Draft I — Review connect opponents

SUPPORT IRRIGATION MANAGEMENT



# A RESEARCH-DEVELOPMENT PROCESS FOR EFFECTIVE TRANSFER OF WATER MANAGEMENT TECBNOLOGY 1/

by
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Irrigation Management has come of age! Over the last fifteen years we have moved from a focus on building dams and main canals to more of a focus on system management. As we move further down the eystem, the problems become more multi-dimensional and complex. No individual discipline, professional group, or any individual has the expertise required to diagnose and find solutions to the physical, biological, and socio-economic systemic problems which exist. Traditional component research has never been adequate to define and solve these complex main, minor, and on-farm systemic problems. In India, for example, within about 15 years (2000 A.D) the present inordinate focus on design and construction will wane. Around the world, it appears that almost all water resource potential will be exploited. The state of Tamil Nadu in India, like most parts of the world today is a good example. Once the mind-fix on design and construction is finally broken, there will likely be a release of more mental and physical energies for modernization, rehabilitation, management and maintenance of both main and minor parts of the system including the often neglected on-farm and drainage problems.

The purpose of this paper is to describe a technology transfer process for the rapid improvement of systems designed to provide farmers improved agricultural production possibilities. The process described focuses on a systematic action research approach for effectively diagnosing, developing, assessing and implementing development programs to improve farmers' resource base for improved production and conservation of land and water resources. An interdisciplinary team executes this research development process with operational staff. Farmers are also members of the team for activities at chak and on-farm water sub-systems. They also can be given a larger role in planning, designing, and operating the main and minor systems. In many countries both historically and today, farmers are the sole owners and operators of many different types of irrigation systems, for example, in India, where the largest irrigation drama is being enacted, it is estimated at about 50.

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1/ An earlier version of this paper was first presented by Wayne Clyma and Gilbert L. Corey in 1979. The original paper and concepts presented are similar except this paper provides a focus on the main system for a total system approach. The author is Deputy Chief of the Irrigation Management Division, USAID, New Delhi. The views presented in this paper are those of the author. They do not necessarily represent the present thinking of AID. This draft paper is prepared for use at the International Irrigation Management Institute Workshop Kandy, Sri Lanka, July 15 to 19, 1985.

Development of irrigation systems in the past has usually meant the construction of new projects or the enlargement of existing projects. The emphasis has been primarily on capital-intensive components such as dams, hydraulic structures and water delivery systems. For example, roughly 80 percent of a 3 to 3.5 billion dollar budget in India goes for new projects. The cost per hectare created of only canal, dam, and reservoir is rapidly escalating. In India, it is not unusual for these costs to be from Rs.30,000 to Rs.50,000 per hectare. To complete the system below the outlet current costs range from Rs.3,000 to Rs.5,000. This is indeed a high cost:

Irrigation Management in irrigated agriculture is the process by which water is manipulated and used in the production of food and fiber. Water management is not simply water resources, irrigation facilities, laws, farmers, institutions, procedures, or soil and cropping systems. Irrigation Management is manifested in how these tools and resources are used to provide the water required for plant growth and for controlling salinity. It encompasses all water used for that purpose, not just irrigation, but rainfed as well. This new term, Irrigation Management, probably describes the process best because more than water, people, credits, inputs, outputs, price policy, other services for farmers and even hydro (water) politics must be managed in the true sense of good management. Where today in irrigation do we have all these resources properly managed?

Large financial resources are now being made available for IM improvements. This is a new development: Therefore, the newly available resources have helped to make many more people become interested in In. This is a plus! Previously, there were few systematic approaches to evaluate existing agricultural and irrigation systems, analyse weaknesses and failures, prescribe and assess technologies for improvement. Even today, each system that is evaluated seems to become a special case study in itself. Improvement programs are developed under severe pressures of unrealistic time frames by governments and donor agencies who within a short time period utilize little more than the experience of costly expatriate professionals and the host country project developers. Seldom is farmers' wisdom and experience utilized in the process. Most frequently, these improvements treat symptoms instead of the real systemic problems. For example, in India at least 20 different technologies have been tried with minor sources because the government of a donor felt that it would pay off. Such conventional approaches not only when used alone often fail, but, the way things are typically done, generally ignore the farmers, system operators, or utilize their perceptions, knowledge, or focus on their socio-institutional constraints. Therefore, the conventional approach has not resulted in sufficient system improvements for better management of the main system. They have done little to improve production possibilities at the farm level 2/. Water management improvement is of crucial importance today because there are an estimated 273 million hectares or more of land, which will be under irrigation world-wide by the year 1990. About 30 percent of this is area will be in India alone. New irrigated areas are being added at the rate of about 3 million hectares per year. But, gravity irrigation systems in Asia, a few exceptions, are characterized by large cost overruns, poor conveyance efficiencies, very little water control, great inequities, and a lack of effective farmer participation. Therefore, most systems operate at relatively low levels of water use efficiency which naturally results in very low levels of production 3/. Thus, a major reform, or a major tidal change is required for the improvement of existing systems. This emphasis must replace the inordinate focus of simply building new projects which result in still more inefficient projects. How long, one asks, will the old ways of doing irrigation development persist? In India, for example, a gradual change may be taking place. The 7th five year plan now proposes changes in the direction of IH promotion versus the traditional thinking of building more new systems. 'The reasons for focusing on the management improvement of existing systems can be summarized as follows:

1. Conserving water supplies by improved management for rapid increases in food production to feed growing populations;

2. Improving the return on Investments of – existing systems because the present cost of doing business is simply too high in the face of serious social as well as political pressures indicating public concern;

3. Reducing costly waterlogging and salinity problems in all old as well as new systems where millions of hectares are going out of production. These factors are in fact, usually, the only symptoms of poor irrigation management;

4. Reducing the need for large capital investments in new systems. Though under certain circumstances in some places, some new systems must be built over the next few years. But the inordinate focus on new systems must be replaced by a more rational analysis of the real value of new irrigated areas;

5. Gaining knowledge through a systematic process, which can provide new criteria for the development and management of other systems.

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2/ Wiener, Aaron. The World Food Situation and Irrigation Programmes. ICID Bulletin, January 1976.

3/ Bos, H.G. and Nugteren, J. 1974. International Institute on Irrigation Efficiencies, Pub. No.19, International Institute for Land Reclamation and Improvement, Wageningen, The Netherlands.

6. Establishment of an approach for comparative analysis of In across systems and as a means for more effective IH knowledge transferred to policy makers, planners, designers, researchers and professional staff at international centers of excellence as IIMI in Sri Lanka.

A concerted effort to improve irrigated agriculture, if focused at helping the small and medium farmers solve their major problems, could bring improved income and better living conditions to a substantial percentage of the world's disadvantaged. It is often not fully appreciated that the preponderence of irrigation potential world-wide, lies mostly in present diet deficient countries and mostly in Asia. This is good but we must remember that in much of South Asia current irrigated crop yields per hectare are three or four times lower than what is possible.

