stages two and three. Some are just entering stage three but all need, as we do in the United States, to focus more on efficient and effective management of the total system from the farm up.

The new approach of farm water management has been emphasised by AID in Pakistan; the theories developed there have spread to Egypt, India, Sri Lanka and now are being considered in other countries of the region. Lessons learned, however, in all these countries need to be synthesized, described and made available to all countries.

2. Given the demands for water management in all countries visited, there is now an awareness of the need to retrain old personnel and train new personnel required through hands-on methods to prepare the large cadres of workers necessary to achieve program goals. AID has helped to evolve a Research-Development Training approach in Pakistan and Egypt which prepares people to diagnose and understand irrigation systems and their priority problems; develop solutions through action and adaptive research; assess these solutions; and implement improvement projects. This systematic approach is being tested in India where the AID Water Management Synthesis Project will demonstrate the process in a proto-type training program in February-March of 1981. This is important because in most countries of the region the majority of professionals still do not know how their irrigation systems work and why farmers behave as they do in the face of existing constraints.

3. In all countries visited, it was evident that there is a need for trained staff who can test and refine technologies and procedures to provide farmers more water control and other improved production possibilities. Even today in Pakistan, after the AID project was completed, there is still not sufficient institutional capability to provide a steady stream of tested and refined production possibilities to support a long range program of irrigation development.

4. There is a need in all countries for improved operation and maintenance of the systems. Operation and maintenance have for too long been overshadowed by design and construction which are still considered more prestigious and more prosperous for the engineers. There is, however, ferment and some countries are considering providing a career structure and incentives to those involved in systems operation and maintenance.

5. In all countries, there is a need for improved monitoring and evaluation of irrigation projects and systems. In this area both the capabilities of AID Missions and host countries are weak. The present structure and mode of AID's field operation is such that technical staff are not available in the Missions to adequately monitor and appraise projects on a continual basis. It is our contention that irrigation projects are complex and those who manage them must understand these complexities. Unlike

credit and fertilizer projects which may be managed from an office in the capital city by a general program officer, irrigation projects require field supervision and regular monitoring to make them effective.

6. In all countries, there is a need to develop better coordinated infrastructure support systems for irrigation improvements. If credit facilities, physical inputs such as fertilizer and insecticides, and extension services as well as markets are not made available for farmers, the extra water from irrigation system improvements may simply be wasted. Everywhere, when more water and increased water control are achieved, farmers are ready to take greater risks in using other inputs and services.

7. The downfall of most systems observed is the lack of functioning water user groups where farmers participate in the operation and continued maintenance of the system. As has often been stated, large investments can improve farm systems but farmers must finally operate and maintain them. We have a long way to go in this area and today there are only a handful of social scientists, trained to tackle this problem. In all of India, for example, where roughly $3 billion a year is being invested, I know of no behavioral scientist who is working full-time in this crucial area. We know of only three U.S.A. land grant universities where efforts are made to train irrigation study teams in an inter-disciplinary mode.

Finally, in AID we must realize that irrigation development requires team efforts and a management approach because it is complex in nature. This process is long term and it requires that projects be well prepared, sequenced and integrated into an irrigation development program. Unless we as an agency are prepared to meet these demands then perhaps we should not be involved in fragmented or short-term patchwork projects which will not have much impact or pay-offs for farmers. If AID is to continue to be involved, then we must evolve the modalities to effectively impact irrigation thinking and actions from the top levels of governments to the farm level. I happen to believe that AID's past record has resulted in significant advances in irrigated agriculture. I also believe that given our present emphasis and our linkages with expertise of institutions in the U.S.A., we can have a tremendous impact in the 1980's. Many of us have lofty goals and perhaps with our host country colleagues we can one day proudly reach past Levine's stage three.

Some Strategy Questions to Address in the Work Group on Irrigation

Following are several broad questions for the Irrigation Work Group, others will surely be added which are just as significant. (The first three are provided by Tom Arndt.)

1. Should the Asia Bureau continue to give high priority to irrigation development in the 1980's?

2. Given AID's resources and the irrigated agricultural situation in respective AID countries, what are the particular emphases or priorities which AID could support?

3. What operational steps in terms of staff, outside support back-up, training, etc. are needed to improve irrigation assistance and effectively implement irrigation programs? (Relate this to existing workloads of Mission staff, hiring of new AID staff, orientation of program officers to manage irrigation projects, work activities of staff in field monitoring of project, use of intermediaries, etc.)

4. In light of AID's linkages with resources such as universities, international research centers, other AID assisted institutions and the mandates of AID, what are those specific types of projects and key strategies where AID can likely make the greatest impacts in the 1980's?

5. Given the recent findings of the Bureau irrigation team visits, what are the strategies within and across countries which should be considered?

6. If strategies are agreed upon, how can these be properly integrated and sequenced in, how can we utilize staff effectively and create a long-term irrigation development program?

7. What are the most effective means to assure that lessons derived in project development can be transferred more adequately within the Asian region and outside the region?

   a. Regional and/or International Institutes for water management research and training (raised in India).

   b. Regional workshops, tours, information networks, etc.

8. Within the context of Asia, how can we provide documentation from empirical field data on the role of women in irrigation development and the impact of these projects on women?

9. Where and to what degree should AID be open to joint efforts and close collaboration with other international agencies involved in irrigation development such as: World Bank, Asian Development Bank, FAO, and CIDO?

Conclusion

My conclusion to this thematic overview is summed up in a few key words: Challenge, ferment, complexities, change and drama. AID has a good reputation in irrigation improvements which focus on the farm. The challenge fits AID's New Directions Mandata and builds on solid past experience. With an adequate utilization of our scarce resources we can utilize the present ferment and changing attitudes to help many countries begin to solve one of their most complex problems, how to improve irrigated agriculture's output. While once there was much drama in building great dams and structures, the real drama, today, is impacting those small farmers in the system where families' livelihoods depend on improved production possibilities in order that they may achieve and maintain higher living standards.

IRRIGATION DEVELOPMENT AND STRATEGY ISSUES FOR THE ASIAN REGION[1]

by

Gilbert Levine[2]

Irrigation development is considered to be major, and perhaps the primary mechanism for agricultural and rural development in Asia in the forthcoming decade. In reflection of this view, the governments in the region are making massive investments in irrigation and related work; they are planning even greater ones in the future. These governments are being assisted in their development efforts by many international leaders and donors, including USAID. Actual investment estimates are difficult to arrive at, but world-wide irrigation and related water investments are estimated to be $1 billion with a significant percentage to be in the Asian region. Within the past few months alone, announcements of irrigation loans to the Philippines and Indonesia represent projects approximating $2 million in each country.

It is anticipated that the USAID component in the region will be on the order of $2 million per year. This is a significant proportion of the anticipated investment, but still relatively small by comparison to the total. Thus, maximum effectiveness of the USAID inputs can occur only if there is a clear understanding of the choices available for development direction and of the options available for implementing the development decisions.

To a major extent, the decisions about development direction are the responsibility of the governments in each of the countries in the region, though inevitably the international funding community influences these decisions. The decisions about the most effective ways to use USAID resources to assist the national government must reflect, however, USAID mandates and experience.

This paper exploring the development and strategy issues is the first stage of a process by which, it is hoped, a set of irrigation investment strategies will be developed by USAID which derive from the considered judgment of those knowledgeable in the field and from a careful review of USAID experience with projects in the region.

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[1]Paper prepared as a point of departure for the WMS Asian Bureau Irrigation Investment Options and Strategies Study Team, May 1980 - Revised April 1982.

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To illustrate the issues most clearly, they will be presented herein in sharper contrast than they actually exist. It is anticipated that the strategies that ultimately result from these deliberations necessarily will be more flexible to accommodate the specific circumstances in each country. In addition, the issues will be categorized separately, but it is obvious that they overlap and interrelate. Nevertheless, we hope this combination of emphasis and sharpness will make the clarificati..' of choices easier.

This exposition of development and investment strategies is intended only to open the discussion about AID's future directions in investment in irrigation in Asia. This paper provides not answers, nor suggestions for what is appropriate. It is anticipated that the forthcoming field visits, coupled with the subsequent discussions with USAID field staff and other professionals and academics will refine and amplify the choices, and ultimately will result in a statement of policy.

Development Issues

Two broad sets of issues are considered, those relating to the development emphasis and those that explore possibilities for USAID strategy. Five issues are identified in each category and each will be discussed separately. The development issues are: (a) irrigation vs. rainfed; (b) wet season vs. year-round; (c) expansion vs. intensification; (d) large projects vs. small; and (e) government vs. private.

Irrigation vs. rainfed. While the underlying assumption of this entire effort is that massive irrigation development is and will take place, the implications of this emphasis should be recognized. This is especially true given the USAID primary objective: to increase production in ways that improve the welfare of small farmers and the landless. In general, where the major objective is agricultural production and where there is a significant problem of water deficiency, there are two basic, not mutually exclusive, development alternatives: to maximize the utilization of natural rainfall; or to irrigate. Where significant sources of water exist, either as surface or subsurface supplies, there tends to be a strong emphasis on irrigation development.

The arguments in favor of this approach start with the conclusion that a reasonable water environment is essential for increases in agricultural production. It is assumed to follow, and there are studies to support this, that irrigation is the best way to obtain this improved environment. The argument is buttressed by the early emphasis in the major international research centers dealing with rice and wheat on technologies appropriate for irrigated conditions. It is further held that irrigation development can result in more rapid productivity increases, both because public investments can be made efficiently and will provide the incentive to "risk-avoiding" farmers to adopt new technologies and to make the investments that make the new technologies productive.

The case for irrigation is strengthened by the argument that with limited technical and extension manpower, a focus on the more limited areas served by irrigation facilities would have a greater and more rapid effect than a more dispersed program.

The arguments for more consideration of the potentials of greater use of natural rainfall tend to center on the issues of equity - the greater sharing of investment resources among the rural population, especially those who are relatively disadvantaged. For example, in Table 1 the income status of irrigated farms vs. resettlement farms in Nam Pong indicate that the farmers in the irrigated areas are better off than the farmers in the resettlement areas. These latter farmers were forced to give up their land to provide water for the farmers downstream and are growing progressively poorer while the farmers in the irrigated areas are becoming richer. Similar examples can be cited in the Mada area of Malaysia, the UPRIS area in the Philippines, as well as others.

Along with the equity consideration is the question of relative economics. It is argued that the marginal returns from investment in

Table 1. Income Status of Irrigation Farms vs. Resettlement Farms in Nam Pong.

Type of Farm	Paddy Yields (Ton/ha)	Gross Income from Crops (Baht)	Annual Household Expenditure (Baht)
Irrigated	2.27	14,342	8,318
Resettlement	1.00	7,383	8,255

Source: Suetrong, Supachi, et al., 1979. Socio-Economic Studies, Bangkok. Nam Pong Environmental Management Research Project, Working Document Number 9. As cited in Johnson, S.H. 1979. Major Policy Issues in the Development of Irrigation in Thailand. Paper presented at the Annual Conference of the Agricultural Economic Society of Thailand.

improvements in on-farm rainfall utilization are higher than those actually achieved by many irrigation projects (in contrast to theoretical achievements). Additionally, it is held that the shifting of emphasis at the International Centers, from the environmentally favored production situations to the less-favored circumstances, will result in significant increases in productivity potential under these rainfed situations. Some of the results from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and from the International Rice Research Institute (IRRI) are examples. In the latter institution, the development of very short-season rice varieties increases the probablity of being able to produce high yields with modest improvements in on-farm rainfall management.

In addition to the major arguments in favor of more balanced evaluation of the merits of rainfall utilization (if not a bias toward it) the potentially adverse impacts on the natural environment and upon human health development are raised. Schistosomiasis is endemic in many parts of the region, often at critical levels; other internal parasites, such as hookworm have been found to increase with irrigation, particularly irrigation of the perennial type.

Wet season vs. year round irrigation. Two broad types of irrigation capability can be categorized: irrigation to supplement natural rainfall and irrigation to provide essentially all of the crop water needs. Each has its relative advantages and disadvantages.

Historically in much of Asia the early systems developed in proximity to flowing streams and other relatively easily developable water resources and require little more than simple diversion structures, usually of a temporary character. Over time, conveyance and distribution channels were added to irrigate areas further from the water source. With larger areas and more people served, maintenance of the diversion structures became easier, though interest in more permanent structures generally increased. With more investment and more organization the systems became an integral part of much of the agricultural production activity. Under population and other economic pressures the command areas of many of these systems has increased to the point where the normal variation in river flows and in the natural rainfall prevents adequate supplemental irrigation and significant year-to-year variation in production results. The data from North and Northeast Thailand presented in Table 2 illustrate this pattern. Systems of this type usually have very little capability for dry season irrigation (often less than 10 percent of the nominal command area).

In much of the region to provide full year-round irrigation capability it is necessary to provide significant storage capacity or access to an appropriate groundwater reservoir.

Table 2. Paddy Rice Production - North and Northeast Thailand (Thousand Metric Tons).

Crop Year	Wet	Dry	Wet	Dry
1968/1969	2587	63	3190	2
1969/1970	3840	-	4580	-
1970/1971	4070	-	4920	-
1971/1972	3557	-	5434	-
1972/1973	2665	45	4189	9
1973/1974	3898	85	4610	24
1974/1975	3780	92	3773	22
1975/1976	4125	197	5321	5
1976/1977	3972	139	4671	15
1977/1978	3549	142	3538	18
1978/1979	4772	240	5261	65

Source: Thailand, Ministry of Agriculture and Cooperatives, Division of Agricultural Economics. As cited in Johnson, S.H., 1979, ibid.

When sufficient storage or groundwater capacity exists dry season production increases over time and may become a major proportion of the total production. Table 3 illustrates the case of central Thailand where dry season production now represents almost 50 percent of wet season production.

Table 3. Paddy Rice Production - Central Thailand (Thousand Metric Tons).

Crop Year	Wet	Dry
1968/1969	3415	109
1969/1970	3926	-
1970/1971	3642	-
1971/1972	3850	-
1972/1973	3772	675
1973/1974	4531	864
1974/1975	3988	800
1975/1976	3657	983
1976/1977	3948	1144
1977/1978	4003	1338
1978/1979	4132	1927

Source: Thailand, Ministry of Agriculture and Cooperatives, Division of Agricultural Economics. As cited in Johnson, S.H., 1979, ibid.

The benefits from an emphasis on supplemental irrigation include: relatively low unit development costs, thus spreading available investment resources to the largest number of individuals; greater stability of wet season production, encouraging inputs of other production resources; maximum utilization of existing experience and expertise; and increased opportunity for staged development, including use of varying levels of technology.

The benefits from an emphasis on total irrigation capability include: maximum utilization of the irrigation and agricultural input infrastructure; greater opportunities for diversification of cropping opportunity, increasing the potential magnitude and stability of agricultural income; increasing the incentive for adoption of more productive technologies; and making greater use of the available natural resources.

Again the major disadvantages to complete irrigation are extensions of the disadvantages associated with irrigation by comparison to rainfed agriculture. Basically these relate to the questions of equity and environmental impact. The provision of year-round irrigation capability by access to either surface or groundwater reservoirs involves much greater unit area investments than are associated with supplemental irrigation systems. Costs associated with year-round capability may be an order of magnitude larger than those associated with supplemental irrigation. Even when the storage type projects are economically justifiable, they represent a concentration of resources into relatively limited area with a relatively small set of beneficiaries. Thus there is a substantial benefit to a relatively small group. In addition to the direct benefit to the beneficiary group however, there is an indirect adverse impact on the non-beneficiary farmers. This results from the lower price for the commodities produced on the fully irrigated land. The irrigation farmers on this land, as the result of the income from two or more crops, can reap substantial economic benefits even at lowered prices per harvested unit. The single crop farmers find their incomes reduced as a result of the lower crop prices (obviously, the farmers on rainfed land are even more seriously affected). The differential between the farmers on the fully irrigated land and those on the supplementally irrigated or rainfed lands can be substantial.

The environmental impact, and particularly the health effects mentioned previously are exacerbated under a complete irrigation system. The periodic drying of fields and channels, characteristic of supplemental irrigation and rainfed areas, does not occur to an extent sufficient to avoid the extension of Schistosomiasis and similar water related diseases. These can seriously reduce the benefits anticipated from the project investments.

Expansion vs. intensification. In many of the countries of the region, the existing irrigation systems are not being utilized to their potential. The reasons include: physical problems -- serious deterioration of the physical infrastructure, excessive use of irrigation water, salinization of the land area, etc; economic problems -- a lack of profitability for the crops being grown, difficulties with obtaining credit and other inputs, etc; social problems -- land tenure arrangements which discourage utilization, caste or other social differences which affect access to production resources, etc.

In some situations, as suggested previously, there may be a lack of storage capacity to permit year-round utilization. At the same time that there is this significant degree of under-utilization of the existing irrigation system, there are opportunities for the development of new projects.

New systems present a sign of progress that has strong political appeal, both internally and externally, and which may have a more general psychological value. Potential benefits may be more easily identified and the requisite technical skills more easily mobilized than in the improvement of existing systems. Particularly when new systems are larger scale, external resources, both financial and technical are more readily available. High quality central design teams can be obtained and concentrated construction can be managed more easily.

The rehabilitation and/or intensification process, on the other hand requires detailed information about many dispersed situations. The manpower requirements for obtaining this field information, for designing the improvements and for supervising scattered site construction, while not necessarily of the sophistication required for new projects still are very demanding. For the same amount of financial investment, many more technical personnel may be required for effective rehabilitation than for new project development.

The direct benefits to be derived from new projects, in principle, can be estimated more easily than those from intensification and/or rehabilitation. This is especially true where the new projects include dry season irrigation capability or are in arid zones. By contrast, the identification of benefits from improved supplemental irrigation systems is much more difficult.

While the relative magnitudes of benefits to be derived from given investments in new vs. intensification efforts is in question, there is little doubt about the actual beneficiaries from the investment. These will be more readily identified in new systems and generally will be fewer in number than in areas being intensified. Similarly, the type of benefit will differ; new systems usually will result in significant increases in land value and changes in cropping intensity and/or type of crop production. Intensification through improvements in system infrastructure and operation is likely to have a lesser impact on land value and less radical, though frequently very important impacts on cropping practice.

Government vs. private. The question of the relative roles of the private and public sector in irrigation and water resource development is one that has grown in importance during the past ten years. The major impact of the private sector in tubewell development, with significant financial resources being mobilized where little were thought to exist, the examples of more effective utilization of private water facilities and the more numerous examples of difficulties associated with public systems have increased interest in the private sector.

However, private development usually has taken place in environmental situations where the technological component for water capture and use is relatively small - readily available groundwater, lands adjacent to streams, etc. Bangladesh appears to have large areas where these conditions exist (though with other constraints), but the full extent of this potential in the region is yet to be documented. The degree to which private development can be extended to more difficult environmental situations is not well defined. In addition, the impacts of this relatively uncontrolled development on both the natural and social environmentals have not been studied. Groundwater depletion is one example of the type of problem that can result from uncontrolled private development. The region has some interesting examples of government assisted private, or at least semi-private or communal development (for example in the Philippines) which should be helpful in clarifying the relative role of the public private sectors. In addition, it must be recognized that failures of private irrigation efforts are not unknown, especially where the projects are cooperative efforts amoung more than a very few farmers.

