Improving the Management of Irrigated Agriculture: A Methodology for Diagnostic Analysis

Water Management Synthesis Project
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IMPROVING THE MANAGEMENT OF IRRIGATED AGRICULTURE: A METHODOLOGY FOR DIAGNOSTIC ANALYSIS

by

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There are many individuals and groups which have contributed to this paper. Chief among these are our colleagues in Water Management Synthesis II Project (WMS II) and in the countries where we have tested and improved our concepts and approaches. Our friendly critics have caused us to think more carefully about system diagnosis.

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Finally, we appreciate the opportunity to provide a synthesis of our understanding about diagnostic analysis through the support of the WMS II Project. Although several colleagues asked "What else could be written about diagnostic analysis?", we think this paper will result in improved understanding of water management systems using diagnostic analysis.

PREFACE

The authors have been concerned about how irrigated agricultural development could be accomplished more effectively since the early 1970s while working in Pakistan. Those initial efforts in Pakistan probably were inordinately focused on field studies to define and document problems; at that time there was much disagreement as to what the priority problems were. Since that time we have worked to further define and refine a model for development which would assist professionals to accomplish development efforts more effectively. Again, much time was spent defining problem identification and then diagnostic analysis.

This paper is an attempt to communicate the lessons we have learned about how to accomplish the diagnosis of complex irrigation systems. We hope professionals in water management can use these ideas and build upon them to better understand how irrigation systems can be improved. This paper builds on two previous diagnostic analysis manuals (Lowdermilk et al., 1983; Fowler, 1988). It incorporates a management emphasis formerly developed, but now more specifically defined. A system management focus has been used in this refined model to structure the diagnosis process so that it provides a less biased disciplinary and a more effective interdisciplinary definition of the irrigation system.

Our concern has been to identify a process to guide an interdisciplinary team through diagnostic analysis, while allowing the team to define the specific concepts and approaches to be used in a particular context. We think the team planning methodology, combined with the diagnosis framework and process, more effectively accomplishes this goal. We believe a team can use its own knowledge and experiences to build on and improve the definitions we have given.

Some professionals have expressed a concern that diagnostic analysis focuses on negative aspects of an irrigation system. Properly used, diagnostic analysis focuses on the priority areas of both high and low performance. Experience has shown that understanding the causes of low performance and then providing visible solutions which result in high performance is a very effective way to obtain the involvement and commitment of government and farmers in improving agricultural performance.

Our previous attempts at defining improved processes and approaches evolved over a period of a year or more. This particular effort was completed in only a few months; therefore, we have not tested our defined approaches as much as we would have liked. Due to project deadlines, we have finalized our effort to provide a current version. We expect that this methodology will be refined in the future based on the suggestions of readers and our own experiences. We solicit your comments and suggestions.

We had anticipated writing a companion paper that would define and describe an implementation planning process. Resources and time were not available to accomplish the task, but perhaps such an effort can be completed in the future. The authors think that much more effective improvements in irrigated agriculture can be made through the processes we have described.

We also think that irrigated agricultural development can occur more rapidly and effectively than it has, and that farmers can achieve improved well-being. Also, we think that governments can achieve significant returns on their investments in irrigation than is currently done. Diagnostic analysis can be an important part of the strategy for accomplishing these objectives, and, when followed with appropriate implementation planning, it can help institute effective organizational change to improve the performance of irrigated agriculture.

EXECUTIVE SUMMARY

Diagnostic analysis has been a key strategy for improving the performance of irrigated agriculture in a number of countries, especially Pakistan, Egypt, India and Sri Lanka, over the past 10 years. Diagnostic analysis is an interdisciplinary field study of an irrigation system to understand the performance of the system and make recommendations for improvement. This paper builds on past experience with diagnostic analysis to apply new concepts for management and diagnosis to define an improved process for diagnostic analysis.

A methodology of diagnostic analysis is developed and presented as a series of phases. Management concepts, systems concepts, and a diagnosis framework are defined that provide the conceptual basis for the methodology. A diagnostic process which uses the supporting concepts and diagnosis framework to measure system performance and identify the causes of high and low performance is described. An overall plan for managing diagnostic analysis is developed using the team planning methodology, which consists of the following five phases:

Phase I: An overall plan for the diagnostic analysis is developed. The context is established, the purpose and outcomes are defined, roles and responsibilites are agreed upon, and an overall plan is developed by the diagnostic analysis team to accomplish the outcomes. A detailed plan for the next phase is prepared.

Phase II: Entry involves organizations in a process to gather information for planning the field studies. This includes receiving input about issues and concerns, providing information about the effort, and receiving a mandate from organizations for personnel involved in the study. The information received is the basis for planning the rapid diagnosis (Phase III).