> The cost of expanding the present 223 million irrigated hectares worldwide by 36 million acres was estimated at about $130,000 million a few years ago. At 1985 prices, this cost has probably more than doubled. The cost is not only exceedingly high but developing major and medium projects is also a slow process. Most medium and major projects from design to completion often take as much as 10 to 20 years. Investments in new projects will continue but, more quick yielding programs are needed to help small farmers. Many new programs, unfortunately, seldom improve the efficiency of farm water use. Therefore, the focus in the years ahead, must be given to finding ways to improve production at the farm-level. There has always been much exciting drama in building large structures. But, now in another context, we must not forget the small and often tragic dramas which take place daily on millions of small holder's farms where water conservation is a matter of success and failure and even of life and death [4].

It should be stated up in front that the process described in this paper is first diagnosing the productive end of the system, to study the consequences of poor total system performance. Then after this reconnaissance, one moves back up the system to each place of physical control and even at times to the policy making levels to determine the major causes of the low agricultural production. An In technology transfer process is needed which results in the rapid adoption of appropriate technologies. This process should be generally applicable across systems. It should save time, money and resources, and it should also produce documented system performance results. This approach can be of immense value in attacking the systemic problems of food production around the world. The overall transfer process as described in this paper along with the concepts and essential elements for the complete process has been field tested and seems to be one approach with potential.

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4/ World Bank, The Assault on World Poverty, John Eopkins University Press, 1975, pp. 95-96.

## Background

Experiences in irrigation water management research program in Egypt, Sri Lanka, Philippines and Pakistan form the basis for this field tested and increasingly used research-development process described. This research process evolved from direct field work with much trial and error efforts. It is not complete. It has gone through continuous refinements but, to date it has helped formulate relevant technical and socio-economic specifications for projects located in several countries in five major areas. These are:

1. Water management improvement programs with farmer and local staff involvement in Pakistan, Egypt, India, Phillipines, Bangladesh, Sri Lanka and to a lesser degree in the other countries;

2. Empirical field data for policy-planning decisions on water resources, planning, design of modernization programs, and new ways of thinking about better ways to increase farm production.

3. Training of personnel and major institution building in Pakistan, India, Philippines, and Egypt. In India, alone, the AID-World Bank, there is an effort funded at over $100 million which focuses primarily on institution building and human resource development for improved Irrigation Management.

4. Information transfer processes which make research results immediately available to policy makers, designers, operational staff, scientists, and farmer users in many countries.

5. A research development process now being introduced in several other countries than those mentioned above. In each place the initial process is being refined and it should be improved on a continuous basis wherever it is used.

6. A more comprehensive total systems approach with a focus on main system management where the process developed earlier has been neglected.

7. An effective international effort for improved IM at centers of excellence and programs such as IIMI, FAO, Water Management Synthesis Project and other Centers with a focus in research, training and technology transfer.

Pilot programs in several countries have demonstrated that with limited capital costs and local staff plus strong farmer participation, significant system improvements can be made. Water losses have been reduced by half or more with significant production increase in some countries. These low cost improvements are relatively easy to implement, highly visible, and prove to be economical. Farmers are enthusiastic where the process has been introduced because they have been able to participate, gain a new sense of ownership in their systems and also have increased both cropping intensities and crop yields with both water and land savings.

This is in contrast to the very high cost of the typical way of developing new systems where they often require rehabilitation even before the project is completed. Cost of irrigation projects are now too high. They often range from $3000 to $5000 per hectare of the potential created, but the potential is seldom fully utilized. In contrast, this process when used for improving existing systems, ranges in cost from about $200 to $750 per hectare depending on the condition of the system which requires treatment.

The Government of India and the United States Agency for International Development, on July 31, 1980 signed an $80 million project agreement for an innovative Irrigation Management Training Project. This project as well as the AID world-wide Water Management Synthesis Project II was influenced by and modeled on the research development process described. The World Bank in India has also developed a most significant National Water Management Program using many aspects of this research development process. Pakistan and Egypt likewise have similar large scale programs. The international Irrigation Management Institute recently established in Sri Lanka has also been influenced by this process and will use the reconnaissance methods, diagnostic analysis, development and assessment of solutions, the team approach and training, institutional development, and technology transfer emphases which are a part of the process.

The possibility of transfer of the research-development process to other countries is also viable. Significant progress has been made by Egypt and Sri Lanka in implementing irrigation management projects along with Bangladesh, Philippines, and Indonesia based on this process. Similar but smaller projects based on aspects of this approach are being introduced in Nepal, Burma and several African countries. Diagnostic Analysis Training workshops based on this model have been successfully conducted in Pakistan, India, Egypt, Sri Lanka, Nepal and Bangladesh. These components are being incorporated in the programs of the new International Irrigation Institute located near Kandy, Sri Lanka. Given the experience gained to date and more refinements, this systematic approach if applied appropriately can help to advance irrigation water management in all the irrigated regions of the world. Though the diagnostic analysis phase of the process has been more fully developed than the three other phases, the existing frameworks planning guides, field manuals and training materials need improvement. More focus is needed now to better define the other phases of how to do development of solutions, assessment and full scale project implementation. This will require much more field testing and learning. The point to make here is that it is an open and not a final model or process. There is and will always be much opportunity for improvement. For example, recently in India in a training of trainers workshop on DA, several new innovations were added such as night reconnaissance of a system, role reversal for a six week period due to the lack of sufficient social scientists and economist and other changes.

## Transfer Process Overview [5/]

The transfer process consists of four overlapping phases. They are not to be thought of as four back-step type of stages. Instead the process is iterative in nature. The four phases are:

I. Diagnostic Analysis
II. Search for Problem Solutions
III. Assessment of Solutions
IV. Pilot Project Implementation

The unique feature of diagnostic analysis, and perhaps the ptocess itself, is the interdisciplinary team approach with operational staff and farmer participation where the first purpose is to achieve a good understanding of how the system is working in relationship to performance objectives. This results in an objective quantitative definition of priority constraints and their causes versus a listing of symptoms. (See figures 1-4, for a check list of factors to examine first at the productive and of the system). The diagnosis is not only to identify problems but also to document what is working well and why. What happens at the productive end of any irrigation system provides a good first approximation of the total system because the consequences even of main system problems show up there. Even the impacts of certain policy and legal constraints impact the productive end of the system. Then moving up the system to every boundary of control and decision nodal point the diagnostic process continues in a search to identify multiple or systemic causes of poor performance. It is also most likely that prior research findings are available and these should be examined thouroughly in order to benefit from them. Sometimes a sense of history is missing from the evaluation of irrigation systems. History of existing systems often provide many good clues to investigations.