Large projects vs. small. In the May 1980 draft of this paper the entire large vs. small argument centered around the relative advantages and disadvantages of large and small scale projects (see sub-topic below). Subsequent discussions with policy makers in a number of developing countries lead to the conclusion that these factors or considerations probably have little relevance to the decision to invest in large projects. It is clear that this decision is based upon a combination of political and financial factors rather than upon an evaluation of the relative economics of this type of irrigation development vis-a-vis another.

It appears that where the opportunity for a large scale irrigation development exists, particularly if it involves a large reservoir structure, it will be constructed. The timing of this development is determined to a large extent upon the availability of external funding and the capacity of the country to carry the financial charges. The priority accorded to a specific project is to a large extent politically based.

If these observations are correct, then the development option actually open is not large scale vs. small scale development, but that of large scale vs. small scale operation of large systems. In many, if not most large systems there are opportunities to provide the physical, institutional and organizational structures that would permit the system to operate: as a single, unified entity; as a linked set of semi-autonomous subsystems; or as a group of independent systems supplied with water under a set of prescribed rules. Each operational pattern has specific requirements for success, and each provides potential benefits in relation to production, equity and efficiency, though not necessarily the same.

The single, unified system requires an effective and efficient irrigation bureaucracy, a rapid communication system, assured financial support for operation and maintenance (probably from central government allocation), and relative freedom from local political influence. Additionally, large areas devoted to one type of crop and relatively large areas of similar soils facilitate the utility and effectiveness of this type of operational pattern. A functional system of this type could result in relatively high production, and efficiency in the use of the water resource. It could ensure regional (sub-regions within the command area) equity, though it would have difficulty in ensuring equity at the turnout and farm levels.

The operational pattern utilizing independent systems has less stringent requirements for the irrigation bureaucracy, for the communication system, and for financial support from the central government. This does not mean that there are no requirements; the reservoir and major channels must be operated and maintained to provide the maximum degree of adherence to the delivery rules. This pattern of organization can accommodate wider variation in physical conditions and cropping systems, but requires greater participation of the farmers in system operations. This is facilitated by a reasonably equitable social structure, which encourages community action, and by a political structure which inhibits the capture of power by a few. From a theoretical point of view, this pattern of operation should yield good production, a higher degree of local equity (though there may be somewhat less regional equity) and probably lower efficiencies in the use of the water resource, especially in water-short years.

The pattern of semi-autonomous subsystems probably has requirements and outputs intermediate between the previously described types of operations.

The issue of large vs. small projects is widely recognized, but not easily resolved. In part, this is due to the complexity of factors, political, economic and technical, that enter into the decision making calculus, but it is also due to the lack of information about the efficiency and effectiveness of small projects.

Some advantages and disadvantages of large projects, as compared to small projects, follow. *Large projects frequently are necessary for the effective utilization of relatively large but variable water supplies.* To stabilize the supply, a large reservoir may be required; this stabilized supply can then be utilized to serve a relatively large area.

The *larger projects permit more efficient and effective use of limited managerial and technical skills.* In many of the countries in the region, there are individuals with relatively high level expertise, but their numbers are small. Drawing these individuals together within the context of large-scale development permits the utilization of these skills most effectively. While there is a feeling of validity to this argument, there also is a potential for adverse impact. In mobilizing local design and managerial talent for the Upper Pampanga River Project, the Philippines drew from its existing system the most competent engineers and administrators. These were concentrated in the single 80,000 hectare area and their impact was substantial. At the same time, however, no evaluation of the impact of the removal of this resource from the existing systems was made. It is at least arguable that an intelligent, vigorous and knowledgeable individual can make a more significant contribution in a position of major individual responsibility in a relatively small project than as a member of . team in a larger project.

A counterpoint to the issue of utilization of local capability is the requirement for external consultants that almost always accompany large projects. The technical requirements and time constraints usually associated with large projects almost invariably necessitate the use of external consulting firms. While these bring special resources to the developing countries, they also bring the lack of local experience and knowledge of the local culture and of the local political situation. At least in part as a result of this combination of skills and deficiencies, large project design is heavily oriented to technical questions.

Large projects permit more economical use of the physical elements of the system. Both the operation and maintenance are more economical when there is a relatively high investment per hectare served and there is more than one crop per unit area. In principle, this seems valid, but difficulties frequently are encountered with large systems in the region. In serving the small farming units typical of the area to achieve the anticipated multiple cropping potential, it is assumed that there must be a very extensive terminal distribution system. Operation and maintenance requirements at this level are almost always delegated to farmers; it is anticipated that the farmers will be grouped into some type of water-user association. The effectiveness of these groups varies widely from country to country within the region and there are very few examples of successful integration of farmer groups and centrally administered systems. As a result, operation and maintenance remain major problems in large scale systems.

The larger projects are more easily financed. While the situation is changing, as exemplified by the Sederhana program in Indonesia and similar programs in some of the other countries in the region, generally it has been easier to obtain external financing for large projects than for small ones. A variety of reasons for this can be cited: many international loans cover the foreign exchange component of the project and since large projects tend to have a relatively larger foreign exchange component they are favored for funding; the accounting and oversight requirements associated with the international loans are more easily accommodated within a large concentrated project than within a set of dispersed smaller projects; the documentation for adequate consideration of the project (basic hydrology, technical details, economic projections, etc.) are more easily developed for large relatively compact projects than for the smaller projects.

The larger projects generate major benefits during the construction period as well as after project operation. Depending upon the mode of construction, labor can represent a relatively large percentage of the input needs. Since both unskilled and skilled labor are required, there can be a significant stimulus to employment during the construction period. This stimulus, however, is not necessarily beneficial in the long term. Unless managed carefully, there is a boom-bust aspect to large project manpower mobilization. Accompanying this mobilization may be a disruption of traditional labor patterns with both wages and occupational choices affected.

Within recent years, many of the problems associated with large projects have been identified and there is growing recognition of the potential associated with smaller irrigation systems. These potential benefits include: more rapid development and utilization; opportunities for the mobilization of local resources, both capital and labor; minimization of large area environmental impacts; broader dispersal of investment resources; and the potential for greater involvement of the local community in system operation and maintenance.

It has been demonstrated that not all of the potential benefits associated with large projects have in fact been obtained, and it is becoming clear that not all of the potential benefits associated with small projects are being obtained.

Investment Strategies

The potential investment strategies include: (a) direct vs. indirect; (b) hardware vs. software; (c) main system vs. on-farm; (d) early vs. late; and (e) easy vs. difficult.

Direct vs. indirect. While it frequently is assumed that irrigation development will have a positive impact beyond the immediate boundaries of the command area, projects may be developed essentially as individual activities or as a part of a formal area development program. Direct investment in specific projects, by contrast to indirect investment through support of the broader development efforts has both advantages and disadvantages.

There are many examples of direct investment in both large and small irrigation projects in the region, e.g., the Gal Oya project in Sri Lanka, the UPRIS in the Philippines, the Sederhana program in Indonesia, etc. This type of investment is relatively straightforward, though not without difficulties. For the individual project, such as Gal Oya, the outputs from the investment can be classified relatively sharply; the terms of reference for the consultants can be established relatively precisely; the schedule for activities predicted within reasonable limits (if not always accurately).

The more complex type project, such as the UPRIS, makes for more difficulties in the specification of outputs, activities and schedules; but again the project is confined to the command area and to those activities more or less directly connected to the irrigation development and to the related agricultural practice.

External investment in small systems usually occurs in a package form, in which the small projects are grouped for programmatic purposes, even though each may be a distinct individual project. This type of program investment frequently is considerably more difficult to specify and to carry through effectively (though it may be more productive). The dispersed nature of the projects imposes more difficulties in collection of essential information for design and construction - and ultimately for monitoring and evaluation. To reduce the burden on the external lender, responsibility for project implementation usually is left with the host country, while oversight and evaluation is focused on the general program.

Direct project investment has two potential weaknesses, one relating to the probability of successful implementation of the project and the other relating to the probability of achieving the desired impact. A successful project results from an appropriate combination of project design, support infrastructure and governmental policies. While these are recognized in most project papers, individual project designs must assume that any weaknesses in the collatoral elements of support infrastructure and/or policy identified during the design process will be rectified. For example, if there is a significant problem with the availability of fertilizer in the project area, as a result of distribution problems or basic inadequacies of supply, the project documents may identify this as the problem which, if uncorrected, would adversely affect project success, but would then proceed on the basis of the assumption that the problem would be corrected. To the extent that this assumption is not valid, the anticipated results of the project would not occur.

On the impact side, investment in individual projects puts an emphasis on the direct beneficiaries within the limited area covered by the project and considers the larger community only in relatively general terms. Outputs usually are specified in terms of production increases, changes in employment potential and in on-farm and/or family incomes, within the project area. Secondary benefits and costs for a greater area may be estimated, but usually are not evaluated with much emphasis. Yet these may be very significant, especially with respect to those in the lower economic levels, as suggested earlier in the discussion of rainfed vs. irrigation development emphasis.

An investment strategy that focuses on area development projects has the potential for minimizing the disadvantages of the direct project approach, but has its own problems. A few examples of area development programs exist in the region. The Bicol Development Program in the Philippines, the Muda Agricultural Authority (MADA) in Malaysia and the Mahaweli Development Project in Sri Lanka are major examples.

These types of developments suggest a very extended investment time horizon, a complex set of activities, major problems in implementation, significant requirements for close interaction between the lender agency and the host country government agencies and the ability, on the part of the government and the lender to modify the development plans as experience is gained. These requirements for flexibility and continuity are not characteristic of most investment activities and must be recognized and accommodated from the outset.

Even with an area approach the difficulties associated with the individual project emphasis may not be overcome. For example, in the Mahaweli Development Project, agroclimatic and soil classifications suggest appropriate areas for the production of rice and for upland crops of various types. Notwithstanding this knowledge, the farmers in response to the economic incentives produced by national policies toward rice and crops such as chiles, produce rice on lands much more suitable for upland crops. Project response is to try to provide structural capability to limit water deliveries at the individual farm level (approximately 4 hectares), a very expensive investment with a questionable probability of success. Even though the project is regional (even national) in scope, and even though it has broad development objectives, it has encountered and not been able to resolve the same type of difficulty more typically encountered with the more narrowly defined and more geographically limited irrigation projects.

Hardware vs. software. Broadly speaking, irrigation systems are composed of two types of components, the physical infrastructure (hardware) and the management (software). Elements of the management component include: the development of operational plans and the capability to modify them; an operational structure that provides for appropriate information collection handling, analysis and decision making; a system for performance monitoring; programs for training of system personnel and the farmer-irrigators; the development and utilization of appropriate farmer organizations, etc.

Usually within any one project, the development costs associated with the physical infrastructure are much larger than those related to the development of management capability. (This is not always the case, especially for small projects. Even in the larger projects, it is probable that the need for investment in the management component is underestimated.) Thus, from the standpoint of the lending agency, it is easier to invest a specified sum of money in the physical works of the project, or in those projects which have a proportionally greater amount of physical infrastructure (e.g., storage-type projects). From the project paper stage to final accounting, the entire process in dealing with the hardware is much simpler than the corresponding process for the software.

Experience in the region shows recent growth and concern for the software elements of irrigation projects. This is reflected in greater emphasis on the training of irrigation department staff, on the development of farmer irrigation associations and on the articulation of the activities of these associations with the irrigation agency operations. In dollar terms, this emphasis is a small proportion of the total irrigation investment in the region. Thus, an investment strategy that emphasizes software will place greater demands on lender agency staff time -- for project development, for implementation, for monitoring, and for many of the same reasons indicated for a strategy that emphasizes small projects. These demands are both in terms of the customary accountability activities associated with project investment and in terms of technical expertise.

Since the recognition of the major importance of the software components, and of the difficulties resulting from their inadequate consideration is relatively recent, there is a very limited corps of expertise available to deal with these aspects. This limitation exists within the major lending and donor agencies, and within the consulting community at large. Thus, an emphasis on the software components requires significant professional development on the part of all concerned. In addition, given the current state of knowledge there must be recognition that trial and error will be an integral part of all programs focused in this area.

Main system vs. on-farm. Irrigation systems extend from the capture of the basic water supply to its utilization on the farm. Historically, government developed systems were first conceived as hydrologic-hydrolic systems, emphasizing the movement of the water in the primary canal system. More recently, the agricultural utility of the water has become an essential component of system design and operation. In a limited number of cases at the present time there is recognition of the varied roles of the farmer and user and of the need to recognize and to utilize farmer knowledge and skills.

In many projects, the systems are considered in two parts: the main system and the "on-farm" portion. On-farm frequently means "beyond the turnout" or that portion of the system that exists beyond the point at which the water is under the nominal control of the governmental authority. Thus, it frequently includes a significant proportion of the project distribution system and may include part of the conveyance system. In addition, it includes all those activities which actually occur on the agricultural holdings.

Within the region, governmental responsibilities for these two parts of the irrigation systems may be assigned to different agencies; a department of public works frequently has responsibility for the main system and a department of agriculture has responsibility for the on-farm portion. The latter may have operational responsibilities for minor irrigation, as in the case of Agrarian Services in Sri Lanka, or be primarily involved in the complementary activities, such as providing credit and/or other production inputs and in the provision of the services associated with agricultural extension.

Obviously, the two portions of irrigation systems must be integrated for a successful project. However, the activities, agencies involved and expertise required may be considered separately, and in projects of significant size or in program terms, there can be an investment strategy that emphasizes one or the other. Typically, the World Bank has emphasized the main system, though there are some projects that have dealt with the on-farm phase (e.g., the extension of Mogha improvement initiated by the Colorado

State University project in Pakistan). A significant proportion of the Asian Development Bank projects have emphasized the on-farm component, with a relatively heavy emphasis on the institution of rotational irrigation and farmer irrigation associations.

Early vs. late. Irrigation projects come to fruition over time with different types of inputs provided as the projects evolve. Many of the projects become productive much later than planned (even in Western United States there is an expression that "it is the third farmer who makes a go of an irrigation farm") and the later inputs frequently were not anticipated in the original plans.

Investing in the early stages of project development permits the lender agency to have maximum input into critical decisions about scope, type, clientele, objectives, etc. In addition, visability and identification with the project are more complete when there is an early association. At the same time, however, uncertainties are at their greatest and the time to productive utilization the longest.

Investing in the later stages of project development has fewer opportunities for influencing the major decisions, but may have more opportunities for relatively rapid demonstrable response. For example, early involvement with the Chao Phya project in Thailand, either in the Bhumiphol Dam or in the construction of the primary canal system showed relatively low irrigation benefit-cost ratios. Subsequent investment in the Sirikit Dam and in the extension of the secondary and tertiary canal system, with a resultant increase in dry season utilization has at least partially captured the results of that earlier investment and this is reflected in relatively high benefits. In this case, however, it would not be possible to shift development emphasis from the relatively more prosperous Central Plain farmers to the poor Northeast, or to make other significant changes that might be desired.

The stage of investment also influences the type and amount of required expertise, with the broadest range required for early involvement. At the same time, however, because later involvement frequently is associated wih lower unit costs, there may be proportionally more staff involvement per dollar invested.

Easy vs. difficult. Projects vary in their difficulty, though the full extent of any project's difficulty rarely is known at the outset. Project size, complexity, physical feasibility, political impact, and data uncertainties are among the many elements that suggest whether a project will be relatively easy or relatively difficult to implement successfully.

Projects vary in their potential payoff. While not a one-to-one correlation, frequently the higher potentials are associated with the riskier projects. Thus, a lending agency often is faced with a choice of investing in relatively sure projects with low or modest anticipated outputs, or of supporting projects of more uncertain outcome, but whose potential impact is relatively large.

Lending agencies which require that repayment come from the project itself will tend toward the easier, more certain projects. Those which require repayment from the country, and not necessarily from the project, may be more venturesome, but if their charter is primarily economic will still emphasize the projects with more certain economic outputs. Lending and donor agencies with broader objectives have a wider option.

The Evolutionary Context of Irrigation Development

The issues, as presented in the preceding sections, do not explicitly consider the implications of the development alternatives within the context of a country's or region's stage of irrigation development. This omission should not be construed as evidence of a lack of importance assigned to this factor, but only a result of the attempt to present as sharply as possible the extremes of available choices.

It would be a mistake, however, not to comment upon what may be two of the most important factors affecting the appropriateness of a particular development strategy.

It can be argued that the evolutionary pattern of irrigation development generally precedes from rainfed agriculture to irrigation supplemental to the wet season in those areas where the water supply can be developed and utilized easily. As the cultivated rainfed area expands to less desirable areas, the area of supplemental irrigation expands with more difficult supplies developed and with more conveyance and distribution infrastructutre constructed. Some dry season capability becomes available and is utilized on the most accessible areas. As the pressure on the land increases, there is an intensification of utilization of the supplemental irrigation and greater emphasis on the development of dry season capability through storage type systems and/or groundwater. In each stage of this development, there is a balance between the forces -- economic and social -- which act to encourage the expansion and intensification of irrigation and those which act to resist its development. Increasing land prices, higher product prices, increased population pressure and the need for more land efficient techniques of production all act to encourage irrigation development. Increasing cost for water supply development and for physical infrastructure of irrigation, social concern for the concentration of governmental investment, the availability of undeveloped land and a lack of population pressure all act to limit irrigation development.

Programmed irrigation development assumes that this normal pattern of autonomous response to socio-economic forces can be superceded by an imposed pattern of development which either brings supplemental irrigation into areas not yet under significant land pressure, or more frequently, introduces dry season capability more rapidly than would otherwise occur. It is not obvious that this will result in the magnitude nor type of utilization typically anticipated in the project designs. In fact, there is at least some evidence to suggest that the availability of irrigation or of dry season capability does not ensure anticipated utilization and that the actual pattern of use more nearly approximates what might be expected in the evolutionary pattern of development. For example, there are a number of areas in Latin America where supplemental irrigation has been introduced, with variable levels of utilization. Similarly, dry season capability in the central plain of Thailand was not significantly utilized for 10 years, and even now, almost 15 years later, represents less than 50 percent of the wet season production.

To the extent this very brief analysis is valid there is an implication that programmed irrigation development must be accompanied by a very careful analysis of the stage of evolutionary development, and a wide range of governmental policies and programs must be adjusted before effective utilization of the irrigation investment could be reasonably expected.

Coupled with the evolutionary development of the irrigation systems themselves is the evolution of governmental attitudes or perceptions about the systems. Three stages of governmental view can be identified. In the early stages of governmental irrigation development, the systems are viewed as hydrologic-hydraulic systems. The emphasis is upon the water, its capture and conveyance. Typically, there is little understanding of the agricultural use of the water and the design, construction and operation of the systems are the responsibilities of an engineering based governmental organization. The second stage in governmental view of irrigation systems is when the agricultural utility of the water is recognized and information about soils, crops and other agronomic elements are incorporated into the design and operation of the systems. By contrast to the headwater down approach of the first stage, there is now a command area upward approach to the design. The third stage perspective recognizes that the farmer is an active participant in the utilization of irrigation capability and that farmer needs, as well as soil and crop needs, must be recognized in system design, construction and operation. It is my impression that Sri Lanka is just starting to move from the first to the second stage; the Philippines and Indonesia are just starting to move from the second to the third stage. It is my view that there is an underlying assumption inherent in the programs for irrigation development that the governmental policies and bureaucracies can be moved rapidly toward the third stage. It is not obvious that this can in fact happen, nor is it obvious that the irrigation bureaucracies can be moved from the first stage to the third without passing through the second for some significant period. Again, there are evidences that establishing the forms for farmer participation does not automatically result in the type of participation necessary for effective utilization of the system's capability. The agencies look upon farmer participation in much the same way that company unions were looked upon by the industrial sector in the United States during the early period of union organization. There is significant evidence to suggest that a lack of effective farmer participation in those systems where there is an intent to utilize irrigation water efficiently will result in significant problems and a relatively high probability of failure.