Phase III: A rapid diagnosis develops an initial understanding of the priority high and low performance areas of the irrigated agricultural system including the priority contributing factors and their magnitude. This understanding is developed by the interdisciplinary team, using indicative field data because of the short timeframe. This information is used to 1) plan the detailed diagnosis of Phase IV or 2) prepare reports for Phase V.

Phase IV: A detailed diagnosis is focused on the hypothesized areas of high and low performance and the priority contributing factors developed in Phase III. Analysis and synthesis of system performance is accomplished by the team. Reports are prepared with recommendations for improving performance for 1) policy makers, 2) executive and operational managers, and 3) water management professionals.

Phase V: The exit phase provides the involved organizations with the results of the diagnostic analysis, accepts their input for formulating goals and a plan for implementation planning to build on the diagnostic analysis to improve the performance of irrigated agriculture.

Diagnostic analysis focuses on improving the understanding of system performance. This understanding effectively provides a base for project designs, sector reviews, project evaluations, diagnostic analysis training workshops, senior officials' workshops, and implementation planning or similar processes. Implementation planning builds on a diagnostic analysis using a multi-organizational and multi-level, problem-solving and planning process to develop a management plan for an irrigated agricultural system. The management plan addresses the problems identified during diagnostic analysis, and outlines changes in facilities and management which address these problems.

An interdisciplinary team applies the methodology of diagnostic analysis during a field study. Disciplinary and interdisciplinary concepts are applied in the analysis and synthesis of the irrigated agricultural subsystems to understand performance and the factors that contribute to performance. The interactions between subsystems are numerous and multi-faceted, and careful interdisciplinary efforts are needed to understand each subsystem and the system as a whole. The suggested variables for measuring performance, indicators of performance, contributing factors, and means for measuring the magnitudes of contributing factors are intended to assist a new diagnostic analysis team to more effectively diagnose an irrigation system.

I. CONTEXT AND NEED FOR NEW DEVELOPMENTS IN IRRIGATION SYSTEM DIAGNOSIS

A. INTRODUCTION

The need to understand the performance of irrigations systems has received increasing attention over the past decade. Concurrently, there has been an increased focus on improving the management of irrigation systems. For example, the creation of the International Irrigation Management Institute in Sri Lanka has resulted from concern about improving irrigation system performance through improved management. A greater consensus exists today that developing an understanding of irrigation systems is integral to improving their management. Consequently, there has been a growing recognition of the need to study or diagnose the field conditions under which irrigated agriculture performs (Clyma and Lattimore, 1987).[1] The result is that more organizations are conducting field studies to understand and improve current levels of irrigation system performance.

The purpose of this paper is to describe a methodology for diagnostic analysis. This methodology can be used by interdisciplinary teams to better understand how to improve the performance of irrigated agriculture. Chapter I reviews the need for improving the diagnosis of irrigation systems and new developments in the methodology for diagnostic analysis. Chapter I also introduces a strategy for using diagnostic analysis to improve the management of irrigated agriculture. Chapter II reviews important supporting concepts for diagnosis. The methodology for diagnostic analysis is presented in Chapter III. Application of the methodology to the diagnosis of irrigation systems is presented in Chapter IV with supporting examples in the appendices. Chapter V reviews a strategy for improving the performance of irrigated agriculture through a process for improving management.

B. CONTEXT FOR IMPROVING DIAGNOSIS

This section reviews the need to improve irrigation system performance through improved diagnosis, the background of irrigation system diagnosis as it has developed, and the context and status of needs for improving diagnosis.

1. Need to Improve Irrigation System Performance

Due to the high cost and low performance of new projects, donor agencies and host country policy makers are becoming more interested in improving the performance of existing systems. New projects typically

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[1] The Water Management Synthesis II Project sponsored a "Rehabilitation of Irrigation Systems" conference in the fall of 1986. All participants agreed that pre-rehabilitation studies were an important part of improving the performance of irrigation systems.

cost from $7,000/ha to $9,000/ha[2], compared to $1,000/ha to $1,500/ha for improving existing projects. For example, in India, due to the low level of system performance and high cost of new projects, policy has changed to focus on existing projects (National Water Policy, 1987). This is significant because India has over 50 million hectares which could be developed into new projects (Planning Commission-India, 1986).

The need to improve the performance of irrigated agriculture is the priority rationale for effective diagnosis. Fasso (1987) at the 13th Congress of the International Commission on Irrigation and Drainage stated that over half of the 230 million hectares currently irrigated in the world require radical improvements. The same congress highlighted the theme of rehabilitation and modernization of irrigation and drainage projects. Another recent high-level conference (Haider, 1987) on system rehabilitation and betterment provided the following reasons for improving systems:

* Rapid deterioration of existing irrigation systems and low irrigation efficiency
* Growing scarcity of suitable land and irrigation water
* Growing recognition of the problems found in older systems and the potential for increasing production in these systems
* The need for increased quantity and quality of food production
* Pressures from farmers to improve the delivery and distribution of irrigation water
* Preference of donors and lending organizations for improvement projects that cost less than new projects

The above conditions suggest the urgent need to improve the performance of irrigated agriculture. Improving the management of irrigated agriculture is a fundamental necessity for improving irrigated agriculture's performance. Knowledge of the areas of low performance and the factors that cause low performance is a prerequisite for improving management. Effectively diagnosing current conditions in specific irrigated projects is the best approach for developing adequate knowledge to improve management.