Systematic mapping procedures including a clinical approach to the farmer-client are used to diagnose physical, socio-economic and institutional problems in Phase I (Table 1). Because all problems can not be identified and solved initially. Priority or central problems, from which highly visible solutions can likely be evolved first, are defined. Often in the examination of irrigation systems, one also finds valuable existing innovations which can be transferred to other farmers. Opportunity Analysis should also be included in the Diagnostic Analysis phase. The reason for this is that by experience and training most professionals have a tendency to only look for problems. This is somewhat dangerous because on complex systems one can usually find the problem he or she is most interested in.

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5/ Table 1 on the following page includes four phases. Other phases being considered by some as essential include evaluation and full scale project implementation.

Table 1 Phases and Major Characteristics of the Research-Development Process.

| Key Concepts for All Phases | Essential Components for All Phase8 |
|---|---|
| 1 Systems approach | 1. Local staff and client involvement |
| 2 Interdisciplinary research | 2 Communication process between all actors |
| 3 On-farm client focus | 3 Team work and collaboration |
| 4 Main system focus | 4 Training (selection and evaluation) |
| 5 Management oriented | 5. Institutional building and linkages |
| 6 Action research | 6 Monitoring and evaluation of process and system |

| Phased Sequences for Transfer process | Major Emphases | Major Activities |
|---|---|---|
| **Phase I**<br>Diagnostic Analysis | Clinical approach<br>Understanding the system<br><br>Integrated system operation<br><br>System constraints | Reconnaissance and field survey8 of system8<br>Delineation for the system boundaries<br>Preliminary and formal field investigations<br>Quantitative system description<br>Priority problem indentification<br>Identification of system values |
| **Phase II**<br>Search for Problem Solutions | Applied research<br>Adaptive research<br>Evaluative research<br>Live system conditions<br>Farmer and local staff interest<br>Trial and adoption | Experiments, trials and demonstrations using various types of technologies and procedures<br>Reservation and interactive process of DA findings |
| **Phase III**<br>Assessment of solutions | Staff and farmer acceptance<br>Evaluative research<br>Transfer vehicles | Adoption-diffusion studies<br>Evaluation of communication systems<br>Enabling and functional plus normative |
| **Phase IV**<br>Pilot Project Implementation | Users and management staff orientation, integrated systems planning protective research | Implementation, planning, training, monitoring and evaluation for continuous process of improving system operations for higher performance levels |

These major emphases are derived from the key concepts and essential components listed above.

Phase II, in Table 1, is known as the search for solutions. The aim is to develop a stage which can produce highly visible results which will benefit farmers significantly. Direct solutions from known information, principles and experiences are sought first and adapted to specific system problems and resources. Testing or demonstrations of known technology is a large part of developing solutions. Applied research at experiment stations and institutes is reserved for evaluating complex alternative solutions to high priority problems which require more careful detailed study. The interdisciplinary team combines knowledge and experience with systematic research approaches to develop solutions which system operators and users can use to solve immediate problems. The priority constraints and their causes are identified and ranked in terms of their potential for improvements and expected effectiveness.

A systematic quantitative assessment of each solution set is made to assure farmers' and irrigation operators' acceptance. This includes determining the cost and availability of complementary inputs, required policy incentives, and requisite supporting services. It also includes an evaluation of the particular socio-economic and environmental impacts which are or might result. Applied, adaptive, and evaluate research methods are used under live system conditions in Phase III for the [illegible]me of solutions. These results are used to review th[illegible] original [illegible] of problems and to improve the solutions already te[illegible]ted These assessments are also used to further determine resource, communication and institutional needs of system operators and farmers in order to assure continued adoption and improvement of the technologies. Farmers' and operators' trial and adaption experiences are evaluated continuously over time to select alternative technology package for the pilot project phase. Socio-economic and environmental impacts are also monitored for long term projections concerning externalities for intended as well as for unintended audiences. Several criteria for technology assessments and rapid diffusion are described in Annex III.

An institutionalized development program then evolves as a pilot project. Trained personnel use the carefully designed technological package to work directly with operators and farmers as team members jointly solve system problems. Many authors have observed that known technologies for irrigation improvements are available [6]. This may be true in terms of having more technology available for good IM that is effectively being used but we must remember that irrigation technology development, especially in the last 10 to 15 years has been accelerating due to better research methodologies, computer aided measuring devices, and the rapidly rising costs of energy.

A major constraint world-wide, is the lack of effective transfer mechanism for irrigation technology especially to those institutions, organizations and farmers who often do not have the necessary resources

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6/ Wiener, op. cit. and World Bank, op. cit., pp. 95-96.

or capabilities to obtain or even learn about its existence. None of our technology is of much value to society, system operators or farmers until it is used effectively for the purposes intended. Today when IM is becoming more important, efforts to transfer useful irrigation technology and fragmented peacemeal, are not very effective in India, for example, often, one state does not understand what is happening in another state. The focus in Phase IV is on the development of selected projects enabling, functional and normative inrtitutional capabilities for effective transfer of technology by carefully designed and evaluated human resources development or training strategies. At the beginning of the pilot project phase, the institutional capabilities and appropriate technologies are evolved and established for an effective development program. These programs will include a long term management performance plan for each project which has built-in monitoring and evaluation mechanisms.

Key Concepts

While each phase of the process emphasizes particular concepts and components, the overall process has certain key concepts and essential components which are vital for activities in all four phases. The key concepts for the process are also shown in Table 1 They are:

1. A systems approach which includes the socio-economic, institutional and physical aspects of the irrigation system.

2. An Interdisciplinary team which plans and executes the program.

3. The farmer and the operators of the system who are of primary concern and are a major focal point of many activities.

4. The program must be accepted and executed by the project personnel of a given project, otherwise it becomes an academic exercise.

5. The research development process is management-oriented and must focus at all times on system management improvements. It is good to remember that most good management is practice and learning by doing under real work conditions.

6. The research approaches used are action and problem oriented in nature.

7. opportunities for improvements and benefits to impact the productive end of the irrigation system are a central focus throughout the total process.

8. An improved means of technology transfer for IM within and across countries.

System Approach

Irrigation operators and farmers manage a complex man-made system composed of many components. Irrigation and agricultural research, traditionally however, has focused primarily on single factors or restricted components of the primary, secondary, tertiary, and the farm Subsystems in isolation. Systems approaches for irrigated agriculture are relatively tecent. It was in 1901 that a researcher of the Ontario Research Foundation first drew serious attention to a new method of agricultural research, management, and production that would view the total agricultural system as a whole. In 1961, Bradfield 7/, gave special emphasie again to this 'new approach. for agricultural research and development. Today, in the agricultural sciences, the farming systems approach is now being widely advocated, funded, and accepted with some good results by international research centers, governments, agricultural scientists at research stations, and by farmers.