If the ideas proposed here are valid, then irrigation investment of a programmed character must either be very selective or must consider a much wider range of factors for inclusion in design considerations than is customary. It must be recognized that implementation and successful operation will be difficult and will require more flexibility than is currently considered necessary. Even with those more open view, the degree of "modernization" that can be instituted is open to question.

CANAL IRRIGATION MANAGEMENT IN INDIA:
SOME AREAS FOR ACTION, ANALYSIS AND RESEARCH[1]

by

Robert Chambers[2]

Summary Overview

This paper seeks to identify and discuss some areas for action, analysis and research to achieve more of the potential under existing canal irrigation in India.

The distribution of water is something of a gap in knowledge and professional expertise. In seeking ways of improving water distribution, the outlet is pivotal, standing as it usually does at the boundary between irrigation bureaucracy and farmers. One path to higher productivity and greater equity in water distribution may be through three complementary measures: (1) main system management to deliver through the outlet a predetermined steady flow at predetermined times; (2) some form of warabundi below the outlet; and (3) a measuring device at the outlet that can be understood by farmers and which enables them to monitor the water they receive.

On many canal systems, higher productivity and greater equity entail induced scarcity of water at outlets in order that available water can be spread more widely. Assessment of scarcity and of the organization needed to manage it must take account of non-canal sources of water, and of night irrigation with canal water. Scarcity of canal water may be offset through increasing the steadiness and predictability of the supply. Steadiness and predictability of supply should make it easier for farmers to organize to distribute water and maintain channels, and for conflict to be reduced between irrigators and between irrigator groups.

Above the outlet, improved main system management can be sought through developing and enhancing professional interests and rewards, supported by better understanding of the constraints and

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[1]Paper for the Workshop on Problems and Research Methods in Irrigation Systems Related to Chak (Outlet) Requirements, held at the Gandhian Institute of Studies, Rajghat, Varanasi, July 27-31, 1981. Revised, December 1981. (For useful detailed comments on the first version of this paper I am grateful to Robert Wade.)

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disincentives faced by staff, including low-level staff. Another way forward is through encouraging and enabling farmers to organize to extend their influence and management upwards into the system above the outlet, and to articulate interests and demands from below. Such organization should make it less difficult for irrigation staff to reconcile political pressures, especially where redistribution of water means that one group must lose. At this stage, however, the most practical way forward may be to concentrate on seeking ways in which all, or almost all, farmers can gain from redistribution. To find such ways requires new forms of multi-disciplinary investigation addressing new questions.

Three pervasive themes in finding ways to achieve more of the potential of canal irrigation are: first, raising the professional status and satisfaction of those who manage water distribution; second, encouraging all concerned to be more interdisciplinary; and third, field research on what actually happens to water, including who gets what, when, how, why and with what consequences.

Potential and Purpose

The unrealized potential of existing canal irrigation systems in India is widely recognized. Lectures, papers, speeches, reports, statistics - presented by political leaders, senior officials, researchers and other informed observers, representing between them a range of disciplines and long and deep experience - have emphasized the scope there seems to be for bringing the benefits of irrigation to larger areas and more farmers, and for distributing and delivering the water in a manner that will be more cost-effective, productive, equitable and environmentally stable. This potential varies by zone and by project. It is perhaps least under the tightly managed canal irrigation of Northwest India (Malhotra, 1982) where strict rotations are practiced both above and below the outlet. But taking India as a whole, one estimate is that only about one-half of the officially estimated utilized hectarage under canal irrigation is effectively irrigated, the rest receiving only erratic and partial irrigation at best (Seckler 1981:10). Whether this estimate is exact, high or low, the potential for additional cropped area probably runs into millions of hectares per year and the potential for additional food production linked with improved management should be a matter of at least several million tons per annum.

This paper seeks to identify and discuss areas for action, analysis and research to achieve more of this potential. The sequence "action, analysis and research" is deliberate, since research and anaylsis can delay action, and so much action (in improving the distribution of water on main systems, in introducing warabundi-type rotations, in rehabilitating and modernizing structures, and in training irrigation staff, etc.) is already taking place and has a growing momentum.

Analysis and research can contribute to the content and direction of action, and are often most useful where it is the action itself and its effects which are analyzed.

Criteria and Definitions

Criteria and good irrigation management in the distribution and delivery of water are taken to be:

- Productivity of water and other scarce resources;
- Equity in their distribution, including a fair deal for tailenders, and other disadvantaged people;
- Stability of infrastructure, environment and production; and
- Low cost.

The trade-offs between these criteria pose problems of measurement and judgment. Methods of quantifying and comparing productivity and equity have been devised by Lenton (1981) but not yet used.

Other terms in this paper are best defined for the sake of clarity:

- "Canal irrigation" refers to major and medium irrigation in India;
- "Chak" refers to the area under command below an outlet;
- "Communal" refers to an irrigation system in which water is not supplied through outlets from a larger canal system but from a local source, with the timing and amount of water distribution determined by irrigators;
- "Management" has three senses:
    - the management of natural resources, especially water management;
    - the management of people, both within bureaucracies and members of the public; and
    - the management of information and controls.
- "Main system" refers to canal irrigation and includes the water source, headworks, canals, branch canals, distributaries and minors down to the outlet. It also refers to drains below the chak;

- "Outlet" refers to the structure through which water passes, usually from a distributary or minor, into field channels which supply farmers' fields. If often corresponds with the point at which water moves from the control of an Irrigation Department to that of farmers and farmers' groups;

- "Warabundi" is a system of equitable water distribution by turns according to a pre-determined schedule specifying the day, time and duration of supply to each irrigator in proportion to landholdings in the outlet command" (Singh 1980:46);

- "Predictable" means coming at times and in amounts known about in advance;

- "Steady" means with a constant or near constant flow; and

- "Timely" means at a time desired by farmers and productive for their crops.

Scope and Caveats

Some of the limitations of this paper are best stated:

- It is concerned with canal irrigation in which water is distributed to farmers' fields by a combination of a bureaucracy and of farmers themselves. It is not directly concerned with communals or with small-scale lift irrigation.

- The orientation is largely that of an undifferentiated social scientist. There are many vital engineering, hydrological, soils, and agronomic aspects of all the topics discussed, which are not covered, not least the crucial significance of the physical structures of distribution systems and of agronomic conditions.

- Generalization about canal irrigation is difficult. It is tempting to study one system or a few, and then generalize. There are, however, great differences between systems, at least in terms of scale and of relative scarcity and abundance of water. If there is one clear lesson emerging, it is that each system is unique in its combination of resources, structures, institutions, procedures, conventions, problems and opportunities. Even if the universe taken is only India, or only one State within India, generalization is often precarious.

- Much of the evidence cited is from India, but there is still a dearth of Indian and other published material on most of the topics discussed. Many assertions should therefore be treated as tentative.

The Water Distribution Gap

Irrigation systems can be seen to include four domains: first, the physical (structures, channels, fields, soils); second, the biological (especially the growth of crops); third, the human and economic (including both irrigation staff, farmers and their households, household economies, institutions, and behavior); and fourth, centrally, pervading and linking the other three, water itself and its distribution. The first two domains - physical and biological - have been and continue to be extensively studied by irrigation engineers, agricultural engineers, agronomists and soil scientists. The third, human and economic domain has until recently been less examined (except from within the concerned irrigation organizations), with rather little researched about irrigation bureaucracy and staff, and about irrigators' organizations and behavior in the chak.[3] The fourth domain, water, has been examined in detail in some of its hydrological aspects, but the actual distribution and delivery of irrigation water, from headworks to the crop in the field, has not received major attention as a subject.

The relative neglect of water distribution and delivery as a subject is surprising until one reflects on some of the reasons. Many biases influence what aspects of irrigation receive professional attention.[4] First, practitioners and researchers alike are directed to certain aspects of irrigation by their training and preferences. The point has often been made that engineers are trained in construction, and to a lesser extent maintenance, but not much in operation of canal systems; that sociologists and social anthropologists are trained to make studies at the village level, and to examine communities rather than bureaucracies; that economists are preoccupied with inputs, outputs, costs, benefits and prices; and that other disciplines - agricultural engineering, agronomy, social anthropology, and so on - all have their central concerns and corresponding blinkers. There is no discipline for which the distribution and delivery of water on canal irrigation systems is a primary focus.

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[3] But there is a growing literature. See especially Bottrall 1981c, K.K. Singh 1980, and papers by Wade.

[4] For an elaboration of some of these points, see Bottrall 1981b, Chambers 1978, and Wade and Chambers 1980.

Second, most disciplines prefer to study what can readily be counted; but, water is maddening to measure: it is devious, unstable and elusive. Water does not just flow, it also seeps, percolates, evaporates, transpires, escapes in drains and is unpredictably added to and subtracted from environments by climatic change. As though this were not enough, the difficulty of measuring it is aggravated by its movement around the clock, including the night. Not surprisingly, those who try to measure it become preoccupied with methodology, leaving little time or energy over for other investigations, or for relating findings to a broader picture.

Third, there are spatial biases in analysis of canal irrigation: analysis tends either to start with the water source - a river or catchment, a diversion weir or reservoir, and sees the system from the top down; or it starts from crop water requirements and farmers' fields and sees the system from the bottom up. The difficulty is that these two approaches - of supply and demand respectively - may never meet. In between lies the great gap of water distribution and appropriation across the spaces of the irrigation system.

Finally, irrigation water is valuable. Competition for it leads into political economy, and questions of who gets what, how, why and with what costs and benefits, a sphere which some are neither trained nor eager to enter but which is vital for understanding and changing actual human behavior and performance.

It is precisely because the domains of human organization and of the distribution and delivery of canal irrigation water have been relatively neglected that they now promise some of the largest gains in trying to achieve the objective of productivity, equity, stability and low cost, realizing more of the potential of canal irrigation.

The Outlet as Pivot

If we abjure conventional analysis from the top down or from the bottom up, and instead examine water distribution from the center outwards, the obvious place to start is the outlet. In the words of S.P. Malhotra, writing of Northwest India,

> "An outlet is the masonry structure through which water is admitted from the government distributary into a farmer's watercourse. It is the border where the State management ends and the farmer's management starts. It acts as a water-measuring device and hence is a subject of great interest to both the government and the farmer. Under the warabundi system it plays a vital role in distributing water and its working can be called the cornerstone of the entire distribution system." (Malhotra, 1982, Ch. 4)

If the outlet is a cornerstone, it lies in a no-man's land. It is situated below the traditional major concerns of engineering with larger structures, and above those of other disciplines such as agronomy concerned with crop growth, agricultural extension concerned with the farmer and the farm level, and sociology concerned with irrigation communities. For economists it is also listed to sight somewhere between the inputs and outputs from agriculture (revenue, returns to the farmers, returns to the economy). For rural development tourists (departmental officials, aid agency staff, academic researchers on short rural visits) there is so much else that is more visible and interesting (headworks, storage reservoirs, large canals and control structures at one end, and fields, farmers and crops at the other). The humble outlet goes unseen; or if seen, it is only noticed at one point of time and the adequacy, fluctuations and predictability of flows through it are not visible.

It lies too on an administrative and social boundary. It is at or beyond the limit to which irrigation engineers and their staffs extend their detailed control. It is also often the official border between the Irrigation Department on the main system and the Command Area Development Authority which, like most new organizations, had to establish itself on unoccupied territory, which it found below the outlet. The fringe status of the outlet may even be reflected in budget discussions about rehabilitating structures when it may not be clear whether upgrading outlets fails under the budget for "above the outlet" or for "below the outlet". It can be seen, too, as a sort of border post through which a commodity of value passes from one jurisdiction to another.

The outlet also has a pivotal position in proposals to improve the productivity and equity of water distribution. Allowances must be made for local conditions, but there is a weight of informed professional opinion (expressed for example at the Conference on Warabandi for Irrigated Agriculture in India in April 1980 (Singh 1980)) that tighter distribution and rotation of water supplies both above and below the outlet are required. Programmers and proposals based on this consensus have various names and forms, including Integrated Water Management (IWA) (ALI 1980), Rotational Water Supply (RWS), and Rotational Water Distribution (RWD). A recent definition of RWD is:

> ". . .a system of water control designed to deliver to each individual farmer in the command area of an irrigation project a proportionate share of the total amount of available water in a reliable way. By proportionate share it is implied that each farmer receives the same amount of water per unit area and by reliable supply that the water is received at fixed times and in fixed amounts known in advance by each farmer."
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> (Roberto Lenton, personal communication)

This objective is exceedingly difficult to achieve unless three conditions are met:

- Management of the main system to deliver through the outlet at predetemined steady flow at predetermined times;
- Timed rotation below the outlet to supply fixed amounts of water at the fixed times to each farmer; and
- A measuring device at the outlet which enables both farmers and irrigation staff to monitor the amount of water being delivered and received.

These preconditions direct our attention to three aspects of water distribution and delivery: below the outlet and within the chak; above the outlet, through main system management; and across the outlet, connecting farmers and their demands and irrigation staff and their responses.

Below the Outlet

Conditions and practices of water distribution below the outlet cannot be discussed sensibly without distinguishing different conditions. As Bottrall has pointed out (1981b), studies at the community or chak level have been subject to biases internationally, with a predominance of attention to small rice-growing communals in semi-humid Southeast Asia. The lessons from these studies may or may not apply to other conditions and areas, for example to the conditions of chaks on the huge irrigation systems of the Gangetic basin. Two contrasts stand out here as general problems.

The first is the difference between a communal and a chak. The water supply on a communal comes from nature in the form of rainfall, runoff, or river flow, and is usually supplied or stored by manmade structures under the control of the community. Measures to improve that water supply in quantity and reliability may be seen to entail propitiation of the Almighty or physical works by the community, or both. In contrast, the water supply to a chak outlet on a large canal irrigation system, though depending on nature to a degree (in the form of rainfall, river flow, and runoff to supply the system as a whole) is controlled and allocated, deliberately or by default, by people - the staff of the irrigation bureaucracy. In addition to the three fundamental tasks of water allocation, system maintanence, and conflict management, which Coward (1980:19) has described and which are found in communals, chak irrigators may also organize (as Wade 1979 has shown for a canal in Andhra Pradesh) to raise funds, to post guards higher up the canal, and to induce irrigation staff and influential persons to assure or augment their water supply.

The second difference concerns relative water scarcity. There may be two polar conditions in which organization for the distribution of water within a communal or chak will be minimal. At one pole, the water supply (irrigation plus rainfall) is abundant and relatively reliable, as perhaps usually on humid and semi-humid communals and on the headreaches of much Indian canal irrigation. In these conditions, field to field irrigation with paddy may make the most sense. Organization is less needed because water is adequate and accessible. At the other pole, as on semi-arid and arid communals and the tailends of many canal systems, water supply is scarce and unreliable. Water quantity and reliability may then be below a threshold at which it becomes feasible and worthwhile to attempt to organize its distribution systematically or equitably.

The situation with which we are concerned lies between these poles. The familiar reasoning is as follows. There are canal systems, it is true, where water is abundant in relation to commandable land; but on most canal systems there is more land potentially under command than there is water to irrigate it. In the common syndrome (outside Northwest India and parts of the deltas), farmers in the headreaches - of canals, branch canals, distributaries, and minors, and of chaks themselves - receive abundant and sometimes excessive water, and the corresponding tailenders receive water that is both unreliable and inadequate. This presents an opportunity to achieve higher productivity, equity and stability through the redistribution of water from heads to tails. In Keller's expression, the physical objective of an irrigation project can be seen as "to stretch the water like a membrane uniformly over the intended command area"(1981:4). This leads to the question which will be increasingly important, and increasingly asked, of how large the commanded area should be. In order to judge answers to that question, the trade-offs for farmers and for the economy between quantity, timing, steadiness and predictability of water supply will need to be better understood, a task particularly for farming system agricultural economists. The optimal condition will be one of induced scarcity, where farmers receive less through the outlet than they would like, but where timing, steadiness and predictability of supply compensate partly, fully, or more than fully, for the lower quantity.

Whether a restricted but timely, steady and predictable water supply at the chak oulet results in higher production and improved equity and stability will depend on the way the water is distributed within the chak. If headreach farmers in the chak take all they wish, the outcome may be that they cultivate thirsty crops like paddy, and others at the tail grow nothing, or only low value drought-tolerant crops. On the other hand, with a steady and predictable water supply, warabundi, in one of its forms is possible. In that case, a larger area may be irrigated, and farmers can decide for themselves what crops to grow with the fixed amounts and timings of water they receive.

The benefits from such rotations within the chak are quite widely asserted as follows, but are best put with questions which research can verify or qualify, case by case:

Productivity. Farmers who know what scarce water they will receive and when they will receive it, tend to adopt higher-yielding practices: to grow crops with a higher value to water ratio; to plant higher-yielding varieties; and to use complementary inputs like fertilizer and pesticides. To what extent does this occur? With what private profitability and thus incentives to what sorts of farmers?

Equity. Warabundi is designed for more equitable distribution of water. To what extent does this in practice occur? What are the actual as opposed to theoretical water distribution practices within the chak?

Maintenance. Farmers receiving large amounts of water have little incentive to maintain field ditches. Similarly, farmers receiving irregular and inadequate supplies may not feel it worth investing their time and energy in maintenance when they cannot be sure they will benefit from it. In contrast, farmers who are assured of a small but predetermined amount of water will be anxious to maintain ditches so that they receive it with minimum losses en route. Does this in fact occur?

Diminished conflict within the chak. Is conflict between farmers restrained by a precise, clearly understood, and legitimated system of turns by time? The tension between farmers may be there, but does this act to make the system work since the sanctions for default may be intense? Does this make incidents less common and arbitration less important?

Diminished conflict between chaks. Does a warabundi system diminish conflict between chaks and between different geographical areas on a canal system, and if so in what circumstances?

Less interference and poaching. On the Pochampad, (Shreeramasagar) Project in Andhra Pradesh, interference with water and poaching has been reduced following the introduction of warabundi (Ali 1980). Is this a general experience?

More needs to be known about the relationship between these benefits and the adequacy, timeliness, steadiness and predictability of the water supply at the oulet. On Pochampad, where the outlet supply has evidently been steady, these benefits have been reported (see e.g., Hassan 1981). On part of Mahi-Kadana in Gujarat, however, the flow through an outlet where warabandi had been setup was observed to vary between less than 0.5 cusecs and 2 cusecs in the course of a day.[5] This meant that allocation of quantity of water by time was impossible, and farmers presumably took what water they wanted, before allowing the flow to pass onto the next person. This raises the question of what methods of distribution are and can be used where the water supply through the outlet is not steady and predictable enough for warabundi. In South India, where common irrigators distribute water for paddy, there is a concept of "adequate wetting" for fields. Each field is adequately wetted by whatever flow is available before the flow is passed onto the next one (personal communication, Robert Wade). With this method, as water becomes scarcer, tighter organization may be instituted. Wade (1979:10) has described a village in Andhra Pradesh where the village irrigation committee started a more formal roster for the sequence in which lands were to be given water in response to scarcity and to the introduction of rotations on the distributary. It was necessary to ensure that when irrigation resumed after a rotational break, the first fields to get water would be those not irrigated during the previous period rather than those closest to the outlet. There is much to be investigated and learned here. Comparisons of benefits would be useful from different matchings of:

- Outlet water supply characteristics;
- Cropping patterns (especially the paddy - non-paddy contrast);
- Types and degree of chak or village organization; and
- Methods of water allocation within chaks.