2. The History of Diagnosis and Diagnostic Analysis

The development model (Clyma, Lowdermilk and Corey, 1977) was originally defined from efforts to improve on-farm water management in Pakistan. Diagnostic analysis is one of the key phases of this cyclic model as redefined by Clyma, Lowdermilk and Lattimore (1981) and presented in Figure 1. Diagnostic analysis is the basis for beginning an irrigated agricultural development effort focused on assisting farmers to improve productivity and water management. This initial focus on interdisciplinary field studies of farm irrigation systems provided the basis for many concepts of diagnostic analysis.

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[2] The authors used figures from Oram et al., 1979, and made adjustments for inflation of costs to arrive at these estimates.

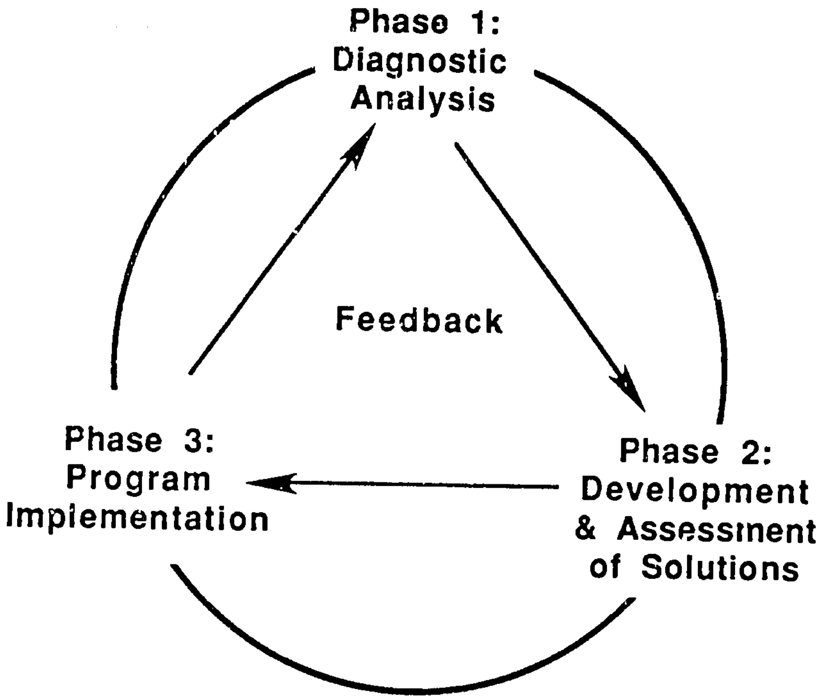

Figure 1. The development model with diagnostic analysis to improve the performance of irrigated agriculture (from Clyma, Lowdermilk and Lattimore, 1981).

Field studies of irrigation systems are limited, especially in less developed countries. Interdisciplinary field studies of irrigation systems are even more limited. Because of this inadequate understanding of field conditions, interdisciplinary diagnostic analyses have changed the understanding of officials regarding the causes and magnitudes of problems in more than 20 irrigation projects in eight different countries over the past 15 years. Other approaches to diagnosis of field conditions such as rapid appraisals (Chambers, 1983) and farming systems (Shaner, Philip and Schmehl, 1982) have also contributed to this understanding.

The greatest impacts of field studies and diagnostic analysis for studying irrigation systems have occurred in Pakistan, Egypt, India and Sri Lanka. The first studies highlighted irrigation efficiencies in Pakistan in the early 1970s, in which multi-million dollar field studies had assumed that irrigation efficiencies were high (90% delivery and 85% field application efficiencies). Subsequent field studies showed that delivery efficiencies were 50% to 60% and field efficiencies were less than 50% in many areas (Clyma and Corey, 1974). Because of the assumed high efficiencies, on-farm water management was neglected for a decade in Pakistan. With the problem of low efficiencies better understood, however, Pakistan has invested several hundred million dollars in improving on-farm water management over the last decade.

The Egypt Water Use and Management Project (Clyma et al., 1981) built on experiences in Pakistan to initiate long-term interdisciplinary field studies and to develop and test solutions to the defined priority problems. An implementation program was defined (Egypt Water Use and Management Project, 1984) which is currently being implemented as a regional irrigation improvement program.