The plight of the small and 'medium farmer, the food and population crisis, and the lack of better agricultural policies and institutional support in part may be attributed to the lack of an adequate systems approach for the total irrigation and agricultural systems in the past. Ronninger, 8/, fir example, has suggested that valuable time and opportunities have been lost in trying to resolve complex environmental system problems such as animal wastes, nitrate and pesticide pollution as well as in evolving the high yielding varieties due to past inordinate attention given to component research which is most often only partial in terms of systemic problems.

Millikan and Hapgood 9/ and others 10/ have also concluded that

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7/ [illegible], in Internatior Congress of Soil Science Transactions of the 7t Internatic Congress of Soil Science, Madison, Wisconsin, 1961, Volume I, Official Communications, [illegible] XXXII. ([illegible] Ri Bradfield uniti of l Scientist in Freeing the World from Hunger," entia addreas.)

8/ Ronninger, T.S., [illegible] Research in Agriculture, "Agricultural Science [illegible]view, Vol. [illegible], No. 1, Cooperative Research Service, [illegible], 196[illegible] pp. [illegible]10

9/ Millikan, Max F. and David Hapgood, No Easy Harvest: The Dilemma of Agriculture in Underdeveloped Countries, Little, Brown and Co., Boston, 1967.

10/ See Mellor, John W., The Economics of Agricultural Development, Cornell University Press, 1966, p. 357, and Dalrymple, Dana G., Technological Change 'in Agriculture, International Development, Foreign Agriculture Service, Washington, D.C., 1969.

insufficient and inadequate system-type field studies have been conducted to improve traditional farming systems. Increasingly, it is realized that irrigation systems do often create negative environmental, human and social externalities due to a lack of adequate system impact studies, and appropriate field diagnosis prior to the design and construction of new projects. To date little attention is being given, for example, to both main and farm system studies in a systematic way using holistic approaches.

The traditional research model in agriculture until recently, is the research station with small experimental plots. In irrigation engineering typical research has been mostly focused on hydraulics or structures in labs. The unstated, but usual primary objective of much of the past research was to produce referred journal articles or technical reports. In contrast, at all phases of this research-development process, we strongly affirn that the focus is on understanding systemic problems and their multiple causes, developing and assessing useful solutions, and implementing 'sound development programs which will impact total irrigation systems. This focus suggests the importance of the next concept, which is that of the interdisciplinary team.

Interdisciplinary Team Research

An effective interdisciplinary research approach is a useful and cost effective means for solving many systemic problems of complex irrigation systems. The key concept for an effective interdisciplinary research team is that it has the essential disciplines necessary to adequately understand the operations of a system. This provides the corresponding ability to define priority system problems. The essential elements of an effective interdisciplinary team are: (1) respect for the contributions that each discipline can make; (2) desire to establish effective communication between the various disciplines; and (3) a common aim to benefit users with each team member understanding their roles with the technical competence to perform them well in the field.

Disciplinary trust and respect are fraught with many difficulties. In academic environments, disciplinary pride and arrogance are often fostered to such a degree that professionals in a discipline act almost as members of a closed clan. The socialization of a new recruit into the profession in terms of values, norms and rank often causes the professional to pursue very narrow disciplinary goals without ever considering the potential contributions of other disciplines to certain problem areas.

Respect and trust of professionals across disciplines and departments is basic for effective teamwork and communication. While it is essential that all team members be technically qualified, experienced professionals in their respective disciplines must also learn to communicate effectively in order to become good team members and leaders of teams. The typical method of selecting the team leader only on the basis of seniority, rank, or status is fraught with many serious problems. Some professionals operate best as loners and should not be brought on to interdisciplinary teams. It is simply too costly.

A strategy for executing an effective interdisciplinary program is as follows:

1. The team defines the parameters of the system to be studied.

2. The primary variables to quantitatively describe the system are identified.

3. A strategy for describing the operation of a system with the defined variables is then evolved.

4. A research program is executed to collect data which quantitatively describe the operation of the system

In some instances, variables must be measured in a coordinated, carefully-planned manner to relate certain variables in the context of management. For, example, data on physical variables should be related to operators' and farmers' perceptions of the physical system to evolve an effective strategy for improvement.

## On-Farm and Farmer Client Initial Focus

Strong farm and farmer focus is essential initially in all phases of the process. If the system is not performing to design standards it will always be reflected at the farmer user end. Actions in any phase of the process are developed from system data without allowing prior assumptions about problems, dictate research or development programs. Farmers, system operator's, researchers, trainees, and all other personnel, are involved in all the phases of the process, as a team. This is a unique aspect of this research-development process. In the past, both in research and in development, inadequate focus has been given to the primary beneficiary who is the farmer user, as well as to the system operators and the complex interface between farmers and operators. The farmer client should be viewed as a key building block in any irrigation system designed for agriculture. It is the end user who is always confronted in the total system perforlance. It is he who must manage the productive part of the system while dealing with many variables over which he has little or no control. The interface between the farmers and system operators is also an area that needs much more serious attention than in the past. Farmers cannot design, construct and operate medium and large irrigation systems. They seem to do a fair job on some small systems but major and medium systems requires resources and skills provided by traditional agencies.

Operational Staff Involvement

while the circumstances under which a water management program is initiated in given countries will vary, it is always executed by people. These may include the operators, farmers, researchers, extension workers and other governmental or private agency personnel. Moreover, not only is involvement from the field teams to important but ways need to be found to get findings and results to official decision makers. Better ways and means are needed to articulate findings and results more widely and better for this important audience. Reports need to be tailored to these people and the analysis of causes versus listing of symptoms, alternative solutions, and knowledge of institutional constraints need to be made clear and crisp to build greater creditability for the program. This involvement of many actors will also help ensure that the program is fully accepted. Without local staff acceptance and committment at all levels to the top, it is unlikely that many irrigation management programs can ever be successfully implemented.

Irrigation and Agricultural Departments should also evaluate their ability to supply technically qualified, experienced personnel as team members. If this is an initial constraint, team members will need to be trained. A major need in many countries presently, is a good manpower assessment study projecting training needs 20 years into the future. This should be associated with a good institutional anaiysis as to where and how the best training can be made available. Such an assessment is now being started in India. Without such an analysis, it is feared that much training for specific performance needs will remain tentative and adhoc in nature.