They would be useful at least to verify or refute the current wisdom that a steady and predictable flow is a precondition for a high level of benefits.

If such benefits from a steady and predictable flow are assumed, then some conjectures can be expressed in the form of the table on the following page.

Any investigation of these relationships should include other sources of water, and the slack, surplus, or cushioning in the system. Elumalai (1980) found no farmers' irrigation organization on the Parambikulam-Aliyar Project where many farmers had alternative sources of water in wells and so did not have to rely heavily on

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[5]Personal communication from Wayne Clyma, T.K. Jayaraman, Max Lowdermilk, and Barry Nelson.

Farmers perceive quantity of water as	Inadequate				Adequate	
Quantity of water through the outlet is	Low		Medium		High	
Nature of water delivery to the outlet	U&U	S&P	U&U	S&P	U&U	S&P
Timed rationing feasible	No	Yes	No	Yes	No	No[6]
Productivity of water	L	H	M	H	L	M
Equity in its distribution	L	H	L	H	M	M
Maintenance by farmers	L	H	L	H	L	L
Harmony within the chak	L	M	L	H	M	M
Harmony between chaks	L	L	L	H	M	H

U & U = unsteady and unpredictable
S & P = steady and predictable
H = high L = low M = medium

canal irrigation. There is usually, if not always, some slack or surplus, even where water is scarce. Even the tight warabandi of Haryana, with its seven day rotation within the chak, has an eighth day of flow in distributaries and branches to allow for transmission time and to ensure that tailend chaks receive their full seven days. This means that chaks at the heads of distributaries receive more than the seven days of water.[7] Again, the tight distributary management on Pochampad allows 10 percent extra as a safety factor; but night flows often have the largest slack. For reasons of convenience, low visibility and even safety, they have been little studied. On the other hand, night flows often seem to represent a major waste of water. On Pachampad, a few chaks have a warabundi at night, but for most of the night water simply flows through the chak to be used by anyone or no one. On part of the Upper Ganga, farmers

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[6]With an abundant supply of water, it is assumed that paddy is grown with field to field irrigation. Strictly speaking, timed rationing is possible, though unlikely.

[7]For detailed discussion see Reidinger 1980 and Malhotra (1982).

are reluctant to take their turns at night because illicit extractions upstream diminish the night flow and they get less water (Personal communication, D. Tyagi). Night flows may also be linked with paddy cultivation (which may or may not be a good use of water) as Elumalai has found on Parambikulam-Aliyar:

> "Since irrigating the dry crops during nighttime is considered not advisable, the flow in the channel during nighttime is mostly diverted to wetlands raising paddy and no rotational system is followed. The distribution of water during nights is either based on <u>mutual adjustments</u> or influence of the <u>head reachers/tail enders</u>." (Elumalai 1980:18. His emphases.)

For field research, night irrigation is one of the next black boxes to be opened up.

A research priority below the outlet is participant-observation of a social anthropological sort to find out what happens to water in the chak, and who gets how much, when, how, why and with what results. This, coupled with study of the institutions and interactions at the chak level, should shed light on relationships between quantity, timelessness, steadiness and predictability of supply at the outlet, and benefits through productivity, equity, maintenance, and reduced conflict. Such studies would investigate the fit between the theory of warabundi and other methods of rotation, and the practice. There is a danger that warabundi will be seized upon as a panacea for all conditions and on a massive scale without such insights. It may or may not be such a panacea. The Training and Visit system of agricultural extension (Benor and Harrison 1977) may provide a parallel. It has been introduced in most Indian States and in many countries in the world. Its benefits may be large, but there has never, to my knowledge, been feedback from an evaluation with the bottom up view of a person living in a village and observing the behavior of staff and farmers over a season or more. In the case of new warabundi, the benefits from knowing just what happens to water under the outlet might be very high. A number of careful, detailed and sensitive studies might reveal opportunities for improving warabundi, the way it is introduced, and its adaptation to local circumstances. Otherwise, warabundi in new areas may become a mythical solution: supposed to happen; said (by staff and farmers to visitors) to happen, but not actually happening; or happening in an alternative manner. The challenge is to bring theory and practice together. To do that, the reality must be known.

Above the Outlet

<u>Distribution on the main system.</u> Which outlets get water, and how much they get, when, and with what steadiness and

predictability, depends on how water is managed on the main system. There are two potentials here for raising productivity, equity and stability.

The first is to redistribute so that top ends (which may suffer from over-irrigation, waterlogging and salinity) get less, and tailends get more. Such redistribution depends on there being adequate physical structures. Recent experiences in Andhra Pradesh suggest that even with present structures, or with only minor rehabilitation, major quantities of water can be redirected. For example, following some structural upgrading and the introduction of a simple rotation between outlets on some majors on Nagarjunasagar Right Bank Canal, some 3,400 additional hectares received irrigation water for the first time for many years in kharif 1980[8] (Personal communication, M. Narayana). Similarly, on the Vantivelagala Distributary on the Tungabhadra Project, in kharif 1980, a redistribution of water from head to tail is reported, in spite of less water being available than in 1979, to have led to a rise in irrigated acreage from 361 to 560 (CADD, AP, 1981:13).

The second potential lies in the complicated and challenging task of ensuring an adequate, timely, steady and predictable supply to outlets. This may require new or modified structures, especially

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[8] Without questioning this figure, a note of caution is in order. There are problems of measurement in determining additional area irrigated following a reform of this sort. It is possible that some farmers who were previously getting water, no longer do so. For example, some farmers at the tailends of outlets at the heads of the majors might receive less water, or even not irrigate at all. However, even if there were instances of this, the overall benefits of this reform could hardly fail to remain substantial. The estimation of costs of new irrigation per hectare is complicated where dams are also used for power, and all figures should be treated with caution. However, the benefits achieved by the redistribution of water on this part of Nagarjunasagar at negligible cost can be compared with the costs of developing the same area of new irrigation. The capital cost of 3,400 ha of new irrigation on the Srisailam Right Bank Canal to be constructed in Andhra Pradesh at about Rs.28,600 (UNIAS 1981) or $3,600 per hectare is over $12 million; and if the higher figures cited by Levine and others (1980:97) of $7,000 to $10,000 per hectare where storage is involved, the cost of 3,400 hectares of new irrigation becomes $24 million to $34.0 million. The comparison is not exact, but even if the capital costs were only one-tenth of those estimated, interventions on existing canal systems to increase the irrigated area would still be likely to appear dramatically cost-effective by comparison with the construction of new major irrigation systems.

on distributaries and minors, together with careful measurements and planning of times and amounts of supply. Minors and distributaries vary in rotations they permit and each minor and distributary requires a separate analysis. The outcome of careful distributary and minor management, coupled with warabundi below the outlet, can be a sharp reduction in total water requirement and a sharp increase in cropped area, yields and returns to farmers (Hassan 1981).

Alternative methods of water distribution and methods of analyzing and managing water on minors, distributaries and main systems as a whole, are not a subject that is widely studied, analyzed, or taught in enginnering or in economics. In Taiwan their is an institute setup to analyze , develop and teach methods of water rotation (personal communication, Robert Wade). Anderson and Maass (1971) have gone into these questions in detail, identifying many alternatives; but, in general the subject still seems a cinderella, at least for much third world irrigation. Even for the United States, a recent manual on Operation and Maintenance of Irrigation and Drainage Systems, published by the American Society of Civil Engineers (ASCE 1980), devotes only some of three pages to the different methods of water delivery, and its brief discussion of demand, continuous flow and rotational methods does little more than tantalize the reader. The academic research does not appear to have been pointed in this direction either. The abstracts of 216 post-graduate theses presented in 1970-1975 in hydrology and related subjects at 22 Institutes of Technology, Engineering Colleges, or similar institutions in India, do not include a single mention of methods of distributing water on canal irrigation systems[9] (INC for IHP 1977). The subject is mentioned in a leading textbook on Irrigation Engineering (Singh 1979:169-169) but the main professional concentration in the section on regulation and control of the canal system is on discharge measurement and the assessment of canal revenue. Two recent studies are hopefully precursors of much more description and analysis. Proposals for the water distribution systems of the Mahanadi Canal System and Hasdeo Bango Project are a rare example of a presentation of alternatives for canal flow levels and methods of rotation (WAPCOS, New Delhi, n.d. 598-599). In addition, a further treatment is in S.P. Malhotra's 1982 book on The Warabundi System and Its Infrastructure, especially the Chapter on "Distributary Design and Rotational Running".

The impression remains that alternative methods of water distribution on main systems are an underdeveloped subject both

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[9] There is one conceivable exception - "Studies in the Regulation and Operation of the DVC" by R.N. De. This was a flow regulation study but the abstract gives no indication that alternative methods of distribution were considered.

internationally and in India. From hard experience, common sense and improvization much is acquired. That learning does not appear to have been analyzed comparatively for third world operating conditions and embodied in methods for identifying and choosing between alternatives. Is it better on system X to rotate between outlets, between minors, or between distributaries? Is it better to run a channel continuously at one-third capacity, for half the time at two-thirds, or for a third of the time at full capacity? What rotation intervals are best in what circumstances, with what mixes of what crops, and how should they be determined? What are the procedures for analyzing the requirements of the outlets on a distributary, and then organizing the water supply so that they are met? What data are needed for such decisions, and how should such decisions be made? Economists, to my knowledge, have not yet turned their minds to critical questions like these. Engineers who often face them have not, to my knowledge, often seen these questions as major professional challenges; and if they have seen them, they have not written about this in professional journals. On the manner in which these questions are answered, channel by channel, depends whether millions of hectares will or will not receive water, and whether that water will be received in a manner which permits and encourages farmers to improve distribution among themselves.

As irrigation engineers and agriculturalists alike know from hard experience, the questions are not simple, and the possible solutions are often numerous. It is not just a question of timing, quantity, continuous flow or rotation, and sequences of water issues. Optimal water supplies are tied in with cropping patterns, labor constraints, planting times, and rainfall probabilities. The questions are also political, since they are concerned with whether certain areas will or will not receive water and how much they will get. The development and teaching of methods to determine and execute water distribution on main systems appears a major need.

Irrigation staff: motivation, management and behavior. Until the last few years, the problems, motivation and actions of irrigation staff were not a concern of social science research. Terms of service, transport, communications, financial regulations and the like have not appealed to social scientists. A number of studies[10] have now illuminated some aspects of the work environment, incentives and behavior of irrigation engineers engaged on operation and maintenance. The Jayaraman's study, (1981) found from a survey of 289 irrigation engineers in Gujarat that they preferred construction and design to operation and maintenance. The

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[10]Especially those of Bottrall, Jayaraman, and Wade (see references in each case). Botrall 1981c is a comprehensive review.

differences they affirmed were, that compared with operation and maintenance, construction and design were:

- More for "hard" applied science people;
- Offered more independence of action;
- Were less monotonous and offered more variety of experience;
- Carried better promotion prospects;
- Involved less public relations; and
- Were less vulnerable to transfers by dissatisfied politicians.

One way of tackling these problems is through greater professionalization of irrigation management. It would be naive to suppose that this would directly or quickly confront the problem of transfers. It is encouraging that the Jayaramans' study did not identify an objection to learning the multi-disciplinary skills necessary for operation. Indeed, the multi-disciplinary and complex questions involved in irrigation managemenet should make it far more challenging professionally than design and construction; consequently, to do well is more difficult. The recommendation often made for an operation and maintenance cadre is one step. The development of simulation games for use in the training of irrigation managers is another. In the long run, the content of training for the irrigation management cadre is critical. A basic problem remains that the system of sanctions through transfers which, while it persists, will inhibit irrigation staff from taking the unpopular measures which are sometimes necessary and may discourage able and committed staff from taking up operation and maintenance.[11]

One approach which has been proposed is the development and introduction of a management system which is concerned more with outputs (area irrigated, yields) and which monitored these to indicate performance (see Seckler 1981). It is also important that irrigation staff, whose efforts to control and operate canals more tightly, should be recognized and rewarded for not only their trouble, but also their risks. Part of the social science contribution here can be to examine and describe the actual conditions and problems of those who work in irrigation bureaucracies. This applies not only to engineers but also to lower level staff like lascars. Is there any description anywhere of a week in the life of a lascar? Unless the real activities and relationships of staff and farmers at the lower levels are

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[11]For further proposals see Jayaraman 1981.

understood, measures to improve performance may fall short of expectations.

Across and Up from the Outlet

The assumption so far has been that there is an organizational break or boundary at the outlet, where water passes from one jurisdiction - that of the irrigation bureaucracy, to another - that of the farmers. This is usually, or perhaps always, the case with existing warabundi. But it is not inevitable, nor is the outlet always the boundary. Two examples have been reported which show a different pattern. Water distribution to the 18 villages on the 1645 ha under the Dusi-Mamandur tank in Tamil Nadu is controlled by an elected organization with 54 representatives. The organization which is seeking registration under the Societies Registration Act, has replaced an earlier Irrigation Panchayat Board which was performing unsatisfactorily. The new organization makes itself responsible for ensuring water supplies into the tank (which entails, among other things, carrying labor by lorry to a point 15-20 km from the command), for maintenance of facilities, for water distribution, and for the settlement of disputes (Elumalai 1980). Similarly, an organization for 550 farmers on three minors at Alampur has elected a President to be responsible for the distribution of the 45 cusecs received by the area under command (Sitapathi Rao, n.d.). Such farmers' organizations, extending above the outlet, may be both more common and more feasible than supposed, especially in Southern and Central India.

This raises more pointedly the question of farmer organization and representation above the outlet. Such representation is increasingly proposed. Kathpalia (1980:41) has mentioned organizing and training farmers not only for distributing water among themselves within the chak, but at a later time to operate the minor as well. Jayaraman and Jayaraman (1981) have gone further and suggested a three-tier system with an outlet committee, a distributary committee, and an apex committee for a project as a whole. Such supra-outlet organizations or committees might simplify the work of irrigation staff in these ways:

- By appointing and paying staff to control and distribute water. This would make the equivalent of the lascar, accountable to the irrigators as a whole. (Such a system is found within communals, for example with the neerthoddis of Tamil Nadu. It has also been found below the outlet on canal irrigation in Andhra Pardesh, where cases have been reported of common irrigators responsible for distributing water to the fields being dismissed for failure to do their duty (Wade 1979:20). In Korea, farmers nominate and pay for patrollers, and similarly can get them dismissed if their performance is unsatisfactory (Wade 1981b).

- By handling conflict and disputes at lower levels.

- By providing a sounding board and a means of communication.

- By aggregating farmer interests and negotiating with other water groups, thus reducing political pressures on irrigation staff, and making it easier, through tailenders' pressures, to redistribute water from headreaches to tailends.

Such farmers' bodies would compliment a shift from an upstream supply approach to water distribution, to a downstream demand approach (Kathpalia 1980). There are many questions involved in any such complete or partial reversal, and one may expect them to be on the agenda for action research for several decades. They include the upward communication of local conditions and needs, and the speed and accuracy of response; the division of responsibility for maintenance; and the resolution of conflict and competition between segments of an irrigation system. At this stage, research could be useful on "spontaneous" examples of farmer organization above the outlet, coupled with monitoring an interpretation of experiences with committees or organizations which are encouraged officially at minor level and above. One question is whether the conditions which favor spontaneous supra-outlet organizations exist, or should be reproduced, on canal irrigation generally. There is here, perhaps, an irony. It may be easiest for such bodies to form and function where there is a clear collective interest in action to ensure their water supplies. If the Dusi-Mamandur organization did not exist, the farmers in the 18 villages might not receive water, or might receive much less. Where there is a strictly managed and routinized system of water distribution, as in Northwest India, the water arrives without such interventions. Most farmers will only invest their time and energy in activities which they see make a difference to their benefits. To the extent that the future lies with rigidly administered rotations to the outlet, as at present in the Northwest, supra-outlet comittees may be difficult to sustain. However, the aggregation and articulation of farmers' interests at different levels are a necessary precondition for some of the redistribution of water that is necessary.

Practical Political Economy

This last statement can be understood from the point of view of practical political economy, from examining who gains and who loses. Political economy is sometimes treated as a moral subject; but it is also practical. If changes in water distribution on canals mean that some have to lose, then political problems requiring political solutions can be anticipated.

This type of situation can be illustrated by a recent example, the introduction of IWM in kharif 1980 on the Vantivelagala Distributary on the Kurnool-Cuddapah Canal in Andhra Pradesh. Headreach farmers had been growing two crops of paddy a year on land which had been localized for one irrigated dry (i.e., non-paddy) crop. Tailend farmers, meanwhile, although they had been localized for paddy, were able to grow only an uncertain dry crop on less than the whole of their planned command area. Redistribution of the available water to enable the tailenders to grow paddy meant that topenders had to lose. The result was country bombs, a meeting addressed by a senior political leader and the District Collector, the imprisonment of one leading protester, and finally success in the sense that a big increase in irrigated area could be reported (CADD, AP 1981). Such confrontations may sometimes be necessary, and can be overcome with political support. But the political support itself requires the aggregation and articulation of the interests of those (usually tailenders) who are deprived. On the much larger scale of many canal systems, the organization of tailenders and political pressure and support from them may often be a necessary precondition for "stretching the membrane" for creating the induced shortages in the headreaches, which are needed for more productive and equitable distribution of water.

We are concerned not with a search for once-and-for-all solutions, but for practicable sequences of change over years and even decades. For early success with water redistribution a large scale, it may be cost-effective on a short-term basis to seek ways in which all irrigators can gain, or in which losses can be minimized. At first sight this looks improbable, since some have to get less water so that others can get more. It is not necessarily a zero sum situation. Headreaches are widely reported to be over-irrigated. The familiar headreach syndrome starts with a new irrigation headworks and abundant water available before the tails of the canals are complete. Headreach farmers then receive more water than they can use, and either opt for paddy or are forced to grow it, sometimes in both kharif and rabi. There may, however, quite often be opportunities for them to gain from receiving less water if it is issued to them in a timely, steadier and more predictable manner. Their benefits may include, for example:

- Reduced waterlogging and salinity;
- Lower labor requirements for water control;
- The chance to grow more remunerative crops;

- Higher returns from complementary inputs (fertilizers, pesticides, etc.).

Here is perhaps the greatest and most exciting challenge for multi-disciplinary research: to appraise canal irrigation systems with the headreach syndrome and to workout, with farmers, whether there are conditions in which with less water, distributed and delivered in a timely manner, and more steadily and predictably, farmers could be (and could consider themselves to be) better off. And then, if such ways are found, to workout sequences of changes to achieve those conditions (Chambers 1981).

Such appraisal requires the combined efforts of key disciplines, for example agricultural economics (to assess the private profitability of alternative cropping patterns, their labor and management demands, etc.), agronomy (to identify alternative cropping patterns under different water supply assumptions), agricultural economics (to assess their private profitability, and labor and management demands), irrigation engineering (to assess the feasibility of different water supply regimes), agricultural engineering (to assess the feasibility of water delivery from the outlet to the farm), and sociology and political economy (to assess the organizational and political feasibility of the change). Such appraisal invites the use and development of methods for the rapid and cost-effective understanding of farming systems and farm-level constraints (see, for example, Collinson 1981 and Hildebrand 1981). An early priority would seem to be to tryout such methods of appraisal and identify how widespread the opportunities are for all, or almost all, farmers to gain from redistribution, and then to test out and monitor such redistribution in practice.

Concluding

In conclusion, three themes from this paper can be highlighted.