India was the site of the first field workshop in 1980 on diagnostic analysis conducted by the Water Management Synthesis Project. Two additional workshops were held in different states. India currently (1988) has a Water and Land Management Institute in each of 11 states which provides training in diagnostic analysis and conducts action research to improve the performance of irrigated agriculture. Over 10 diagnostic analysis studies have been conducted by these institutes over the past several years. In addition, diagnostic analysis has been used to train field staff to collect data for the design of minor irrigation systems, to sensitize senior officials to the use of field studies for planning and designing micro-networks, and for project evaluation.

Sri Lanka has completed a long-term diagnostic analysis study to provide baseline information for improving the performance of irrigated agriculture in four irrigation schemes. The diagnostic analysis studies provided input for designing the improvement project and for planning the improvements (Skogerboe et al., 1983; Nelson et al., 1988). An irrigation management division now focuses on improving the management of irrigation tank systems in Sri Lanka. Studies of the tank systems changed professionals' understanding about the needs for system improvement and management.

3. Strengths and Weaknesses of Diagnostic Analysis and Other Diagnostic Methods

The use of diagnostic analysis in eight countries and 16 workshops over the past several years has helped to identify a number of strengths and weaknesses in diagnostic analysis. In addition, Oad, McCornick and Clyma (1988) reviewed the use of diagnostic analysis and other diagnostic approaches under the Water Management Synthesis II Project and suggested a number of limitations in the approaches used for diagnosis. Clyma (1986) analyzed several approaches to development that included a diagnosis phase Limitations and strengths for each approach to diagnosis were identified.

A major effort has been made to evolve a farming systems research and development approach (Shaner, Philip and Schmehl, 1982). Though the focus is primarily on rainfed agriculture, the emphasis on field studies is sound. Key concepts such as the systems approach, farm and farmer focus, and action research studies are the same as those in diagnostic analysis. Clyma (1986) concluded that the farming systems problem identification and diagnostic analysis are two sides of the same coin.

Another contribution from which diagnostic analysis can benefit is the learning process approach (Korten, 1982; Uphoff, 1984), which includes a focus on farmer involvement in developing organizations, organizational change and reform, the need to provide reorientation to officials, and a focus on farmer training. Though this is not a complete methodology for irrigation system diagnosis, it does highlight some needs related to organizations and program implementation.

Rapid appraisal has been a focus of discussion for Chambers (1983), Yoder and Martin (1983), and Bottrall (1983). Bottrall (1983) emphasizes the performance of the irrigation system and measures of performance. Rapid appraisal methods were developed for quick evaluation of a system. Bottrall (1983) also suggested a specific focus on performance, factors to explain performance, and recommendations for needed action.

The above experiences suggest that diagnoses of irrigation systems have been applied and used to effectively direct development efforts. The authors of each approach have suggested needs for improvement, usually from experiences of application in the field. The following improvements for diagnostic methods are suggested:

* Improve team building and management procedures for the process.

* Focus more specifically on the management objectives of irrigated agricultural systems.

* Focus on the priority needs using a structure and logic that limit data collection to the priority needs.

* Use a structure and process to develop an interdisciplinary understanding of a performance area and the factors which contribute to the given performance.

* Obtain assurance that the knowledge and understanding developed from the diagnosis effort is used by the relevant organizations to improve performance of irrigated agriculture.

These needs have been identified from lessons learned in the field, from formal evaluations of diagnostic analyses after completion, and from the experiences of others in their approaches to system diagnosis.

C. NEW DEVELOPMENTS IN DIAGNOSTIC ANALYSIS

The purpose of diagnostic analysis is to develop an understanding of how to improve the management performance of irrigated agriculture. Experiences in diagnostic analysis and the efforts of others in diagnosis have provided insight and understanding to improve the **concepts, process** and **performance** of diagnostic analysis.

The previous definition of the concepts for diagnostic analysis (Lowdermilk et al., 1983) and the procedures (Fowler, 1988) for accomplishing diagnostic analysis are still relevant. Because new concepts have been defined and the process has been revised and improved, the process for diagnostic analysis is redefined in this paper. Concepts previously introduced, such as synthesis, interdisciplinary teamwork, and a number of systems concepts, are still appropriate for use in diagnostic analyses. They are not discussed here in detail due to page limitations.

The methodology is designed to be flexible. Each diagnostic analysis team may build on the predefined concepts and process to create a specific diagnostic analysis procedure to use. In adapting the methodology, the team should call on their own knowledge and experience and consider the specific conditions under which the methodology will be applied. The new concepts and processes defined for the methodology of diagnostic analysis include the following:

* An overall management process
* Small group processes for problem solving and planning
* System management concepts for focusing on priority performance areas and the priority causes of the performance
* System management concepts for interdisciplinary integration of understanding
* A diagnosis framework and process
* Information on how to apply the methodology based on previous experience
* Diagnostic analysis as Phase I of a process that leads to implementation planning to improve irrigation systems and their management

Subsequent chapters define these concepts and the methodology, and provide information that assists in applying the methodology.