Management Oriented

Irrigation management with its biological, physical, socio-economic, and institutional components which interact with each other, is indeed, a most complex development process. Social, economic and institutional issues in irrigation systems usually outweigh the purely technical ones. The interface of physical and organizational factors are still not adequately understood. Operators and farmers must orchestrate many complex decisions in order to achieve their goals which are often in conflict. The decisions they have to make are seldom simple 'on or off' "use or not use" decisions. These complex management decisions always involve risk and uncertainity. Farmer and operators interact with each other and with the physical system. The interests and performance objectives between farming and between farmers and many public and private organizations also vary. Therefore, efficient utilization can seldom be achieved by simply improving a single technology or input such as, seed, fertilizer, more water, or improved implements. A definite management process is needed to coordinate, integrate, and monitor inputs and outputs at several levels. Management is important because a change in one component of a dynamic system creates a chain of interactions between many components. For example, when increased irrigation water is made available to the soil-crop complex, much more than water is always involved. Changes also takes place in other factors. Therefore, there is always a need to improve monitor and maintain management approaches, control structures, measurement devices, new crop mixes, new markets, modes of collective action with other farmers, credit and input facilities, and other services. This illustrates the complexities of system interactions which are probable the least understood aspects of modern irrigated agriculture. Management includes planning, setting objectives, measuring, coordinating, integrating, monitoring and evaluating in order to improve performance in terms of some standards. IM, like all good management, is learned primarily through practice. It requires training of all concerned at every level of man-made irrigation systems.

## Action Research

Action research involves a combination of systematic and investigative approaches for the identification and solutions of complex systemic problems as they occur throughout all phases of the research-development process for improving the performance of systems. Research does not start at the research institutes, Labs or experiment stations, instead action research takes places on live systems. Action research also does not stop at the research station or the lab either. It takes place on a total system and reaches to the farm and the drainage subsystem. Action research is not completed with a report either. Instead it provides data on which to build or improve the institutional capability of several organizations to find ways and means to transfer solution found useful to other system operators and farmers. The solution of a problem is never accomplished until there is an institutionalized procedure to facilitate its wide scale use to operational staff and farmer users.

## Essential Emphases

Embodied in the key concepts described above and throughout the four phases there are also some essential emphases to keep in mind (See table 1). These essential emphases desire in each phase are as follows:

1. System operators and farmers participate in each of the four phases of diagnosis, search for solutions, assessment of solutions, and project implementation.

2. Communication and feedback between system operators farmers and researchers.

3. Effective, interdisciplinary team collaboration in planning and executing the process.

4. Careful selection, training and evaluation of all personnel.

5. Institutions developed to serve farmers.

6. Monitoring and evaluation of all aspects and phases.

Involvement of the farmers and those who are designated to serve farmers is given high priority. The results of their actions must be measured and monitored. Their explanations of their actions on irrigation behaviour are also important and must be obtained. Before farmers and operators irrigation behaviour can be changed significantly, they must feel that they have ownership in the process. Their trust is essential so efforts are made to build up creditability. Farmer participation is essential in the diagnosing, searching, assessing and in implementing the solutions. Likewise, Operational staff involvement is essential to build the committment for improved system performance. Today, there is rightly a growing concern for more and better farmer involvement but, it is of equal importance to find ways to involve and improve the performance of operational staff.

Effective participation of all key actors in the system is seldom obtained without effective communication mechanism. To evolve effective and clear non-conflicting program goals and procedures always requires careful planning and much open communication. Training is a formalized transfer of ideas and skills through visual, written and oral procedures. Team collaboration is a process that becomes effective when there is good open communication. Team collaboration and learning then requires much work on how to communicate with each other. When roles and responsibilities are not crystal clear interdisciplinary research process is greatly weakened.

Building an institutional capability for each phase of the program and linking the phases together is essential for a successful program. In some instances old institutions may be modified or new ones developed. Until the process is institutionalized, the transfer process is not complete. Par too little is known about how to effectively build sound functional linkages between the array of organizations and key actors of an irrigation system.

Monitoring and evaluation should be done by an interdisciplinary team. Team effectiveness, research accomplishments, training, and other administrative aspects should be monitored, evaluated for performance based on objective criteria and continually improved. Emphasis on evaluation is to improve program effectiveness. It is not to be confused with fault-finding.

Unique Aspects

The research-development process described in this paper may seem familiar to many researchers. It involves the conceptual steps of most formalized research procedures in which the problems are defined, solutions are sought and the final product is evaluated in terms of performance standards. There are several unique aspects in this research development process which are seldom found in conventional research programs. These unique aspects are as follows:

1. Formalized diagnostic analysis;

2. Assessment of solutions at the user (farmer) level:

3. Project implementation including institutional building as a part of the research process;

4. A focus on system operators, chaks, farms and farmers at the productive end of the system;

5. Useful research as a mode of operation throughout the process;

6. A coordinated and integrated interdisciplinary research-development process;

7. A continuous development process versus one that is time bound:

8. A process with which adaptations can also be used for farming and other systems.

## summary and Recommendations

An irrigated area or project that has significant potential for significant improvement in terms of performance, is selected. An interdisciplinary research team quantitatively and qualitatively measures these variables which describe system operations including water inputs and outputs, agronomic and economic inputs and outputs, and the resulting costs and returns of various cropping systems. Institutional, legal and social Constraints and the priority organizational problems which restrict proper water use are identified and measured. Priority constraints using agreed upon criteria of performance are identified and ranked by their potential for improvement and the expected effectiveness of their solutions.

When a solution has been selected, assessment of the solution will be conducted under live system conditions and evaluated to determine the real costs, benefits, and institutional resource needs for successful adoption. A strategy for institutional implementation of the solution will then be devised. For example, delivery channel improvements may involve much capital or less depending on the degree of labor intensive approaches desired. The conveyance systems at the chak level may be executed by agriculture or irrigation departments separately one jointly. It may involve services from development or research personnel and the private sector or both. Knowledge of the benefits and costs of such a program are provided both to the farmers concerned and to government officials by the executing agency. Particular strategies for implementing each technology or set of technologies are devised as well as procedures which ensure the acceptance and continuous maintenance of system operators' and farmers'.

The last emphasis is on assisting a particular institution to implement technology transfer to provide a continuous flow of useful information to system operators and farmers. Usually there is need to identify from the data and experience obtained, the training needs of personnel and farmers. Specific materials for the training institution and for training farmers may also be needed. Much of the content of this training come from data and experience gained in the actions studies. Policy papers and special high level forms may be needed to influence public attitudes or to effect new laws and change old laws. The emphasis here is on insuring that the technology which solves farm problems is effectively transferred.

This technology transfer process can be implemented on a small or large scale in any country at low cost. For example, a new irrigation project today may cost about Rs.30,000 to Rs.50,000 per hectare of land to be served. Recent studies have shown that typically only about Rs.200 to Rs.400 is invested for all the training needed by professionals and farmers on a per hectare basis. Currently only about Rs.8 to Rs.10 are being invested solely for farmer training. For training a type of process is needed with a management improvement focus. This interdisciplinary team approach described in this paper has application for use on any type of agricultural systems, irrigated or not.