- The need to raise the professional status and satisfaction of irrigation system management, especially water distribution. It is a complex and challenging task, and deserves recognition, resources, and public rewards.

- The need for interdisciplinary collaboration and thinking. One way forward lies through professionals in each discipline learning from others, not least social scientists learning from engineers and agronomists, so that each actor becomes a multi-disciplinarian.

- The need for field research and comparative analysis. This should examine what happens to water and who gets what, when, how, and why, and with what consequences; and investigate and compare relationships between the charcteristics of outlet water supplies, the allocation of water within the chak, cropping patterns, chak or village organization, and benefits and their distribution.

Pursuit of these three themes can be only part of any strategy for achieving more of the potential of canal irrigation; but, each has a strong contribution to make.

References

Ali, Syed Hashim 1980 "Integrated Water Management Above and Below the Outlet", paper for the Workshop on Warabundi, Administrative Staff College of India, Hyderabad, 23-26 April.

Ali, Syed Hashim and Syed Turabul Hassan 1980 "Management of Canal Irrigation Systems and Warabundi", in K.K. Singh ed. Warabundi for Irrigated Agriculture in India, pp. 32-37.

Anderson, Raymond L. and Arthur Maass 1971 A Simulation of Agricultural Systems: the effect of water supply and operating rules on production and income on irrigated farms, Technical Bulletin No. 1431, Economic Research Service, U.S. Department of Agriculture.

ASCE 1980 Operation and Maintenance of Irrigation Drainage Systems, ASCE Manuals and Reports on Engineering Practice, No. 57, American Society of Civil Engineers, 345 East 47th Street, New York 10017.

Benor, Daniel and James Q. Harrison 1977 Agricultural Extension: the Training and Visit System, World Bank, 1818 H Street, N.W., Washington, D.C. 20433.

Bottrall, Anthony 1978 "The Management and Operation of Irrigation Schemes in Less Developed Countries" in Carl Widstrand ed., The Social and Ecological Effects of Water Development in Developing Countries, Pergamon Press, Oxford, pp. 309-329.

Bottrall, Anthony 1981a "Water, Land and Conflict Management", ODI Review No. 1 1981, Overseas Development Institute, 10 Percy Street, London W1P 0JB (reviewing Coward 1980).

Bottrall, Anthony 1981b "Improving Canal Management: the Role of Evaluation and Action Research", Water Supply and Management, Vol. 5, pp. 67-79.

Bottrall, Anthony 1981c Comparative Study of the Management and Organization of Irrigation Projects, World Bank Staff Working Paper No. 458, May.

CADD, AP 1981 Final Report on Integrated Water Management in Vantivelagala Distributary of Revanur Branch Canal of Kurnool-Cuddapah Canal During Kharif Season of 1980 in Allagadda Taluk-Kurnool District, Tungabhadra Project Command Area Development Authority, Anantapur.

Chambers, Robert 1978 "Identifying Research Priorities in Water Development", in Carl Widstrand, ed., The Social and Ecological Effects of Water Development in Developing Countries, Pergamon Press, Oxford, pp. 383-398.

Chambers, Robert 1981 "Appraising and Improving Canal Irrigation" (draft for comments), Ford Foundation, 55 Lodi Estate, New Delhi, April.

Collinson, Michael 1981 "A low cost approach to understanding small farmers", in Agricultural Administration, Special Issue on Rapid Rural Apraisal, November.

Coward, E. Walter ed. 1980 Irrigation and Agricultural Development in Asia: Perspectives from the Social Sciences, Cornell University Press, Ithaca and London.

Elumalai, G. 1980 "Farmers' Organizations for Efficient Water Use in Irrigated Agriculture: a case study in Tamil Nadu", typescript.

Hassan, Syed Turabul 1981 "Evaluation Study of Warabundi (Rotational Supply System) under Sreeramasagar Project Command Area, Jagtial, Andhra Pradesh (since 1978)", Command Area Development Department, Jagtial, January.

Hildebrand, Peter E. 1981 "Combining disciplines in rapid appraisal: the Sondeo approach", in Agricultural Administration Special Issue on Rapid Rural Appraisal, November.

INC for IHP 1977 Water Abstracts 1970-1975, compiled by the Indian Institute of Technology, Kanpur, published by Indian National Committee for International Hydrological Programme, Council of Scientific and Industrial Research, New Delhi.

Jayaraman, T.K. 1980 "Farmers' Organizations in Surface Irrigation Projects: Two Empirical Studies from Gujarat State, India", paper for Workshop on Farmers' Organizations for Efficient Water Use in Irrigated Agriculture, Indian Institute of Management, Bangalore, 8-10 August.

Jayaraman, P. and T.K. Jayaraman 1981 "Attitudes of the Irrigation Bureaucracy in India to Scientific Water Management Tasks in Irrigated Agriculture: a case study from Gujarat State", Zeitschrift Fur Auslandische Landwitschaft, Quarterly Journal of Agriculture, Berlin Technical University.

Jayaraman, T.K. 1981 "A Case for Professionalization of Water Management in Irrigation Projects in India", Public Administration and Development, Vol. 1, No. 3, July-September.

Kathpalia, G.N. 1980 "Rotational System of Canal Irrigation and Warabandi", in K.K. Singh, ed., Warabundi for Irrigated Agriculture in India.

Keller, Jack 1981 "An Overview of USAID's Irrigation Investment Options and Strategies for Asia", paper for USAID/Asia Bureau Agricultural/Rural Development Conference, January 11-16, 1981 at Jakarta. Revised 1 May.

Lenton, Roberto 1981 "A Note on Alternative Forms of Performance Evaluation in Irrigation Systems", typescript, (available from Ford Foundation, 55 Lodi Estate, New Dehli 110003).

Levine, Gilbert, Peter Oram and Juan A. Zapata 1979 Water, report prepared for the conference "Agricultural Production: Research and Development Strategies for the 1980's", Bonn, October 8-12, 1979, DSE, GTZ, BMZ and the Rockefeller Foundation, (Report available from the Rockefeller Foundation, 1133 Avenue of the Americas, New York, NY 10036).

Malhotra, S.P. 1982 The Warabandi System and Its Infrastructure Publication No. 157, Central Board of Irrigation and Power, New Delhi, April.

Rao, C. Sithapathi, Departmental Report on Alampur Village, Rejolibanda Diversion Scheme, Command Area Development Department, Andhra Pradesh, cited in Ali and Hassan 1980, pp. 33.

Reidinger, Richard B. 1980 "Water Management by Administrative Procedures in an Indian Irrigation System", in Coward, 1980, pp. 263-288.

Seckler, David 1981 "The New Era of Irrigation Management in India", mimeo, Ford Foundation, 55 Lodi Estate, New Delhi, January (draft).

Singh, Bharat 1979 Fundamentals of Irrigation Engineering, sixth edition, Nem Chand and Bros., Roorkee.

Singh, K.K., ed., 1980 Warabundi for Irrigated Agriculture in India, Publicaton No. 146, Central Board of Irrigation and Power, New Delhi, November.

UNIAS, 1981 UNI Agricultural Service, Vol. III, No. 24, 11 June.

Wade, Robert 1979 "The Social Response to Irrigation: an Indian Case Study", Journal of Development Studies, 16, 1, October.

Wade, Robert and Robert Chambers 1980 "Managing the Main System: Canal Irrigation's Blind Spot", Economic and Political Weekly, Vol. XV, No. 39, Review of Agriculture, September, pp. A107-A112.

Wade, Robert 1981a "The Information Problem of South Indian Irrigation Canals", Water Supply and Management, Vol. 5, 31-51.

Wade, Robert 1981b "Employment, Water Control, and Water Supply Institutions: South India and South Korea", typescript, Institute of Development Studies, University of Sussex, Brighton, UK.

WAPCOS n.d. ?1981 "Planning of Water Distribution System - Rotational Water Deliveries", (transcript), Water and Power Consultancy Services, Ltd., "Kailash", 26 Kasturba Gandhi Marg, New Delhi.

APPENDIX A

SUMMARY AND RECOMMENDATION SECTIONS

FROM

IRRIGATION DEVELOPMENT OPTIONS AND

INVESTMENT STRATEGIES FOR THE 1980'S

REPORTS PREPARED FOR USAID

CONTENTS

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SUMMARY OF IRRIGATION TEAM'S RECOMMENDATIONS

BY COUNTRY VISITED

by

Max K. Lowdermilk

SOFTWARE STRATEGIES	Bangladesh	India	Pakistan	Thailand	Nepal
1. Provide diagnostic analysis training: for:					
• Project staff	X	X	X	X	
• Managers of systems	X	X	X	X	
• Policy makers orientation	X	X	X	X	
• Monitoring and evaluation teams	X	X	X	X	
• Project appraised teams	X	X	X	X	
2. Provide minor officials training for:					
• Gate keepers		X		X	
• Section officers		X	X	X	
• Extension	X	X	X	X	X
3. Improve information systems from farm level to reservoir	X	X	X	X	
4. Present special orientation for AID program offices dealing with projects with irrigation components	X	X	X	X	X
5. Provide AID Missions with more personnel technically trained in irrigation to help identify, prepare and monitor projects in the field.	X	X	X	X	X
6. Technical assistance for action-research to improve systems.					
• Conduct benefit/cost analysis of extending or improving systems vs. new systems.	X				
• Make careful economic assessments of all costs (energy, organizational management) in terms of per unit irrigated area to be served.	X				

SOFTWARE STRATEGIES (Cont.)	Bangladesh	India	Pakistan	Thailand	Nepal
6. Technical assistance for action-research to improve systems (Cont.)					
• Analyze development model management systems for medium size irrigation systems.		X			
• Promote more pre-project diagnostic analysis which includes physical, social, legal, economic and agronomic dimensions and utilize in project design.	X	X			
• Support analysis of power development for irrigation.		X	X		
• Inventory the number and characteristics of existing shallow wells.			X		
• Analyze existing systems and develop models of the whole basin to improve on-farm water management.			X		
• Conduct socio-economic analysis on trade-offs between canal, watercourse improvements and small tubewell development.			X		
• If the above analysis is positive, support small tubewell development and role of in-country private sector for manufacturing of pumps, pipe, motors, services, etc. (test, refine, evaluate).			X		
• Conduct a research and development program on the cost effectiveness of small tubewells in order to select best technologies.			X		
• Study existing electric pump systems for improvement.	X		X		
• Place adequate attention on studies and experiments to gain more farmer involvement.	X	X		X	X

SOFTWARE STRATEGIES (Cont.)	Bangladesh	India	Pakistan	Thailand	Nepal
6. Technical assistance for action-research to improve systems (Cont.)					
• Conduct system analysis to ascer tain alternate cropping systems and special studies of problem soils.				X	X
• Investigate water power development of small rivers.					X
• Utilize special consultants for drainage and salinity problem analysis.		X	X		
• Analyze improved monitoring methods and ways to train team monitors for large systems.		X	X		
FOCUS ON SPECIAL TYPES OF TECHNOLOGIES					
1. Pump systems for dry and wet season.	X				
2. Improved gravity systems designed for dry seasons to supply water during critical periods of wet season.	X				
3. Focus on improved water control at the farm level in all irrigation projects.	X	X	X	X	X
4. Avoid pumping projects unless there is assured adequate power supply.		X			
5. Consider need to focus on finance and development of electricity and other power supplies for irrigation where needed.		X	X		

FOCUS ON SPECIAL TYPES OF TECHNOLOGIES (Cont.)	Bangladesh	India	Pakistan	Thailand	Nepal
6. Focus on programs to reduce erosion, i.e., watershed management to assist marginal hill people, provide protective irrigation and protect the irrigation system downstream.		X	X	X	
7. Support small tanks and tubewells in hill areas.				X	X
8. Support village ponds for household water, fish and irrigated vegetables, and promote equitable distribution of benefits.				X	
9. Provide technical assistance, and perhaps some credit, for refining and demonstrating precision land leveling technologies, but do not finance large LL programs.		X		X	
10. Test, adapt and utilize new technological innovations such as:					
• PVC pipe		X	X	X	X
• Underground pipe systems					
• Reduced size of unit command areas			X		
• Improved farm level irrigation structures			X	X	
• Improved channel lining	X	X		X	
• Warabundi allocation	X			X	
• Precision land leveling				X	
• Using farm tractors					
11. Make designs more flexible so changes can be made when evaluation results indicate need.		X	X		
12. Insure that people displaced (unindated) by tanks are fully compensated.				X	
13. Test technologies which can be used to minimize farmer conflict such as smaller unit command areas and underground pipelines where there are problems over land and water rights.	X	X	X	X	X

STRATEGIC POLICY CONSIDERATIONS	Bangladesh	India	Pakistan	Thailand	Nepal
1. Study social and environmental impact.				X	X
2. Make careful economic examination.				X	
3. Promote equity between users.	X	X	X	X	
4. Consider role of women in planning and implementation.	X	X	X	X	
5. Focus on:					
• Small vs. large scale projects	X			X	X
• Medium vs. large scale projects		X			
6. Encourage private systems (tanks, pumps, tubewells) where feasible and promote the private sector.	X	X	X	X	X
7. Avoid projects where there is no strong problem-solving and monitoring capability.	X	X	X	X	X
8. Front-load or include training, adaptive research (testing and refinement) and institutional building as key components.	X		X		
9. Support the development and monitoring of tank systems which range from 10 to 2000 ha.		X			
10. Do not support irrigation development unless other inputs will be made available (varieties, fertilizer, credit, extension).				X	X
11. Support credit where it does not exacerbate other problems.		X			
12. Support dual strategy for both irrigated and rainfed areas.			X		
13. Promote the establishment of and support legal water user associations.	X	X	X	X	

STRATEGIC POLICY CONSIDERATIONS (Cont.)	Bangladesh	India	Pakistan	Thailand	Nepal
14. Support efforts to modernize the water codes and laws which are used to govern systems.	X	X	X		
15. Provide TA for planning and design of large scale systems.				X	
16. Support basin wide planning and design.				X	
17. Change emphasis from wet season irrigation to dry season irrigation with a focus on equitable distribution.				X	
18. Provide sinking fund for O&M over life of new projects.				X	
19. Base irrigation project success on improvements in production possibilities and actual production increases for all classes of farmers.	X	X	X	X	X
20. Continue to focus on improving rainfed farming systems.				X	X
21. Develop a comprehensive approach to help LDC's coordinate government agencies involved in irrigation.	X	X	X	X	X
22. Place emphasis on improving on-farm water control.	X	X	X	X	X

IRRIGATION DEVELOPMENT OPTIONS AND INVESTMENT STRATEGIES FOR THE 1980'S

BANGLADESH

SUMMARY AND RECOMMENDATIONS

Very clearly, there is a substantial opportunity to increase production in Bangladesh, given the abundant water resources. Thus, irrigation must be considered a priority in the country's development. Unfortunately, the donor financed irrigation schemes which have already been put in place fall short of realizing the desired level of output. Thus, the economic benefits (and probably the social benefits as well) are considerably less than costs. Furthermore, the necessary production levels for achieving food self-sufficiency in the future are far from being realized.

The disappointing output for most irrigation projects is to a major extent due to the general lack of attention which has been given to: equitably distributing project developed water supplies to the individual farmers' fields; and assisting the farmers in managing the irrigation water, along with other necessary inputs.

The discharge from a typical gravity canal outlet, low lift pump, or deep tubewell is about 2 cfs (900 US gpm or 60 lps). In Bangladesh, farm holdings and fields range between 1 and 5 acres (0.4 and 2 ha) and a 2 cfs supply should be sufficient to irrigate 80 to 160 acres (32 to 64 ha), depending on the crop, season and percentage of time the water is flowing. Thus, potentially 50 to 100 farmers can be supplied from a 2 cfs source. To accomplish this requires an extensive watercourse (channel or pipe) system to distribute water from the source to the fields plus coordinated management. Since watercourses are not normally provided, water is distributed by flowing from field to field (paddy to paddy); and lacking coordinated management (through such enterprises as water user associations), the average area irrigated from a 2 cfs source is only about 40 acres. Furthermore, field to field distribution is only practical for rice paddy irrigation where a large supply of low cost water is available.

The main text contains additional descriptive and background information for the recommendations which follow. The review team presents these recommendations as kinds of objectives for AID's investment policy to emphasize in irrigated agriculture during the decade of the 1980's in Bangladesh.

1. The team recommends that the proposed Rural Irrigation Works project which is designed to produce and test model projects should be totally overhauled to reflect:

a. An appreciation and exploration of alternate design possibilities.

b. An organizational structure which integrates government agencies necessary to successful implementation of the project.

c. Training and monitoring programs which are better integrated into the Bangladesh system.

2. The team believes that the proposed Nobaçana Integrated Land and Water Use Study project is unrealistically ambitious considering the complexity of developing four major components (irrigation, fisheries, village industries, and agricultural practices on non-irrigated land) simultaneously. Furthermore, the irrigation component is even more difficult than the existing deep tubewell projects which are severaly under-utilized and a procedure for improving their performance is still to be tested (see recommendation 1). Therefore, we recommend that the project be restructured and/or simplified before proceeding further.

3. The general consensus seems to be that a substantial technology for rainfed paddy production is not yet available, but it is likely to be so, well within the next five year period. It is too early to determine: (a) the yield and income potential of that technology, and (b) the relative profitability of investments in delivering that technology compared to investments in irrigation. Reliance on rainfed agriculture leaves much of Bangladesh without year long crop production and limits production to those periods when sufficient moisture is available. Therefore, the soil and climate resource goes unused for six months or more every year. In addition to increased production, irrigation affords a degree of insurance against unusual drought periods. Furthermore, one of the principal resources in Bangladesh is a cheap and readily available water supply. Therefore, the study team recommends that AID provide some development assistance for rainfed agriculture, but places a major emphasis on irrigation project development and improvement.

4. At the present time, the economic benefits of supplemental irrigation have not been thoroughly investigated. It is highly likely, however, that supplemental irrigation with existing pump operations is economically feasible, especially under those circumstances where there is no competition between seasons for the available water supply. There are no studies which compare the marginal benefits of limited water supply between seasons or between crops within seasons. For the most part, however, pump operated systems should be designed for operation in all seasons

(year-round). Clearly, there is strong evidence that any gravity canal system designed for dry season irrigation should be organized and managed to provide full season irrigation. However, there is not sufficient evidence available at present to advocate building gravity canal systems with only a supplemental irrigation capability for paddy.

5. It is quite clear that the planned-for potential of none of the irrigation alternatives, large or small, has been achieved. There are long lists of possible causes, but in all cases these are either informed judgments, hypotheses or pure speculation. There have been no attempts to determine if the costs of increasing the irrigable area can be justified by the potential benefits. Indeed, some consultants are even suggesting that it may be more economical to sink new tubewells than to improve the distribution systems and bear the organizational and increased water management costs on existing installations.

   There is strong evidence to suggest an opportunity to increase irrigation from existing projects. There is no available information to evaluate the capital and operating (energy and management) costs and benefits associated with choosing that particular development option. The study team recommends that investigations of these costs be undertaken in an organized, professional manner. A project might be developed with this as its objective (giving special emphasis to energy use efficiency).

6. Bangladesh is committed to an irrigation program which includes both very large and very small projects (i.e., individual irrigation units). The available evidence to date shows that small scale projects in the less flood prone areas of the country have higher rates of return than large projects. Given AID experience with larger projects and the evidence favoring small projects (as well as the considerable support being given for the larger gravity-pump systems by other donors), AID should not provide financing for large scale projects in Bangladesh at this time.