D. IMPLEMENTATION PLANNING FOR IMPROVING MANAGEMENT

Diagnostic analysis has frequently been applied in training workshops where the primary outcome was trained staff. Specific improvements have evolved from the initial workshops in a number of countries over long periods of time, but these have often been of limited scope. Pakistan (through the On-Farm Water Management program) and Egypt (through the Regional Irrigation Improvement Project) are exceptions to this. India and Sri Lanka have improvement efforts that currently build on diagnostic analysis, but the initial training workshops resulted in limited improvement efforts.

Recent experiences in Pakistan (Jones and Clyma, 1988) suggest that implementation planning can build on diagnostic analysis using a multi-organizational and multi-level, problem-solving and planning process to develop a management plan for an irrigated agricultural system. This management plan addresses the problems identified during a diagnostic analysis, and outlines changes in facilities and management which address these problems.

Diagnostic analysis focuses on improving the understanding of system performance. This understanding effectively provides a base for project designs, sector reviews, project evaluations, and other related purposes. Diagnostic analysis is appropriate for these purposes.[3]

A key purpose of diagnostic analysis is to improve the performance of irrigated agriculture. Thus, the purpose of diagnostic analysis assumed throughout this paper is to develop an understanding of the irrigated agricultural system for use as the basis for conducting implementation planning (Jones and Clyma, 1988) in order to improve the management of irrigated agriculture. When there is no serious commitment to implementing improvement activities, then investing human and financial resources to conduct a diagnostic analysis should be seriously questioned. Further, diagnostic analysis should be postponed until it can be followed by implementation planning.

The process of implementation planning is discussed in more detail in Chapter V. During the discussion of the diagnostic analysis process, the implications of the diagnostic analysis results to implementation are frequently illustrated.

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[3] In India, for example, diagnostic analysis forms part of 9- and 12-month training courses for existing and new irrigation department personnel. The purpose is to teach operational staff and recruits how to view a system as a system, and the importance of interdisciplinary teamwork in understanding complex irrigation systems.

II. SUPPORTING CONCEPTS FOR DIAGNOSTIC ANALYSIS

The management and diagnostic concepts used during diagnostic analysis are important to the success of a study. Often, concepts are not explicitly defined by diagnostic teams. This section reviews these important concepts and suggests how individuals and teams can better use them when conducting a diagnostic analysis.

A. MANAGEMENT CONCEPTS

Management in its simplest definition is the organization of people to accomplish the essential objectives of a particular enterprise. People, organizations and objectives are important in management. Management processes that facilitate the effective performance of the diagnostic analysis team and ultimately improve the performance of irrigated agriculture are the focus of this discussion.

There are three essential managerial focuses in a diagnostic analysis: 1) the management of the diagnostic analysis team to accomplish team purposes; 2) the integration of the diagnostic analysis study (training workshop or field study) into an organizational context to develop the managerial capabilities of the involved organizations; and 3) the improved management of the irrigated agricultural system to achieve its purpose.

1. Team Management

The team management process explicitly includes the use of the team planning methodology (Kettering, 1985; Levine, 1988) as the strategy for implementing diagnostic analysis. The team planning methodology is used by the team to establish the context for the diagnostic analysis, reach agreement on the purpose and objectives of the intervention, define roles and responsibilities for the team, and develop an overall plan for how the objectives will be accomplished.[4] The overall plan includes a detailed plan for the next phase of the effort and immediate next steps.

Diagnostic analysis personnel often come from diverse disciplines and have diverse experiences. A diagnostic analysis team does not just happen. Putting together a good team requires training, planning, and good team management. The team planning methodology is a useful aid for developing a good team.

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[4] The team planning methodology uses small group processes to involve individuals, gain their input, develop ownership by addressing their concerns and incorporating their approaches, and using brainstorming techniques to generate ideas. Management concepts continually guide each group in its effort to establish a context; agree on purpose and outcomes, define roles and responsibilities; and plan how to accomplish the outcomes.

Oad, McCornick and Clyma (1988), in a review of several representative diagnostic studies, concluded that many of these studies did not provide for sufficient planning, including specific agreement of team members on the process and activities of diagnosis. The team planning methodology substantively addresses the concerns expressed by Oad, McCornick and Clyma (1988) that diagnoses of irrigation systems are not adequately planned and implemented.

2. Organizational Development

Recent experience in Pakistan (Jones and Clyma, 1988) has shown the value of implementation planning to effective management. Management in this sense is the use of group processes to gain more effective involvement from people (including farmers) and organizations (government and private industry). This involvement is used to improve planning and make implementation or management more effective. The experiences in Pakistan suggest that coordinated activities and motivated participants can result in more effective management in irrigated agriculture (Jones and Clyma, 1988).