This framework may also have relevance to the general field of rural development. The performance improvement of irrigation systems is and can be a powerful stimulus for rural development. Water management in fact, touches all the facets of rural life in many areas of the world. In programs can be viewed as a major vehicles for the transformation of village life.

> Wiener (1972) 11/, states that 'engineering is not the fundamental problem underlying irrigation development in the LICs. Engineering principles are known and can be adapted but the major problem, is to discover ways to utilize farmer clients more efficiently in operation and maintenance and develop programs which will create rural transformation. Rural transformation casentially requires changes in farmers' behaviours, motivations, and expectations which is hardly possible until institutions exist to provide them with improved production possibilities and incentives..

Finally how do we build the necessary alliances and linkages between researchers, operational staff and farmers to achieve improved irrigated agricultural production? This research development process is only one small step in a long journey.

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11/ Wiener, Aaron. "The World Food Situation and Irrigation Programmes. ICID Bulletin, January 1976.

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Final: 7/11/85 MKL:ec

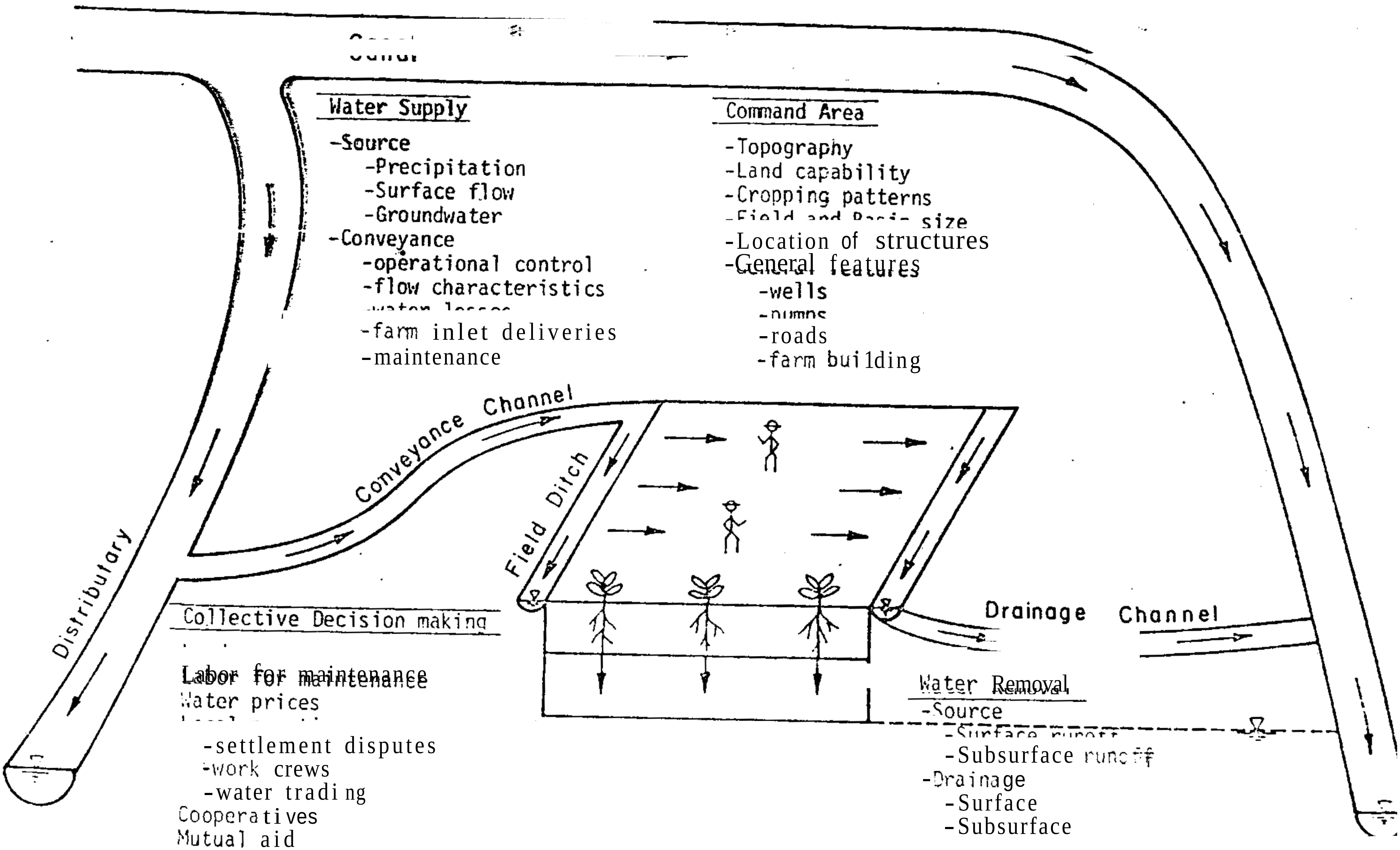


Figure 1 Idealized sketch of a farm irrigation water supply and removal subsystem.