7. The team recommends that AID encourage development of the private sector in Bangladesh when it appears consistent with their capability and the equity concerns of government. (In reality, it is likely that irrigation will be developed jointly in the private and governmental sectors).

8. The study team suggests that the Mission avoid involvement with integrated land and water management projects which do not have a strong monitoring and problem solving capability. This may depend ultimately on the Government of Bangladesh's commitment

to facilitating projects of this nature. Integrated projects should reflect experience gained by donors who have been funding these types of projects. Given the Mission's lack of experience with integrated projects and the present restructuring of in-hourse supportive research and monitoring capability, the team suggests that the Mission concentrate efforts on direct irrigation projects with adaptive research and institutional building components.

9. The opportunities for investment in the provision of software to support irrigation development in Bangladesh appear great. Training and demonstration activities might be provided through short courses, grants to other agencies involved in institution building, fellowship programs, construction of schools and buildings, preparation of training materials specific to local conditions, sponsoring of country and regional seminars and workshops. In addition, adaptive research to improve farm water delivery efficiency and equity and field irrigation application practices is needed. Studies and planning for comprehensive agricultural resource (rainfed as well as integrated) development are also essential.

10. The failure of all types of projects in meeting projected outputs can in part be attributed to inadequate water distribution to the field. Therefore, the review team recommends that AID emphasize on-farm delivery in any project which they might undertake. The team cautions against acceptance of any system without first assessing the costs (including hardware, energy, organizational and management) per unit of command area. As an example, for tubewell projects, costs of different combinations of well size and distribution systems for serving the respective command areas should be assessed.

11. The effect of irrigation development on the roles of women in the Bangladesh social system has not been seriously considered in project planning and implementation. This seems an unfortunate oversight because undoubtedly women play important roles in decision making, organization, and are a part of the agricultural labor force. The survey team recommends that the role contribution of women in irrigation project planning and implementation be seriously considered. The team feels this will be to the benefit of all of the projects.

12. The rural population in Bangladesh is grossly malnourished; and irrigation can enable the growing of vegetables during all seasons. This can materially improve the nutritional status of the farm families. Both ongoing and proposed irrigation projects have unrealized potential for vegetable production.

The review team recommends that exploitation of the potential for vegetable production be considered when developing new projects. Systems should be designed and managed to provide irrigation water to family garden areas during all seasons.

IRRIGATION DEVELOPMENT OPTIONS AND
INVESTMENT STRATEGIES FOR THE 1980'S

INDIA

SUMMARY AND RECOMMENDATIONS

Irrigation in India has been practiced from ancient times and has expanded steadily since then. Irrigation development continues to be given priority, and as of the end of 1979-80, the estimated irrigation potential stood at about 58 million hectares; this accounts for roughly 51 percent of the gross ultimate potential of 113.5 million hectares. But this considerable potential already created, is under-utilized. According to a recent (1980) American Embassy Report (see Appendix A), this is caused by a sizable gap between potential and actual utilization due to inefficient water management practices. The report suggests that a 25 percent increase in utilization can be obtained by improved on-farm delivery systems and in-field water management.

The importance of irrigated agriculture to India can hardly be over-emphasized. While only 37 million hectares out of the total 127 million hectares of foodgrains are irrigated, the irrigated area produces half (63 million MT) of the total grain produced. Average irrigated yields are 1,700 kg/hectare, while unirrigated yields are only 700 kg/hectare.

The conjunctive use of surface and groundwater is extremely important in India's irrigation development program. The average total annual surface water resources are estimated to be about 178 million hectare meters (Mha.m). However, this resource cannot be fully utilized due to the highly variable character of the flow and other limitations imposed by the country's geology and terrain. Given these limitations, the Irrigation Commission, in 1972, estimated the total directly usable surface flow for irrigation at 66.6 Mha.m. The National Commission of Agriculture estimates that this quantity will be sufficient for ultimately irrigating 73.5 Mha (58.5 Mha of major and medium irrigation projects and 15 Mha of minor projects) by the end of 2025 A.D.

The Central Groundwater Board has estimated that, by 2000 A.D., the total annual groundwater resources will be 57 Mha.m with recharge of 29 Mha.m from rainfall, 22 Mha.m from canal seepage and return flow, and 6 Mha.m seepage in return flow from groundwater systems. However, various factors limit utilization of the total groundwater for irrigation to an estimated 26 Mha m. The National Commission on Agriculture estimates that this quantity is sufficient to ultimately bring an area of 40 Mha under irrigation by 2025 A.D. Thus, pumped irrigation from groundwater is expected to account for 35 percent of the estimated total of 113.5 Mha by 2025 A.D.

The scope, structure and operation of existing and projected irrigation projects and enterprises are extremely varied in India. They range in sizes from small wells serving a few hectares to projects of over a million hectares. Irrigation is practiced under numerous different soil, topography, climatic, and crop conditions. Furthermore, there is considerable diversity in the policies of different states and the social relationships in different villages. Therefore, there can be no singular set of directives for irrigation development in India.

Government policy has emphasized extensive distribution (over a large area) of irrigation benefits from a given water supply, while at the same time trying to achieve equitable distribution of these benefits within the extensive areas served. This dual objective is commendable; however, to accomplish it is indeed a challenge, especially considering the relatively limited resources of water, capital and professional irrigation management personnel plus the political realities in India.

From a political point if view, every district naturally wants a share of irrigation development activity. This has resulted in thinly spreading the available resources between too many new irrigation projects and the operation of existing ones. Thus, many projects are started and not completed in a timely fashion; and most of the officially completed projects are incomplete in that they cannot deliver the planned-for stream of output benefits.

Most projects visited lacked the following: (1) efficient and effective facilities to distribute water from the project canals (or pumps) to the farm fields; (2) efficient means to destribute water to the plants growing on the fields; and (3) effective management of the total irrigation system between the plants and the water supply. These deficiencies cause under-utilization of the irrigation facilities which have been constructed and considerable inequity in the distribution of benefits from them. We estimate that the utilization of the theoretical irrigation potential of the projects we visited range from a low of about 10 percent up to 100 percent. Private wells were effectively utilized but too many of the major and medium projects seemed to fall in the 50 percent utilization range.

Many projects are also uneconomical because only a fraction of the irrigation potential can be realized since relatively few (lucky) farmers are provided with a reliable water supply. These are the farmers who happen to have fields at opportune locations along the extensive canal distribution systems.

Fortunately, the seepage from unlined channels and drains, plus percolation from excess and non-uniform irrigation, recharge the groundwater reservoir. This in turn may support intensive groundwater development in the command areas of under-utilized gravity irrigation projects. Thus the project may function as an extensive water spreading system and the groundwater withdrawals recover some of the lost benefits and improve equity.

The non-saline aquifers underlying large alluvial plains serve as both excellent storage reservoir and intensive water distribution systems, for they hold a ready supply of water beneath each field. If it were not for the unpredictable escalating cost, and more importantly, unreliability of energy supplied (and in some areas salinity and waterclogging), a combination of private and public groundwater would usually be the most effective way to optimize irrigation potential from under-utilized gravity projects. While it might be thought best to always use the surface water efficiently while it is on the surface, the reservoir function of the aquifer for carrying water from the wet to the dry season, the availability of drought years, and the higher distribution efficiency of private tubewells all argue to the contrary, if the energy is there and is not too expensive.

Government planners generally recognize that the irrigation potential which has already been created (in theory) cannot be realized without rehabilitating most projects. Actually, much of what is called rehabilitation is simply extension of the distribution system with the related structures for delivering water from the project canals to the individual farms. Extended delivery systems are needed in order to effectively manage projects so they can provide equitable and reliable irrigation water to most farmers in the command area.

The American Embassy report points out the desirability of extending the canal system and providing field channels and gives the following review of progress in this direction. Irrigation Departments have been charged with constructing and operating at project cost the canal system down to an outlet serving a farm area (called a chak) of 10 to 100 or more hectares. The farmers below the outlet are expected to construct the channels and operate them to deliver water to their holdings. This is responsibility which is beyond the technical and organizational capacity of most groups of farmers, many of whom operate one hectare or less. The result is that only about half of the 25 million hectares in major and medium irrigation schemes have field channels, and most of these are unreliable and inadequate.

In October 1978 the GOI instructed the States to include the channels from the 40 hectare level down to the eight hectare level as

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project costs for all new and rehabilitation projects. Organized public sector credit is available for channels to each farm holding and on-farm development on the 76 CAD and foreign donor-financed projects in the country with unorganized credit (private) used by farmers where possible on non-CAD projects. Watercourses are commonly lined down to the eight hectare level. Present USAID policy is similar, except funding is provided for lining based on technical and economic considerations which in some cases would be down to the eight hectare level.

With a water delivery system and the necessary structures to control deliveries to each holding, total irrigation system management is the next necessary ingredient for success. A formal rational water delivery schedule, called a warabundi must be enforced in each chak to assure each farmer a fair share of water where a demand system is not practical. The main system must be managed to provide equitable and timely supplies of water to each chak and the total system must be maintained in good working order.

The team found ample evidence that Indian farmers, who have a reliable and predictable water supply, will commit needed resources to effectively irrigate their holdings when this is economically justified. The numerous (millions of) private tubewells, many of which have pipe distribution systems serving graded fields, are evidence of this. However, farmers do need credit and technical support to fully develop the irrigated potential provided.

In 1973, the Central Government called on the States to establish Command Area Development Authorities (CADA's) to optimize irrigation potential. CADA's are given the task of providing management and technical assistance and coordinating financial support for improving on-farm water distribution and in-field application within the command area. In addition, CADA's coordinate other infrastructural inputs such as storage and markets are charged with strengthening the organization of agricultural extension activities in general.

The CADA's now coordinate services for almost all of the 60 major irrigation projects in India (covering a cultivable area of 13 million hectares), but their record has been disappointing. The most obvious problems which the review team observed are that: (1) the main system (between the chaks and water supply) operation is unreliable because of mismanagement, poor maintenance, and the lack of effective control structures; (2) there is little coordination between the main system management, which is the responsibility of the State's Irrigation Department and the CADA's, which are usually under the State's Agricultural Department; and (3) most of the CADA's themselves are weak and ineffective because they only coordinate, not control, inputs and personnel from other agencies.

The Central and State governments are aware of the problems with CADA's and efforts are under way to remedy this situation. There is serious discussion concerning dividing the Irrigation Departments into two separate, but parallel, cadres. The traditional roles of planning, design and construction will be housed in one cadre; a new cadre staffed with professional irrigation system management personnel will be established to manage, operate and maintain (MO&M) the total irrigation system. However, since irrigation development is the perogative of each State, a unified approach to system management may be long in coming. In the meantime, AID and other donors can play an important role by encouraging projects (through funding) that are designed to provide the needed delivery and control facilities and a coordinated program to manage the total irrigation system.

Currently, the Mission's program is mostly directed at medium irrigation projects and the development of CADA's and training programs in the States of Gujarat, Maharashtra, and Rajasthan. The Mission is also involved in credit programs for minor irrigation (mostly wells and pumpsets). Projects which are being considered are a small tank rural development project with activities in several States including Haryana, medium irrigation projects under improved criteria in Maharashtra, establishment of a CADA for AID supported MIP's in Rajasthan and a minor irrigaton scheme in Madhya Pradesh. (Under current criteria medium irrigation projects serve 2,000 to 10,000 hectares and minor schemes serve 2,000 hectares or less). This is a well-thought-out program and it should provide a good base to build on in the future.

The Mission is also planning a project to support water management training and special studies which can have a long term positive impact on irrigation development in India. The Mission technical staff is hardly large enough to adequately serve this set of programs and projects. Besides program officers and technical field staff are needed to monitor progress and encourage desirable performance. The review team visited irrigation projects and facilities in most of the above-mentioned States. The recommendations which follow are based on team field visits, document reviews and discussions with numerous officials at the National, State and project levels, and visits with many farmers while in their fields and villages.

Recommendations

We present these recommendations as kinds of objectives for AID's investment policy to emphasize in India during the decade of the 1980's. However, we realize that, because of political, social, managerial and financial restraints, it will be impossible to completely follow them. We believe it is most important to maintain a pragmatic investment program and use our recommendations to focus on options and strategies rather than use them to control the program.

The team also recognizes that the Mission will need a larger technical staff to carry out a program which addresses these recommendations and helps the Central and State governments to significantly improve the performance of existing and future irrigation developments. In view of the short period of our visit, in relation to the magnitude of the irrigation potential in India and our own limitations for carrying out this task, we present these recommendations with a great deal of humility:

1. We applaud the Mission's current medium irrigation program and believe it provides a good basis from which to build. We agree with the policy of having distribution channels constructed at project cost and/or credit mechanisms to each farmer holding; and the practice of 40 percent lining of watercourses to reduce losses. We recommend that additional lining and control structures be considered to make the farmer management unit smaller.

   We also recommend that the Mission expand its technical staff in order to properly monitor the field activities of this irrigation program. (A larger technical staff will become essential as the program expands.) We realize that some of this medium irrigation program is piggybacked on World Bank projects, but these, too, need more monitoring than the World Bank provides.

2. USAID should attempt to set up a model management irrigation system in a medium command area in India of say 4,000 to 10,000 hectares. The purpose of this model management system would be to rehabilitate an existing irrigation command to improve total crop productivity in the command area and to demonstrate the importance of effective management for other commands in India. The model requires efficient management and distribution of water, control of other water-related inputs such as hybrid seed, fertilizers, and where necessary, credit.

3. In connection with the model management sytem, AID should energetically stimulate new technical innovations in irrigation systems. For example, it now appears to be clear that, for irrigation commands with hydraulic slopes of greater than 25 percent, PVC pipe distributaries are both cheaper and more effective than lined channels for carrying flows of less than two cubic feet per second and quality

installation is more assured. AID should also sponsor intensive research and demonstration work on the use of small storage (surge) tanks within the command area to avoid some of the problems of night irrigation and intermittent electrical supplies on tubewells.

4. A particularly important deficiency in the management of irrigation systems in India is the lack of information on the actual performance of irrigation systems. We are pleased to find that USAID is beginning to sponsor innovative operational research and training in the design of rapid appraisal and monitoring systems for large command areas to determine the performance of these systems in efficiently delivering water to the fields at the right time in the right quantity to the right farmers.

5. There is a crucial need for better pre-investment and diagnostic surveys for all projects in India. Before any new or rehabilitation project is undertaken there should be a field analysis of soil characteristics, hydrological information, social systems, current cropping and irrigation practices, and land ownership and farming patterns in the command areas. The design evolving out of the pre-investment survey should explicitly address such issues as: soil-water relationships, water duty under alternative crop regimes; the economics of conjunctive use trade-offs and energy requirements; the equitable distribution of water between users; and problems identified in the diagnostic review of systems to be rehabilitated. Explicit attention should be paid to providing physical facilities which fit the specific management structure intended to realize project objectives and the means of monitoring the performance of the system with respect to those objectives.

   Irrigation systems should be diagnosed periodically in order to provide information for upgrading design assumptions (criteria) and provide necessary feedback for adequate system management. While design criteria must be momentarily fixed to provide a structure for each increment of investment capital, any set of criteria should be subject to change pending new technical, economic, and/or social developments and findings. A similar statement can be made for management organizations and programs.

   Because of the scarcity of trained personnel in India, the study team recommends that the diagnostic surveys suggested above be phased into all AID projects as talent becomes available. Realizing that adequate numbers of trained personnel are not available in India for this, we

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recommend that AID support an appropriate training program. The objectives of this program should be to train multidisciplinary teams to systematically analyze the agronomic, economic, engineering and social aspects of irrigation systems starting from the bottom (on-farm level) and synthesize the component analysis into an interdisciplinary diagnostic report decribing how the system is working and how well it is producing the desired output (i.e., crop yields and equity of benefits).

The Water Management Synthesis Project (which has funded this India study) has already developed a pro forma training program and test materials to begin addressing this need. Since the team visited one course was given in Gujurat and another requested in Rajahistan. It is hoped that similar courses will become part of a continuing national training program.

6. It is clear that the quickest, most cost-effective means of bringing effectively irrigated acreage into production in India is through tubewell development. It must be realized, however, that India is undergoing a severe energy crisis which is reducing the pumping time of tubewells to perhaps one-half. The solution is to invest more in power development, not to stop tubewell development. Power availability is expected to improve steadily with gaps narrowing sharply and being eliminated by 1990. It should be considered, however, that previous power development programs have not kept pace with projections and expectations. During drought years power demands increase and hydro power availability is at a minimum. The team therefore points out the obvious benefits of tubewells, but cautions against investment when availability of power may be too uncertain. The use of diesel powered pumping may be considered if adequate.

   There are in India vast areas such as the Deccan plateau where groundwater is developed through hand dug wells into fractured rock with low specific yield. These wells can only be pumped four to six hours a day and even in areas of power shortage there is much room for development using off peak power.

7. In light of the absolutely crucial threat to the food production system of India posed by the power shortage, and the confusion we find in trying to pinpoint the practical and timely availability of energy for irrigation pumping, we recommend that AID give serious attention to helping the Government of India understand the nature and concentration

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of the irrigation pumping load. This is necessary to better utilize existing and potential power resources through seasonal load shifting and development of hydro and coal power facilities. AID should commission a power consultancy team to investigate the current status of and opportunities for managing and developing power sources and improving operational efficiencies for tubewell and lift irrigation throughout India.

One of the suggestions for this team to investigate would be to create small captive power units in the 1,000 hp range (which have been shown to be economical in the United States) utilizing coal resources. Some of these plants may be located in the high groundwater table, such as the extensive coal reserve regions of Bihar, where many of the poorest people of India desperately need tubewell development. Also, these captive power stations could be scattered along the railway systems over groundwater ares in the Indo-Gangetic plain. The team should also investigate the possibility of small micro-hydel units in existing reservoirs, run of the river systems, and systems in the drop structures of large canal distributaries. For example, all small reservoir may be equipped with micro-hydel to generate electricity for tubewells out on the periphery of surface irrigation commands (thereby making head-enders out of tail-enders). The power team should realize that it is not only cost that matters in this situation, but it is the difference between production or no production from tubewells.

In addition, we suggest that official USAID policy for India consider investments in the development of electric power generation (and energy in general) as complementary to irrigation and thus equivalent to food production. In the Sixth Plan, half of the 15 million hectares of proposed developments depend on pumping (mostly from groundwater). In much of India more power means more food!

8. While we did not see the waterlogged and saline areas of India ourselves, the Government of India is very concerned with the estimated four to seven million hectares of land which are seriously affected by these problems. Cost effectiveness suggests that canal water be used more effectively on the surface in the saline areas. This can be accomplished by lining channels to reduce water losses throughout the distribution and application systems and improving farm water management practices. Vertical drainage through tubewells, where practical, is the best solution once waterlogging has occured. But again this

problem can be solved only if power is available. Captive power plants for tubewell drainage would be a very beneficial investment. AID may wish to constitute a special drainage and salinity team to advise the Government of India on this problem.

9. Over the next few decades the next most severe threat (after power shortages) facing food production in India is the rapid siltation of existing reservoirs caused by inundation of catchment areas. A recent survey of nearly 30 of the larger reservoir systems has shown that the current rate of siltation is on the order of three times the design rate. AID may be able to provide technical help in estimating the current rates of siltation into these systems and to devise programs for arresting the rate over the future; for example, through creating a program of soil and water conservation and aforestation in the catchment areas of some of the endangered reservoirs. One of the Government officials we visited suggested this type of project for AID support. AID's current forestry project may provide guidelines for such future projects.