Individuals in organizations can reach a common understanding of the problems to address. They can agree on roles and responsibilities, plan how problems will be solved by a single organization or jointly by several organizations, and arrange to receive information and support from all levels within an organization to accomplish the objectives of an agreed-upon management plan (Jones and Clyma, 1988). A management plan is the basis for future actions taken to accomplish objectives, improve performance, and enhance capability to improve management in the next inter-organizational management plan.

Once the process of improving management is initiated, continued improvement is expected through better problem solving (by continually utilizing the power of small group processes), through improved performance (because objectives and actions needed to accomplish objectives will be more clear), and through better coordination. Improved performance of irrigated agriculture that benefits farmers is the focus of organizational development (Jones and Clyma, 1988).

3. System Management

A typical medium-sized irrigation system of about 7,000 ha probably constitutes a business valued at $45 million to $70 million in productive assets. Thus, irrigated agriculture is a production complex worthy of the best industrial management techniques. Management in irrigated agriculture must focus on achieving its purpose, which is to make it possible for farmers to produce food and fiber and improve their well-being.

The management focus of diagnostic analysis requires that the purpose and objectives (or outcomes) of the irrigation system be defined. The revised general objectives of irrigated agriculture should be as follows (Clyma and Lattimore, 1987):

1. Achieve the potential productivity of irrigated agriculture within the environmental, organizational, and technological constraints present in a system.

2. Practice resource conservation to sustain irrigated agriculture.

3. Ensure that farmers and government receive a financially appropriate return on investments.

4. Provide water control for delivery and use to achieve dependable, adequate, and equitable water supplies.

In addition to these objectives, experience with irrigation development suggests that certain emphases are necessary if irrigated agriculture is to achieve its potential. These emphases are as follows:

1. Farmers should be involved in making management decisions.

2. Organizations should coordinate their activities as necessary to effectively achieve the purpose and objectives of irrigated agriculture.

The concepts of system management are represented in Figure 2. The overall purpose of irrigated agriculture -- farmer well-being -- is the central focus of system management.[5] The four management objectives (productivity, resource conservation, return on investment, and water control) are given equal emphasis and must be integrated to achieve farmer well-being. The two major management emphases (organizational coordination and farmer involvement) are necessary in accomplishing the four objectives.

Other concepts important to management include the definition of appropriate, interrelated subsystems to allow for more careful study of the irrigated agricultural system. The concepts and principles for understanding the physical, biological, social, and organizational processes involved in each subsystem are important in disciplinary and interdisciplinary analysis and synthesis. The diagnostic analysis manuals (Lowdermilk et al., 1983; Fowler, 1988) provide additional relevant information on these concepts and principles.

Previous approaches to defining the purpose and objectives of irrigated agriculture have listed farmer involvement and organizational coordination as objectives. Some professionals have suggested that these are not objectives for which achievement can be measured. Instead, they are emphases that must be considered, provided for, and achieved as necessary to effectively attain the objectives of irrigated agriculture. In any particular context, farmer involvement or organizational coordination may take different forms and still contribute to achieving the objectives defined for irrigated agriculture.

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[5] Appendix A gives a further discussion of the purposes of irrigated agriculture.

The objectives defined above are classed as fundamental because they are basic to effective management in all irrigation projects. Additional specific objectives may be substituted for any one of the above for a particular project. A water control objective can specify the volume of water to deliver which is adequate for rice cultivation, and that the supply should be dependable and equitable; the number of inadequate, but equitable, irrigations to supply to a command area for growing wheat and the timeframe or criteria for delivery; or the expected level of production to achieve for rice or wheat. These specific objectives replace the fundamental objectives, but they do not replace the need to achieve adequacy, dependability or equity in water control and a yield that is appropriately related to potential yield. Also, resource conservation is still essential if irrigated agriculture is to be sustained, and incomes must be sufficient to pay costs to governments and farmers if irrigation is to continue.