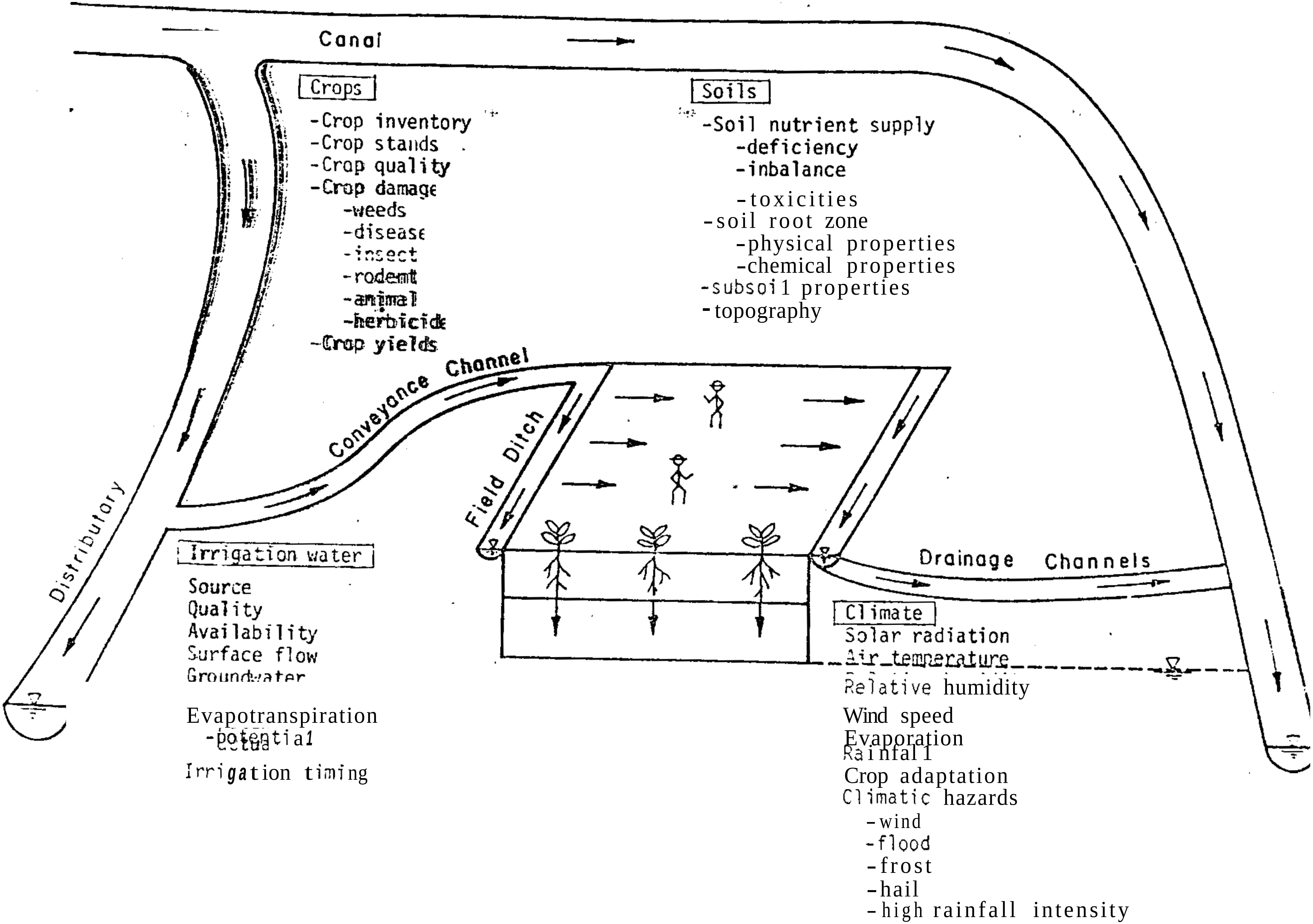


Figure 2 Idealized sketch of the plant environment.