10. From studies conducted by the Ford Foundation it appears that in India there is substantial under-exploitation of the opportunities for minor irrigation projects with small reservoir and tank developments (10 to 2,000 hectare command areas). In some areas these small tanks can provide a means of relieving the pressure on tubewell facilities. For example, in the Maharashtra lift scheme area there were many sites suitable for tank irrigation. The problem with small reservoir and tank developments is again a management problem, i.e., management of the watershed, reservoir and complete distribution of the water. We recommend that AID support this area over the future and want to encourage the Mission's current efforts in developing such projects.

These minor irrigation projects are particularly attractive because they can be developed quickly. It only takes one to three years to go from implementation to delivering water to farmers. New medium irrigation projects typically take over five years and major projects may take more than nine years.

11. USAID support to the Agricultural Refinance and Development or other credit agencies should be carefully evaluated in terms of specific objectives. For example, because of the power shortage as outlined above, it is not at all clear that tubewell development should be encouraged over the immediate future. Also very close inspection should be

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given to credit facilities and subsidization for land leveling activities. The rate of default in many of these loans approaches 90 percent. Land leveling is in essence a private good which farmers can do themselves if they so desire, but they should be provided with adequate technical support and demonstration programs; for example, in new and rehabilitation projects 10 percent of each farmer's land up to a limit of one acre might be leveled as a project expense, but the farmers should be expected to pay for the balance. Experience in other countries suggests that cost-effective, well-managed organizations which provide farmers with an appropriate land leveling service can be developed.

12. There needs to be a broadening of the base of expertise in water management through more effective use and training of agricultural engineers and training of irrigation engineers wishing to specialize in water management. Special training emphasis on water management will demonstrate the need for integration and application of the skills of crop production practices, extension, economics, management science and engineering. This training is especially needed in the CADA system. We recommend that AID develop appropriate training support programs to address this need.

IRRIGATION DEVELOPMENT OPTIONS AND
INVESTMENT STRATEGIES FOR THE 1980'S

PAKISTAN

SUMMARY AND RECOMMENDATIONS

The Indus Basin irrigation network supplies water to 13.6 million hectares of land. This is the world's largest continuous interlinked irrigation system. There is relatively little surface storage in the system and most of the canal water is diverted from rivers. Water conveyance and application efficiencies are low. This causes waterlogging and salinity problems but it also recharges the groundwater aquifer. Since existing and potential surface storage is insufficient to meet peak use rate demands, tubewells to tap the very large groundwater reservoirs are an important component of the comprehensive irrigation system. This conjunctive use of surface and groundwater is also important in efforts to control waterlogging and salinity.

The unlined canal systems deliver continuous flows of 1 to 3 cfs (30 to 60 lps) to command areas which usually exceed 250 acres (100 hectares) for each cfs (30 lps). Unlined public watercourses were originally constructed along with the main canal system. These watercourses are maintained and operated to deliver 1 to 1.5 cfs flows through earth outlets on a fixed weekly rotation schedule (warabundi) to each farmer's fields. Typical operational holdings range from 10 to 25 acres and in accordance with the warabundi schedule, each is supposed to receive the full watercourse flow for a length of time proportional to the area of his holdings.

The public watercourses are poorly maintained and field ditches are usually inadequately graded for efficient irrigation. Thus, cropping intensities have not improved to the degree expected and crop yields have remained low in spite of the costly development of major storage dams, barrage and canal systems, and tubewells. It has become evident that more cost effective means of increasing irrigation water availability must be pursued -- one such is that of improving water management at watercourse and field levels. With this in mind both the World Bank and Asian Development Bank are presently considering loans totaling over $200 million with the major emphasis on watercourse and distribution system improvements and surface drainage.

The principal watercourse improvement activities suggested in these Bank projects involve unlined channels. The pending Bank projects provide little support for: adaptive research to develop and test model projects; train the technical staff needed to design, construct and monitor the projects; and conduct studies to move strategically target investments in terms of water tables and conjunctive use.

In addition to the 13.6 million hectares of cultivated land which can potentially be served by irrigation there are approximately 5.9 million hectares of cultivated land that depends entirely on rain. Much of this rainfall area is in hilly regions and this is where poverty is greatest.

The main text contains additional descriptive and background information for the recommendations which follow. The recommendations are presented to provide guidance for any future USAID investments in irrigated agriculture in Pakistan during the decade of the 1980's.

1. The study team endorses an AID strategy that fully develops the potential for irrigation. It recognizes, as discussed elsewhere in this report, that the potential for creating a new irrigation capability is limited. Given this, a dual strategy of addressing both irrigation and rainfed agriculture seems highly appropriate.

2. It is apparent that there is only limited potential for expansion; i.e., 120 BCM current withdrawals (from the river inflows to the Indus Basin) vs. 139 BCM potential. The team suggests that some of this potential for expansion be directed to: rainfed hill areas by developing small reservoirs (tank) projects to provide supplemental irrigation; and possible tubewell developments outside of existing command areas where water depths and quality is suitable. This would be one way of addressing the equity issues and providing benefits to those farmers most in need.
   The study team also suggests that any studies of tank or tubewell development include a consideration of the new technologies (low pressure sprinkler, buried pipes of various designs and layout configurations, and so forth) which are under development in India and Bangladesh.

3. Since the pending Bank projects are heavily focused on financing watercourse improvements, the study team recommends the following programs as appropriate for USAID's dealings with intensification within the existing Indus Basin irrigation command area:

   a. An evaluation of the existing shallow tubewell pumping in terms of: present (and projected) numbers, distributions, capacities and duration of operation per year; and static and dynamic lifts, drawdown characteristics, service life and overall pumping plant energy use efficiencies.

b. A general analysis of the existing irrigation system (including conjunctive use) to develop overall basin, sub-basin and specific area models of water balance, water quality and drainage projections for different development and improvement scenarios.

c. A comprehensive economic analysis of the tradé-off between: canal, watercourse and on-farm irrigation improvements; development and operating costs for deliveries more nearly on a requirement of demand basis; and shallow tubewell development and operating costs in light of inflating energy costs and pending shortages.

d. If appropriate in light of the above, a program of shallow tubewell development that compliments total water resource management.

e. An applied research and development program to improve the cost effectiveness of shallow tubewell pumping plants in terms of investment cost, maintentance, operating costs and discharge capacity for the ranges of pumping lifts encountered. After selecting and developing the ideal pumping plants, provide aid to existing pumps and power unit manufacturers to develop in-country capability to produce the units.

f. Aid in extending rural electrifications to service shallow tubewells and consider possibilities for increased generating capacity by direct river-run hydroelectric power plants.

4. The team recommends that AID support increased emphasis on the importance of promoting Water Users organizations which are politically acceptable and the role they must play in improving on-farm water management and better use of the water resource. In close association with this, and in view of the Bank's watercourse improvement program, the study team believes AID should support the development and distribution of training materials and also support training programs for field and professional personnel. The efforts which AID has already expended in this direction appear to have been thoughtful, well executed and valuable.

5. The team feels a continuation of the adaptive research programs developed under earlier AID projects are essential to provide models for the large pending Bank projects and

make better use of the available water. Given the upper limit on water availability, production increases in the foreseeable future will be totally dependent on: an agressive research system; and an efficient extension and training network. This area of development can scarcely be overemphasized and the review team recommends that AID provide significant support for adaptive research to improve water management and crop production under both rainfed and irrigated agriculture.

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IRRIGATION DEVELOPMENT OPTIONS AND INVESTMENT STRATEGIES FOR THE 1980'S

THAILAND

SUMMARY AND RECOMMENDATIONS

The main thrust of USAID agricultural development program in Thailand is directed at the Northeast region. For purposes of water resource planning the Northeast region can be divided into three major zones (or categories) based on irrigation potential:

1. Areas irrigable by large reservoirs, which can provide water for a total irrigable area of 2.1 million rai (6.25 rai = 1 hectare) and benefit 8 to 9 percent of farm families.

2. Areas irrigable by pumping from reliable rivers which can provide water for a total irrigable area of 1.9 milion rai in the wet season and benefit a maximum of 10 percent of farm families.

3. Areas inaccessible from large reservoirs and reliable rivers which contain 80 percent of the rural population and where small water projects at the village level, as well as larger tanks in selected locations, are required to supply basic village water requirements. These small projects may take the form of small tanks, natural or dug ponds, weirs and topographical alterations to nearby watershed areas, and shallow or deep wells.

At present only 3 percent (15 percent of the potential of 20 percent) of the population in the Northeast is provided year-round irrigation from medium to large reservoirs or pumping from major rivers.

There is a general awareness, as pointed out in the Thailand CDSS for FY 1982, the the existing irrigation systems in the Northeast have largely failed to deliver planned for benefits because of slow progress in completing on-farm distribution systems, difficulty in organizing water-user groups for effective water management, inadequate maintenance leading to deterioration of the systems, and insufficient market inducements to diversified and dry-season cropping. As a result, a majority of farm families in the planned service areas of irrigation systems continue with traditional rainfed agricultural practices to meet subsistence requirements despite the availability of high yielding crop varieties (HYV) suitable for irrigated areas.

According to the CDSS, the Mission proposes to assist the Royal Thai Government (RTG) primarily on a functional basis in developing and exploiting the productive potential of irrigated and irrigable areas of Northeast Thailand through the following means:

1. Rehabilitation and completion of existing small scale irrigation systems with emphasis on on-farm water distribution.

2. Support for additional small scale irrigation development through reservoir systems and through pumping from groundwater sources where technically/economically feasible.

3. Adoption of a comprehensive approach to irrigation system development that includes on-farm water distribution and appropriate provision for operations and maintenance (O&M).

4. Operations research on means of organizing farmers for effective water use and maintenance of irrigation facilities.

5. Promotion of increased and diversified agricultural production in the service areas of established irrigation systems, including attention to agricultural extension, market development, and food processing industry.

The basic principles for an improved small scale irrigation program will be drawn from experience with the Northeast Small-Scale Irrigation (tank rehabilitation) Project scheduled for FY 1980 start-up, and from an overall strategy for small scale water resource development in the Northeast being formulated by an RTG task force. Consistent with AID's role definition, they do not propose financing for construction of large or medium scale reservoirs and related main canal systems. These activities will remain the province of the IFI's.

The Lam Nam Oon (LNO) Reservoir and small tank projects which the team visited relied on field-to-field (paddy-to-paddy) flow for on-farm distributions and only a limited amount of field leveling is evident. However, there were three small pilot areas with some Government built watercourses and field channels. The main and lateral canal systems on these projects are only organized to deliver continuous (but unregulated or measured) stream of water at outlets spaced 250 to 500 m apart. Each outlet has a potential command of 100 to 200 rai (16 to 32 hectares); but in most cases, only part of the command receives irrigation water even during the wet (monsoon) season, and there is practically no irrigation (except adjacent to the outlets during the dry season. (Full details of the traditional method and pilot activities are presented in Appendix D, "Description of Irrigation Practices and Systems.")

The lined sections of the main and lateral canal systems are in poor repair with siltation and broken linings due to rapid drawdown and/or side drainage and spills. Unlined sections of the tank projects are completely mission. Many of the turnouts along the functioning canals (perhaps over one-third of them at LNO) are not even provided with sufficient structures and channels to supply water to any fields.

The Northeast has enough rainfall during the monsoon season to produce about 1.5 to 2 tons of sticky (glutonous) paddy per hectare without irrigation and irrigation without other inputs results in 0.5 to 1 ton per hectare increase. Other inputs which when added to irrigation could easily double yields but they are not applied because water deliveries are not dependable and advanced farming practices are not well understood. Without on-farm distribution systems it is impractical to irrigate field crops and only a small area of paddy close to canal turnouts can be irrigated during the dry season.

The resulting situation, i.e., an undependable and practically unmanaged canal system, field to field water delivery, limited production increases from wet season irrigation, and little possibility of irrigating during the dry season, is that less than one-third of the potential command areas receive any irrigation. The crop production increases (output) from these irrigation projects is probably less than 10 percent of the potential that could be achieved from irrigating all the command area during the wet season, half the area during the dry season, and adding the other important inputs, such as HYV/s and fertilizer.

The two major deficiencies in irrigation in Thailand are: (1) effective management and on-farm facilities of existing irrigation systems; and (2) planning and design of new irrigation systems. We therefore recommend that USAID concentrate its future efforts in providing these software inputs to irrigation in Thailand leaving the larger hardware developments to the World Bank and other international funding agencies.

With respect to the USAID area concentration in Northeast Thailand we strongly endorse the current USAID stragegy of enhancing the productivity of rainfed agriculture and providing small village based tanks for domestic water supply, nurseries and fisheries. We also endorse the two USAID irrigation projects (Lam Nam Ooon and Northeast Small-Scale Irrigation), but would not undertake additional hardware oriented projects before: (1) demonstrated success has been achieved (and even this may take redeployment and/or additional resources); and (2) the pool of technical Thai manpower needed at all levels for comprehensive irrigation system management has been significantly upgraded and expanded.

Our specific recommendations follow:

1. The Royal Irrigation Department (RID) has requested AID to provide technical assistance in large scale planning and design of irrigation systems. Since this is a particular area of American competence, we believe that AID should sponsor some technical assistance and staff to work within the RID for this purpose.

2. AID should set up some model management systems for existing irrigation projects, for example, in the Lam Nan Oon project area (see Appendix A).

3. There is a notable lack of basic information about the physical and social environment of Northeast Thailand which we feel will be essential to any rational investment policy in that area over the future. Therefore, we recommend that AID sponsor collaborative basic investigations into the soils, hydrology and potential cropping systems, together with socio-economic research into patterns of land ownership and extent and distribution of real poverty in the area so that it might better focus its efforts in this large region. Among these investigations should be serious consideration of the potential of alternative cropping systems, particularly of upland paddy and wheat production and the use of leucaena tree species for pulp, lumber and fodder supplies to animals.

4. One of the fundamental problems of irrigation in Thailand is that it is targeted mainly to wet season paddy production objectives. The problem with this target is that as the irrigation system provides only supplemental water for occasional dry spots in the wet period, the incremental return to irrigation is very low (on the order of 25 percent or so). We believe serious consideration should be given to retargeting the irrigation objective toward the dry season. This retargeting implies a re-evaluation of the irrigation distribution system in the various command areas to provide water distribution directly to each field (rather than paddy to paddy). Our investigations indicate that at current prices, irrigation through the use of networks of buried PVC pipe (in areas with greater than 1/3 of 1 percent slope) appear to be feasible. Among the many advantages of buried pipe distribution systems is that they are not subject to washing out during the flood season and will deliver water with very high efficiency in the dry season. This alternative should be thoroughly investigated, particularly for demonstration in the model management systems.

5. We strongly support the development of small village based ponds for domestic water, nurseries and fishery production in Northeast Thailand. However, we do feel that much more attention must be paid to the distribution of the benefits of these small tanks in the various villages. As it now stands, there are no very clear guidelines on how the water or the fish are to be distributed among people in the villages. Simply handing it over to the local government authorities is of course fraught with dangers of maldistribution of benefits of these projects. AID should devise very firm guidelines to assure that all of the people in the area benefit from these projects and that the benefits are not concentrated in the hands of the few.

6. USAID should also guarantee that any people displaced from submergence areas in its project areas are in fact fully compensated for their losses. We recommend a close inspection of this problem in the Lam Nan Oon and Northeast Small Scale Irrigation project areas.

7. In order to provide reliable and reasonably efficient irrigation to paddy during the wet season or to field crops at any time, it is necessary that watercourses be constructed and maintained to deliver water directly to each irrigated field (rather than field to field, which is the typical practice in the Northeast today). While land consolidation and/or leveling may appear desirable, it should not be publicly financed except on a selective basis where essential for water delivery purposes. However, technical assistance and credit should be provided to encourage the use of appropriate land leveling practices (see Appendix B).

8. Lift irrigation systems are generally reported as being relatively efficient for both wet season paddy and dry season field crops. Furthermore, the power input records of the approximately 200 electrified lift systems can be used to estimate water inputs. At least 20 of the electric lift systems should be selected for various soil-crop-weather patterns under practical field conditions. In addition, these systems should be diagnosed to evaluate system performance and pinpoint conditions which lead to success.

9. The water resources in the Northeast are limited as pointed out in the report prepared by AIT (see summary in Appendix C). Conflicts will begin to develop between small tank, large reservoir, and river run lift projects as developments proceed. Furthermore, there are relatively few good (deep) tank or reservoir sites and the rainfed farmland submerged

by some new (as well as some existing) developments may actually reduce overall potential benefits in the region.[1] With these thoughts in mind we recommend that USAID provide technical assistance and support professional training activities for RTG personnel in: project and basin-wide planning and design; reservoir operation and canal management to maximize benefits within equity restraints and reduce structural damage to canal linings; and basin-wide water routing to optimize the irrigation, fishery and hydro potential and reduce flood hazards.

10. We note that RID's O&M budget has been increased from 61.4 million Bhat in 1972 to a projected 463.8 million Bhat for 1981; however, during the period O&M as a percentage of accumulated construction has decreased from 7 to a projected 2.6 percent (see Table 3). This is seriously inadequate. Therefore, we recommend that USAID in negotiating support for new projects should provide a sinking fund for O&M budgets over the projected life of the project.

11. In addition to the professional training activities mentioned in recommendation 9 we encourage USAID to become involved in sponsoring the following:

    a. Training of multidisciplinary teams for diagnosing irrigation systems to:

        (i) pinpoint and understand successful elements in existing systems for improvement and transfer;

        (ii) monitor and assess total system performance; and

        (iii) identify operational and technical problems.

    b. Training technical personnel at all levels needed to undertake recommendation 1 (see Appendix A). This training should involve main as well as on-farm system management.

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[1]Since the average working depth of many tanks is only 2 to 3 meters, deep-water rice might be considered as a possibility for increasing benefits from submerged areas. The constraint is that the water level should not rise over 5 cm per day so the rice can grow with it.

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APPENDIX B

USAID/ASIA BUREAU

AGRICULTURE/RURAL DEVELOPMENT CONFERENCE

January 11-16, 1981 Jakarta, Indonesia

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UNITED STATES INTERNATIONAL DEVELOPMENT COOPERATION AGENCY
AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

ASIA BUREAU
AGRICULTURE/RURAL DEVELOPMENT CONFERENCE

January 11-16, 1981
Sari Pacific Hotel
Jakarta, Indonesia

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SUMMARY OF IRRIGATION GROUP WORKSHOP

COMMENTS AND RECOMMENDATIONS[1]

Reported by

Mike Korin[2]

Group discussed a number of different subjects relating to irrigation including certain technical aspects of the activity. Those matters which may be of general interest are:

1. What priority should USAID's in Asia place on irrigation development in the 1980's?

• Thailand	Low priority since only about 13 percent of NE is irrigable.
• Indonesia	Complete existing project; in the future let WB fund major works and USAID fund TA.
• Pakistan • Sri Lanka • India	High priority.

2. Given AID's resources and irrigated agricultural situation in respective countries, what are the particular emphases on priorities which AID should support?

<u>System emphases</u>

• Pakistan	Move west of Punjab to area presently rainfed but with irrigation potential: this is a high risk area. Water storage systems will be needed.
• Sri Lanka, India and Indonesia	Continue present programs.

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[1]One of four workshops held as part of the USAID/Asian Bureau Agriculture/Rural Development Conference, January 11014, 1981, at Jakarta, Indonesia.

[2]USAID/Indonesia, reporter for Irrigation Work Group.