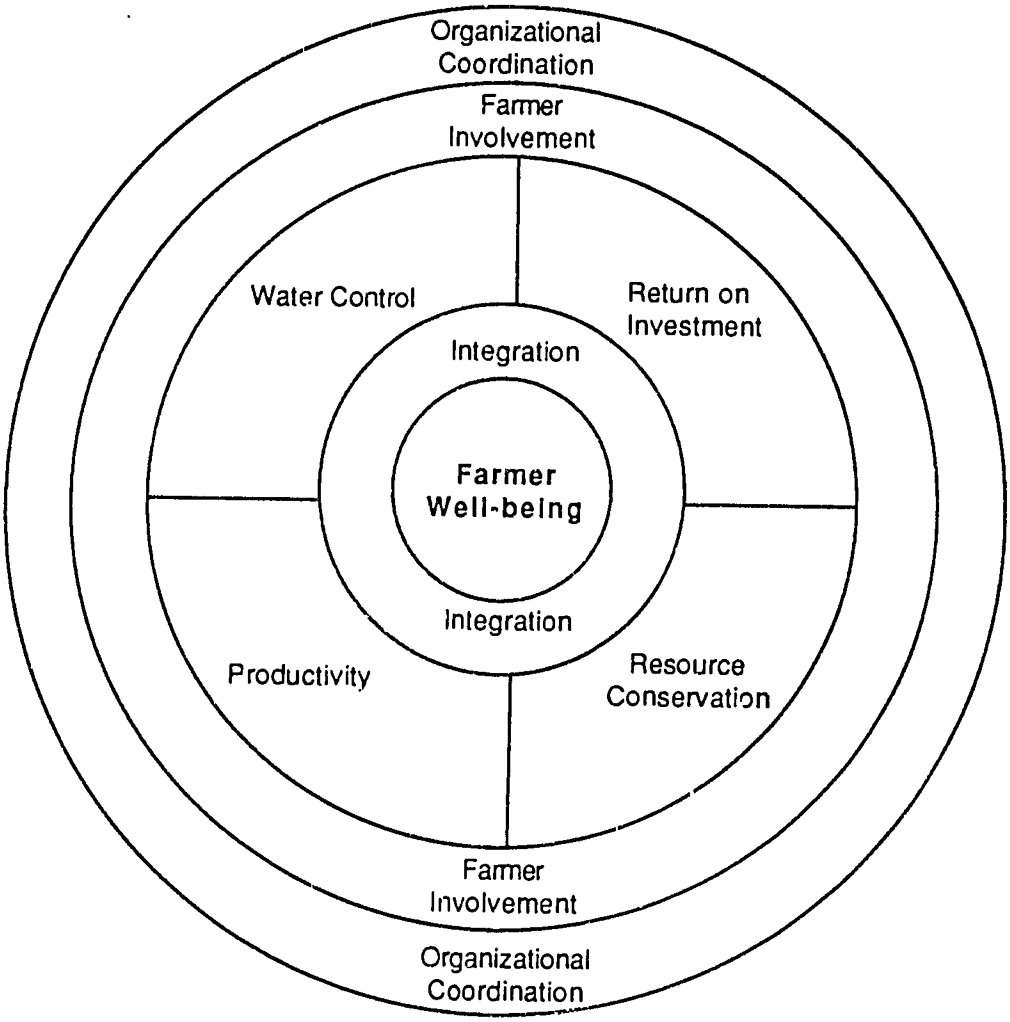

Figure 2. The purpose and objectives of management in irrigated agriculture.

Some individuals have suggested that the above objectives are in conflict. Instead, they should be perceived as complementary. That is, adequacy must be defined such that waterlogging does not subsequently become a problem of inadequate resource conservation. Productivity must be kept at a level that will sustain the farmer, even when planned inadequate water supplies result in reduced yields. Government and farmers must also sustain their continuing investment. Thus, none of the objectives is more important than the others; each must be achieved within the constraints imposed by the desire to achieve the other objectives as well.

Additional objectives can be added if they are deemed necessary. In several years of applying these objectives to irrigation projects, however, no additional objectives have been identified. A more appropriate way to state these objectives has evolved during this period. Water control, for example, has evolved and been influenced by the work of Mohammed (1987).

Once management objectives have been established, the focus of diagnostic analysis or system diagnosis is on understanding the levels of system performance such that high levels of performance can be maintained and low levels improved. Performance must be measured for each of the above objectives. Productivity can be measured in yield per hectare, for example. In some projects, it is the total project productivity that is of interest. Cropping intensity and cropped area may also be important parameters in some appraisals of productivity. Variance of yields from year to year may be of concern if crop failures are probable. Thus, performance must relate to the objective being evaluated. The level of performance may be measured differently for different projects, different crops, or differing conditions.

The emphases must also be evaluated objectively to determine if adequate farmer involvement or organizational coordination has been achieved for effective decision-making. For example, if the irrigation department is supplying water to prepare lands for rice when farmers are not ready to prepare their land for rice, then farmers are not sufficiently involved in management. If the irrigation department has planned the seasonal water supplies for short-season rice varieties and agricultural extension only has long-season seeds available, or has not provided the farmers with enough information about the need to plant short-season varieties, then organizational coordination has not been sufficient.

There is also a necessity for involving farmers in order to understand the basis for their decision-making in terms of knowledge, skills, and cultural norms. Their perceptions of problems should be integrated with an interdisciplinary understanding of the system in order to compare and resolve differences between farmer perceptions and the physical, biological, economic, and social-organizational conditions measured in the system. This understanding is not only important when attempting to resolve problems caused by farmer perceptions, but also for resolving the causes.