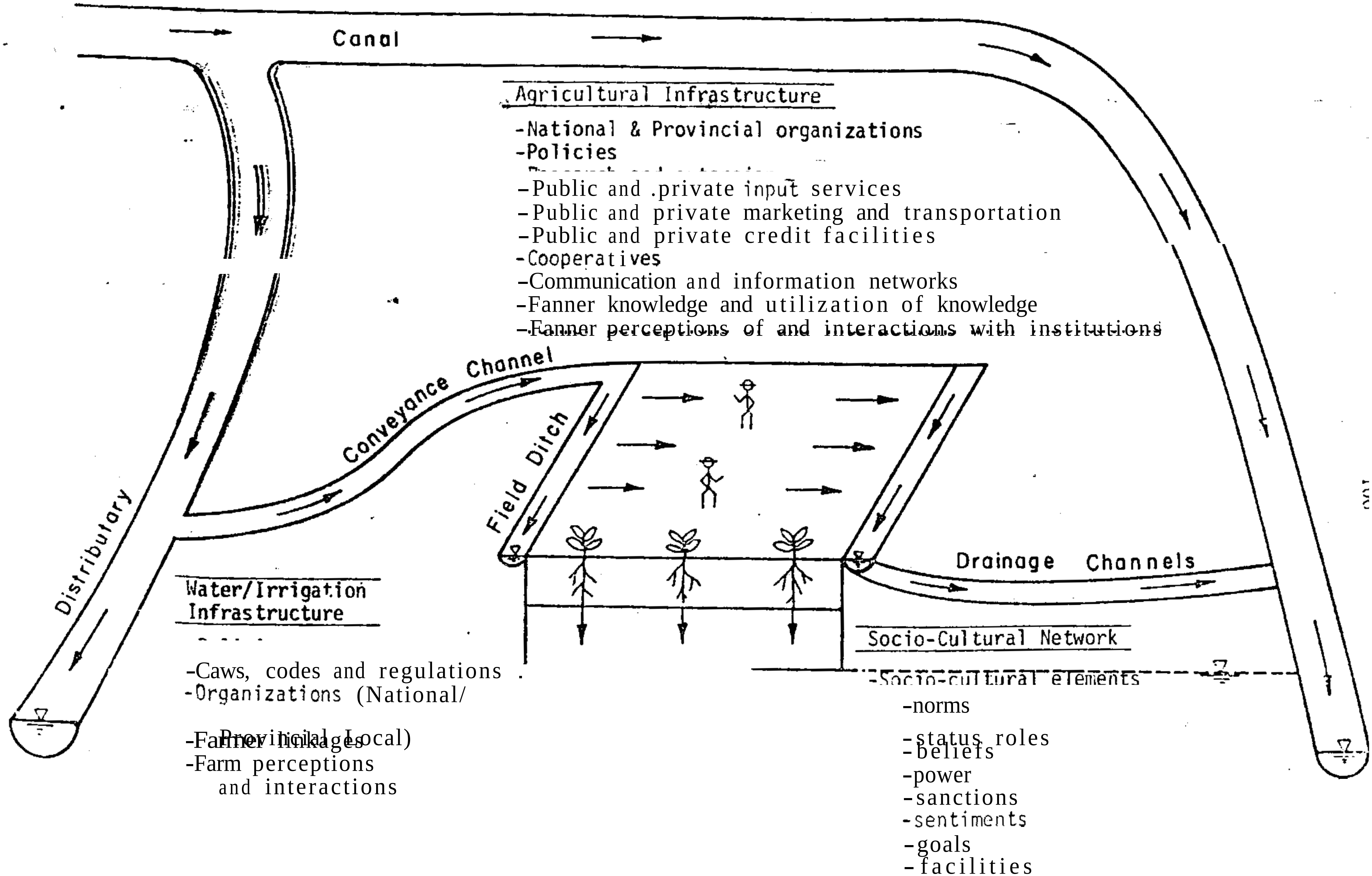


**Figure 3** Idealized sketch of the institutional infrastructure for a farm irrigation system.

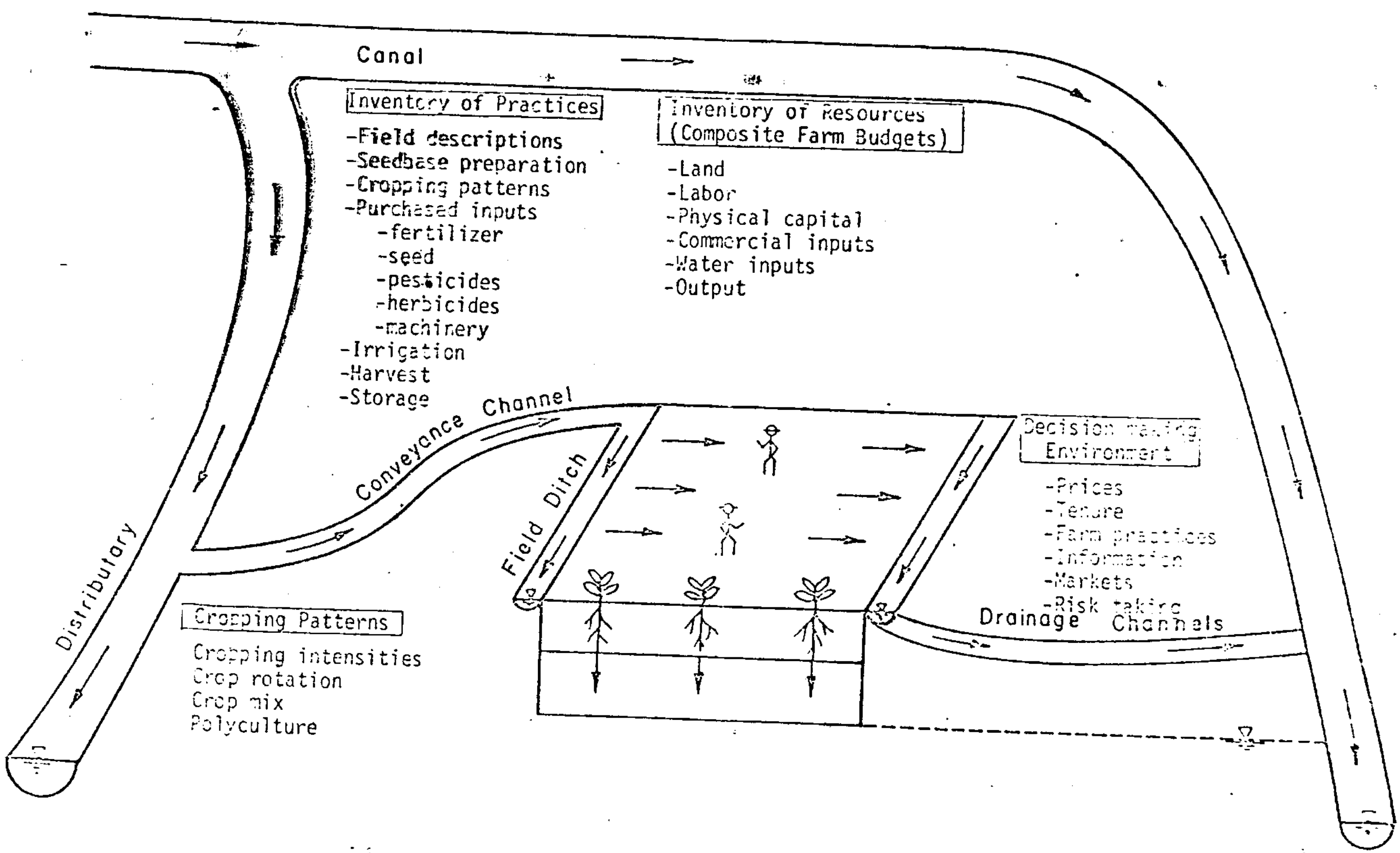


Figure 4 Idealized sketch of a farm irrigation system and farm management practices.

# WHAT IS IRRIGATION WATER MANAGEMENT AND ITS REQUIREMENTS ?

There is a need for a more comprehensive understand of the meaning of irrigation water management. The term is often misunderstood and used almost as a dangerous fad because many international agencies are now willing to invest in water management improvement projects. Irrigation water management is the process by which water is manipulated and used in the production of food and fiber. Water management also includes the management of water in rainfed areas as well as water artificially provided for perennial irrigated areas but the focus here is on man-made irrigation systems. Irrigation water management is not water resources, dams or reservoirs to capture water, nor canals to convey water, nor codes, laws or institutions to allocate water, nor farmers' organizations, nor soils or cropping systems. It is, however, the way these skills and physical, biological, chemical and social resources are utilized to provide water for improved food and fiber production.

Irrigation water management for agriculture requires that six criteria be utilized in the design of new systems and the improvement of existing systems. These are:

- Increased water control and reliability of supplies to the farm level;
- Increased productivity of water to farms and farmers;
- Improved equity of water distribution among all classes of farmers;
- Improved maintenance of soil and water resources over time;
- Increased participation of farmers in the operation and maintenance of the farm system;
- Increased cost effectiveness of investments in the system.

To achieve the six criteria of successful irrigation water management requires:

- Professionals trained with comprehensive irrigation water management focus backed by institutions which provide incentives and mechanisms to utilize new knowledge and skills in project implementation and system operations.

- A systems approach which links water source, water supply, water application, water use and water removal.

- Team diagnostic analysis and development of solutions, skills and procedures acquired on live systems with farmer involvement used to design, implement and operate systems which fit particular physical and cultural settings. A design approach from the bottom up and back.

- A solid focus and orientation to the needs of farms and farmers at the productive end of system and farmer involvement in design, implementation, operation and maintenance of the system below the outlet.

- System demonstration areas where farmers are the chief salesmen of useful technologies.

- A marriage relationship between irrigation and agricultural bureaucracies where roles and responsibilities are designed to achieve coordination of activities and integration of timely inputs and services for end users,

# CRITERIA FOR TECHNOLOGY ASSESSMENT

## 1. Visibility of Innovations

a. Highly visible benefits.
b. Trial and adoption can be done easily and immediately
c. All classes of farmers can be benefited.
d. Communication to other farmers can be done easily.

## 2. Economic Advantage

a. Substantial relatige economic benefits over other practices.
b. Initial investment within farmer resources.
c. If indivisible and a collective good, farmers will cooperate to secure the innovation.
d. Sufficient incentives such as markets and price policy to maintain economic advantage.
e. Sufficient assurance that economic benefits will not be captured by only large landlords.

## 3. .Technical Aspects

a. Level of complexitiy of adopting the technology not too great for clients.
b. Congruence with innovations replaced and the complementarity with other innovations in a package.
c. Trialability of the innovation.

## 4. Requisite Infrastructure for Widespread Adoption

a. Institutional government services.
   i. Continuing research capacity.
   ii. Sufficient farm level advisory services.
   iii. Sufficient mass media and information services.
   iv. Credit and market facilities.
   v. Price incentives or other incentives.
   vi. High level government support.

b. Agro-business supplies and services.
   i. Necessary inputs.
   ii. Credit facilities.
   iii. Repair end replacement facilities.
   iv. Incentives far private businesses.

## 5. Social and Environniental Impact Estimates

a. Related to land, water and health.
b. Related to authority, tradition, cohesion and conflict.
c. Equity of benefits.
d. Cumulative impacts of scale.
e. Reversibility of impacts.

## 6. Cultural Compatibility

a. Present value system.
b. Past experience.