Software emphases

- Formal training
- Hands-on training
- Information systems
- Operation-maintenance
- Monitoring/evaluation
- Organizational improvements
- Water user associations
- Water laws - costs
- Water management advisory service

These software needs, especially the participation of local farmers to operate, manage and maintain systems, are areas where AID can assist. In some areas the knowledge and research are limited but AID probably has more experience and knowledge than other donors.

3. There is a need for experimentation and adaptive research in all of the countries for diagnostic analysis and technology. Some examples of the letter are:

   - Prefabricated concrete watercourse outlets made in Pakistan have a great potential.

   - Canal lining.

   - PVC pipe and other underground conveyance systems.

4. Some factors to consider with any irrigation project in addition to the recommendations in the irrigation overview prepared by Jack Keller are:

   - Agro-socio-economic analysis.

   - Developing a project which can be a model for management.

   - Role of women.

   - Flexibility of design.

   - Do an analysis of TA needed from universities, private sectors, etc.

   - Support training and manpower development for government to carry out projects.

   - Credit for land leveling, etc., but not complete financing since some want resource commitment from client.

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- If tubewells and pumping involved, do careful energy analysis. Ex.: May be a lot of groundwater, but fuel is expensive for a pump, or electricity may only be available a few hours a day.

5. On an annual basis, work out TA needs and project them to AID/W. Let Asia Bureau study how to best meet field needs with appropriate expertise.

6. Discussed idea of an international water management research and training institution; perhaps along the IRRI model, to focus on training and research for water management. (Research should be on-farm, not on a station.) Did not reach a specific recommendation.

7. Group encourages collaboration with WB, etc., especially on software areas such as training. Let the Bank take care of high financing and AID provide TA; however, the projects would need to be developed in a way which would allow AID and whatever TA is provided to have some influence. To the extent AID wants to concentrate on software such as training, grant funds will be required and this may be a limitation.

8. Need better system of sharing irrigation knowledge within the region, especially work with water management. There are lessons to be learned in all countries which may be applicable to other countries.

9. The group noted that the agency's technical expertise with irrigation/water management is inadequate for AID's level of financial commitment in the area. The group recommended that the Asia Bureau explore DH increases and/or TA contracts to better cope with the technical requirements of the subject area -- Bureau and Agencywise.

10. The Asia Bureau and Missions should consider dovetailing AID's irrigation and energy programs.

11. When assisting to establish water user or other similar organizations to manage and maintain irrigation systems, foreigners should be cautious not to impose unfamiliar structures just because they worked elsewhere. The local social-cultural-value system should be studied and provide a guide as to what may be needed.

13. Additional coments at the conference open forum:

    - Chuck Antholt noted that irrigation is also a high priority for Bangladesh.

- Doug Pickett indicated that USAID Nepal is planning on doing some small scale irrigation activities in the future.

- The expanded group came out in strong support of the ADC irrigation proposal.

ASIA BUREAU AGRICULTURE AND RURAL DEVELOPMENT CONFERENCE

Summary of Proceedings and Recommendations

The Asia Bureau Agriculture and Rural Development Conference was held January 12-15, 1981 in Jakarta with forty persons from the Missions, AID/W and U. S. universities in attendance. The purposes of the conference were to enhance communication on Asian Ag/RD matters and to make recommendations on issues affecting the effectiveness of A.I.D.'s Ag/RD assistance in Asia. This summary briefly summarizes the proceedings of the conference and lists its principal recommendations.

I. <u>Program Content and Direction</u>

Two days of the conference were devoted to the overall content and direction of A.I.D.'s Ag/RD assistance and specific examination of A.I.D.'s programs in agricultural research, irrigation, integrated rural development, and rural industry.

With populations growing at 2-3% a year, Asian countries need to increase agricultural production at 3-4% a year in order to increase food availability and generate economic surpluses for investment. This is an unprecedently high rate of growth in historical terms (e.g., U. S. and Japan's agriculture grew at about 1.8% a year from 1880-1980). A large fraction of the labor forces in Asian countries are landless or near-landless and will not be fully absorbed by even rapid growth of agriculture and auxiliary activities. The importance of stimulating non-farm employment is increasing in many countries. Furthermore, lack of jobs and income among the poor means that malnutrition may increase even in the context of increasing aggregate food production. In addition, population pressure is increasing intensity of land use and deforestation.

Against this panoply of problems, A.I.D. has emerged as a relatively minor donor and faces continuing constraints in its funds and personnel. The operative question for the conference was how A.I.D. should focus its relatively limited resources to maximize its assistance. Considering this question, the conference made or endorsed the following recommendations:

(1) Increasing production of both food and cash crops should be the core of the Asia Bureau Ag/RD program. Section 103 programs should continue to emphasize increasing commercial small farm production of food and other crops. This emphasis is necessary to produce the economic surpluses needed to create jobs and income. It also represents A.I.D.'s largest area of expertise and staff competence. While farms which produce a marketable

surplus are the goals of A.I.D.'s program, it is also understood that there are backward areas where subsistence agriculture will represent the principal farm economy for sometime to come.

(2) Within this broad framework, the conference recommended that Missions should focus their assistance in a relatively limited number of functional areas. Other projects can be supported according to opportunities in individual countries, but the following were endorsed as long-term core programs around which the bureau should seek to mobilize the professional staff and outside resources needed to support them.

(A) Irrigation, particularly water management, training, and "soft-ware"

(B) Development of national agriculture research, extension, and education institutions

(C) Upland and secondary crops, including labor intensive non-food crops

(D) Watershed management, including forests

(E) Agriculture sector analysis, policy, pricing, and marketing

These items above are not rank ordered according to priorities, and the conference recommended that Missions should, if possible, seek to direct their assistance dollars in the first instance to projects within the above areas.

(3) In addition to the above, the conference also endorsed continued emphasis on area development projects with a wider focus than the agricultural subsectors above. The conference cautioned that such projects shouldn't be treated as panaceas and should be utilized only when the nature of the problem makes integrated planning and budgeting essential and when conditions favoring successful use of the integrated approach exist. (Some of these conditions are listed in the report of the conference workshop on integrated rural development.)

The issue of whether and to what extent the Bureau and Missions should undertake small-scale industry projects as adjuncts to the mainline program of generating employment through agriculture was a clear issue in several conference sessions. Views expressed ranged from those who believed rural industry development programs should become a major element of some country programs to those who counselled against entering this area of development activity at all. A variety of views were also expressed on the content of such programs with respect to scale and type of industry that should be supported. Clearer guidelines for the Bureau and missions on the size and scope of rural industry programs are needed. As a start to sorting through the issues, a short options paper will be circulated to missions for comment on the direction Agency programs should take in this area.

Another topic discussed at the conference was nutrition. There was recognition that increased food production does not easily translate into increased food consumption by the poor, if the poor do not have the jobs and income needed to buy more food. The proposal by the principal speaker on the subject of nutrition was that A.I.D. should simultaneously maximize production of crops that provide the most jobs for the poor, are most commonly consumed by the poor, and provide the most nutrition to the poor. Internal inconsistencies and failure to take account of economic and financial consideration in the proposal were pointed out in the discussion. For example, it was noted that the principles that A.I.D. support crops which maximize (1) jobs and (2) are consumed by the poor were potentially in conflict because the most labor intensive crops tend to be consumed by the rich rather than the poor. Also policy prescriptions to the effect that A.I.D. projects should concentrate on producing "poor peoples" crops such as cassava for domestic consumption, not export, did not deal adequately with economic questions. The conference was unable to reach firm conclusions on this subject aside from the general consensus that more examination is needed.

In addition to these recommendations on the content of the Asia Ag/RD program, the conference made several firm recommendations on A.I.D. assistance methods and programming styles.

First, there was strong endorsement of the concept that Missions need to concentrate on fewer, long-term programs rather than a series of disparate five-year projects. Fewer, longer-term programs by Missions are both less personnel intensive and more conducive to building up professional expertise than the traditional kaleidoscopic pattern of annual projects. Programmatically, this suggests that Missions seek to reach agreements with host countries to work in given subsectors (e.g., irrigation, forestry) or geographic regions over an extended period.

A second related change strongly recommended by the conference is better and longer-term mobilization of outside resources to help Missions implement their programs. At present, A.I.D. Missions mobilize outside resc rces strictly on an ad hoc, case-by-case basis. However, if Missions tend to concentrate on fewer, long-term programs, within a set of agreed priority project areas as above, the bureau should be able to make longer-term arrangements to supplement their in-house capacities and help them carry out programs. The conference recommended that ASIA/TR give concerted attention to this.

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Finally, the conference endorsed the concept that A.I.D. has a comparative advantage among donors in providing technical assistance and in human and institutional development. Such assistance--when done well--pays large dividends over time. Hence, the conference recommended that A.I.D. programs concentrate on human and institutional development within the priority emphases cited above.

II. Workshops on Agricultural Research, Irrigation, and Integrated Rural Development

Agriculture Research: The Asia Bureau is sponsoring an 18-month review of the productivity and effectiveness of agriculture research development in Asia and the priorities for future development. Dr. Vernon Ruttan, of the University of Minnesota, described the progress of the review at the conference.

Preliminary impressions and conclusions are: the national research systems of Asia have made considerable progress in the past two decades with India leading the pack. There is great contrast in organizational styles from the highly centralized Korean system to the fractionated Bangladesh system.

Studies in several Asian countries (Japan, Malaysia, Pakistan, India, the Philippines) have shown high rates of return to LDC investment in research. Even in Bangladesh, Carl Pray's very conservative estimates indicate internal rates of return of 30-35% for investment in rice and wheat research.

Of the research systems in Asia, however, only India's is approaching world class status, and there are still serious weaknesses in some of India's state systems. Other Asian systems still require considerable development. Problem areas include:

- -- excessive development of research facilities without attendant development of scientific staff
- -- excessive administrative burdens that stifle both routine investigations and research entrepreneurship
- -- siting of research facilities in areas which lack the physical and institutional conditions which contribute to successful research
- -- lack of congruity between allocation of research funds and the economic importance of major crops

Considering these and other issues, the conference participants who met on agriculture research made the following recommendations:

(A) A.I.D.'s present programs in support of ag research development in Asia are extensive. Development of national agricultural research systems represents one of the most important investments A.I.D. can make, and missions should explore every opportunity to become involved in agricultural research.

(B) A.I.D., as an agency, has a hodge-podge of programs to assist agriculture research: mission assistance to national systems, support for international centers, CRSPs, A.I.D. Science Advisor program, and DSB funded research. AID/W should review these programs with an eye to redeploying funds away from some to others which more directly enhance national capacities.

(C) The World Bank financed T and V system of agricultural extension is the dominant model in the region. Although A.I.D. will support extension in many projects, there does not appear to be a leading role for A.I.D. in agriculture extension in Asia.

(D) Support for agriculture university development and other agricultural education activities are integral to ag research development and should be of high priority.

<u>Irrigation:</u> The background for the conference's consideration of this topic was the review of irrigation projects in India, Pakistan, Nepal, and Thailand conducted by A.I.D. financed teams in the summer of 1980. (The team's summary recommendations are included in the conference papers.)

Briefly, the review indicated serious failings with most country sponsored or donor financed irrigation projects in: (1) ineffective distribution of water to farmers' fields and (2) poor distribution of water to crops growing on individual fields. For instance, the A.I.D. sponsored Ganges-Kobadek project in Bangladesh is supposed to irrigate 120,000 acres; at the present time the project is irrigating between 30,000 and 65,000 acres. Similar problems are common in Thailand, India and other countries. The reasons for poor performance are primarily social, not technical. It requires a high degree of social cooperation, administrative skill, and political accommodation to spread water thinly over a large land area and among numerous small farmers. As these social conditions are lacking in most Asian countries, water delivery becomes unreliable as "head-enders" use disproportionate amounts of water, maintenance is neglected, water-user associations become ineffective and so forth. Without assurance of reliable and timely water, farmers are reluctant to invest in the inputs needed to maximize yields. Small irrigation systems temper these problems somewhat, but do not avoid them. In India and Pakistan, there has been rapid growth of individually owned tube-wells as a partial substitute for inefficient conveyance of surface water, but this remedy is limited by constraints on energy supplies.

Against these circumstances, the team and conference made the following general recommendations for A.I.D.'s pursuit of irrigation projects. (Specific recommendations for individual countries are contained in the country reports.)

-- A.I.D. should insist that success in irrigation systems sponsored by it should be measured in gains in production.

-- A.I.D. should emphasize assistance to countries in the "software" side of irrigation systems: organization and management, operations and maintenance, training water-user associations, research, methodologies for system monitoring and design.

-- A.I.D. should organize and hire more technical staff and consultants so that a consistent, systematic irrigation program can be developed and carried out.

-- A.I.D. should be aware of energy implications of ground water irrigation development and should exploit complementarities between irrigation and energy assistance.

-- A.I.D. should encourage closer relationships with the World Bank's irrigation development program, in particular opportunities to blend our technical assistance capabilities with the Bank's large capital resources.

Area Development: In the past few years, several A.I.D. missions have begun large area development projects. Area development projects are basically a response to specific political, economic, and physical situations and are difficult to categorize except in general terms. Area development projects are complex and in some cases impacts have been less extensive and cost per beneficiary higher than anticipated. Administrative unwieldiness is a frequent problem; de facto focus on a few aspects of an area or target population's problem is sometimes found. In this context, the conference workshop met to review progress and problems in these projects. Some conclusions were:

-- The bureau should continue IAD projects although such projects should not be treated as panaceas and should be utilized only when the nature of problem makes integrated planning and budgeting essential and when the conditions favoring successful use of IAD projects exist.

-- These pre-conditions include capacity at the local government to "pull" in the services of central line agencies and capacity of the sector agencies to deliver services.

-- A.I.D.'s "blueprint" approach to project planning--with its attempt to spell out inputs and outputs five years ahead--may not be appropriate to IAD projects. These projects need clear and clearly understood goals and intensive examination of local conditions and the feasibility of interventions. But they also require considerable flexibility in management, and ability to shift resources as projects proceed.

Rural Industry: Countries throughout the Region are emphasizing policies for industrial development, especially small scale industry, as part of their strategies for dealing with the problem of poverty among the large and growing numbers of underemployed landless and near landless workers. Several missions as part of A.I.D.'s response to country employment problems are planning rural industries projects.

The issues of the (1) extent and (2) content of A.I.D. promoted rural industries programs and projects was the focus of the session on rural industry. The widely divergent views expressed can be summarized as follows:

-- do not promote rural industry

Agency resources are stretched too thin already; shifting staff and program funds to rural industry would damage agricultural programs. Agency rural industry programs in the 1950's and 1960's were failures. Why will we succeed this time?

-- proceed cautiously with limited types of rural industry projects

The U. S. has nothing to offer in the area of small scale industry; if the Agency wants to promote rural industries it should be done in agro-based industries such as food processing and fertilizer plants where the U. S. has some know-how. The Agency has had positive experiences with small scale industries projects in other regions. Small scale industry projects using appropriate technology should be the focus of any Agency rural industry program. Rural industry projects should be done only in the context of integrated area development projects. The Agency does not know what the record of the 1950's and 1960's was and cannot easily find out about it because there is no institutional memory on this subject.

-- promote rural industry projects

The employment problem in Asian countries is such that A.I.D. cannot ignore the role of rural industry programs in host country employment strategies. The Agency industry programs of the 1950's and 1960's were by and large successful. The U. S. with its problem solving and management capability can provide valuable assistance at all levels of industry including cottage and small industries.

-- promote U. S. commercial interests

At the opening session of the conference, the suggestion was made that A.I.D. consider ways to promote U. S. exports in light of a deteriorating trade position of the U. S. in Southeast Asia. Activity in this area could be, in addition, to activities presently covered by A.I.D.'s legislative mandate.

The conference did not reach any conclusions on promotion of rural industry programs. It was proposed, that the content and extent of rural industry programs in the region be the subject of a short options paper that would start development of bureau guidelines for rural industry program development in the Region.

III. Personnel

The next major topic for the conference was personnel. The background for this discussion was the drop in agricultural professionals within the Agency in the past decade. From 1970 to 1980, the Agency's budget for agriculture programs almost doubled while its direct-hire agriculture staff has dropped 57% (from 302 to 189). At the same time, the Agency's cadre of general development officers had jumped from about 50 to 150 reflecting the addition of social scientists and generalist rural development officers. Yet the Agency does not have a definition of the types and numbers of rural development skills it needs. The conferees' recommendations on personnel issues were:

(A) Agriculture and rural development officers should be included in one job category or backstop. There was general agreement on the difficulty of drawing a clear distinction between agriculture and rural development programs or the responsibilities of the officers. There is more to be gained by individuals and the Agency from combining forces than by functioning separately. The TPCA should be revamped and expanded to reflect this new grouping and the career development position in PM should include this broader role. The general development officer grouping should be retained for those officers managing programs and projects outside of the agriculture/rural development cluster.

(B) The Agency must focus and stabilize its agriculture and rural development program over time to allow for a rational, planned recruitment and career development of its ARD officers.

(C) The proportion of agriculture and rural development officers in the Agency must be increased to more accurately reflect the size of the Agency's programs in this sector.

(D) New recruits should have superior technical skills and demonstrated or perceived management skills. Prior to recruitment, they (new recruits) must be informed that they will not function as specialists but will perform as managers of agriculture and rural development programs and projects.

(E) More emphasis must be placed on the career development of agriculture and rural development officers. Possible options include:

-- Every 2-3 tours, an officer should receive up to one semester of professional career development training.

-- Officers should periodically be obligated to spend 2-3 weeks in other countries or at international centers for professional updating.

-- Every 10 years, a year of long-term training should be mandatory.

(F) To enhance personal and professional satisfaction and achievement, assignments should be made on the basis of tasks to be accomplished over a period of time. An officer would work on all phases of the project (design through implementation) and would likely stay longer at one post.

(G) The "no third tour" policy should be revised to permit third tours when the officer, the host country, and the mission request it.

IV. Operational Issues:

On its final day, the conference addressed a number of operational issues including Title XII, impact evaluations, DSB-Regional bureau relationships, and A.I.D. relationships with the World Bank. Some observations and recommendations emerging from the discussion were:

-- Perceptions of Title XII involvement in Asia Bureau remain clouded. The group underscored that Title XII is generally accepted as a valued resource and important to the development process; however, the field missions and host countries are encountering problems which are deterents in fully subscribing to the legislative guidelines. Some observations follow:

- The strengthening grant concept is not fully understood, is troublesome to many missions, and is particularly in need of re-examination.

- Mission personnel, and in some cases host country professionals, are already quite knowledgeable concerning scientists in the various fields whom they would like to employ--the trick is in getting them without going through the time-consuming competitive bidding process.

- Technical expertise is more easily and inexpensively obtained through private consulting firms or via USDA than through universities.

-- The Asia Bureau should fund a RSSA with USDA to facilitate hiring consultants and expert teams for Mission programs.

-- The Asia Bureau should explore the scope for collaboration between A.I.D. missions and the World Bank. As the Bank's funding role has grown, its difficulties in providing technical assistance have similarly grown, and there is room for linking with A.I.D. as a relatively efficient provider of TA.

-- The conference strongly endorsed DS/AGR's attempt to involve missions in planning its budget. There was also support for DS/AGR to use some of its funds for research at the "leading edge" of development issues. DS/AGR should not attempt to match in total its budget with Mission priorities of today.

-- The Agency has gone overboard on impact evaluations. While useful on the Hill, such evaluations are divorced from actual program operations and are simple in content and methodology. Their benefits to the program do not appear to justify their cost.

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