B. CONCEPTS FOR DIAGNOSTIC ANALYSIS

Diagnosis of irrigation systems involves the use of a number of important concepts. Concepts, principles, and approaches for diagnostic analysis have been defined previously in the diagnostic analysis manuals (Lowdermilk et al., 1983; Fowler, 1988). In this section, the irrigated agricultural system and its primary subsystems are reviewed and defined. Important subsystem interactions that occur when completing a diagnosis are reviewed and specified. The relationship between management objectives and subsystems is explained, and a framework for completing a diagnosis is presented.

1. The Irrigated Agricultural System

Irrigated agriculture is a system that commonly encompasses the water supply, the area under crop production, the supporting facilities, and the organizations, public and private, that support irrigated agriculture, including farmer organizations. This water management system for irrigated agriculture includes the following (Lowdermilk et al., 1983):

1. Productivity subsystem
2. Economic subsystem
3. Social-organizational subsystem
4. Water control subsystem

These subsystems[6] follow the traditional breakdown of disciplines involved in irrigated agriculture. To understand the total system, the various, traditional discipline perspectives must be integrated. Each of the subsystems is defined briefly below.

Productivity Subsystem. The productivity subsystem (Lowdermilk et al., 1983) starts with the individual plants, trees, or animals as a subsystem, expands to include a field (which corresponds to the water use subsystem in the water control subsystem) or herd of animal species, and increases to include the farm and eventually the irrigation project as units of productivity. Multiple projects can also be considered a management unit.

Economic Subsystem. The economic subsystem relates to costs, returns, and profit for agricultural productivity. Resource allocation is important to effective investment. Risks of investment are of concern. Return on investment must be considered from the farm level to the government policy level. The economic subsystem affects decisions about alternatives for all the other subsystems, and economic criteria are important to decisions at all levels of management.

Social-Organizational Subsystem. The social-organizational subsystem focuses on the farmer, his decision-making, and his needs. Farmer deci-

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[6] These subsystems are meant to be fundamental, but not exclusive. Water delivery often includes wells and a groundwater subsystem. Productivity may include livestock enterprise.

sion-making involves the use of current knowledge, the receipt of appropriate information, and the individual and collective decision-making process for management. Decision-making -- whether individual or collective, or at the policy or farm level -- takes place in a particular setting, is goal-directed, requires motivation, and is influenced by norms and traditions.

Organizational participation in decisions is also of concern in the socio-organizational subsystem. Thus, individual and organizational decision-making from the farmers to the highest levels of government are included in the social-organizational subsystem.

The performance of organizations is an important aspect of improved management, and organizational development and improved management have important interactions in this subsystem. Organizational management of the other subsystems is a priority focus for improving the performance of irrigated agriculture.

Water Control Subsystem. The water control subsystem includes the following (Gates, Ley and Clyma, 1981):

1. Main water control subsystem
    * Main delivery subsystem
    * Branch delivery subsystem
    * Distributary delivery subsystem

2. On-farm water control subsystem
    * Farm delivery subsystem
    * Water application subsystem
    * Water use subsystem
    * Water removal subsystem

The water control subsystem commonly encompasses the water supply from the source to the farmer's field, including the disposal of excess water from irrigation or drainage. This subsystem can be appropriately extended to include the watershed if management efforts are to be expended there. In some irrigation projects, improved management of the watershed is the priority problem that must be resolved to improve the reliability and the quality of the water supply for irrigation.

The main, branch, and distributary delivery subsystems carry irrigation water from the source to the point where a farmer or group of farmers take control or manage the distribution of the water. The farm delivery subsystem usually is partially managed by a group of farmers and partially by a subgroup or an individual farmer. The water application subsystem is the field irrigation system, such as borders or furrows. The water use subsystem is the crop root zone of a field, which provides water for crop growth. Surface and subsurface drainage is accomplished by the water removal subsystem.

2. System Applications and Interactions

Improving the management of irrigated agriculture is the focus of both diagnostic analysis (Lowdermilk et al., 1983) and the development model (Clyma, Lowdermilk and Lattimore, 1981). This focus requires the involvement of an interdisciplinary team and the organizations (public, private and farmers) necessary for successful agriculture. Improving management starts at the farm level from the farmers' perspective and goes up through the water control, productivity, economic, and social-organizational subsystems to the required level for a predictable boundary.[7]

Prior to recent efforts in Pakistan (Jones and Clyma, 1988), working through a line organization was the recommended approach to improving management (Jayaraman, Lowdermilk and Clyma, 1982). With experience in organizational coordination and management (Jones and Clyma, 1988), however, improving management through existing organizational structures, including farmer organizations, seems a more appropriate alternative.

Frequently, approaches to improving the management of irrigated agriculture focus on the water control subsystem, and even on the main water delivery system in particular (Wade and Chambers, 1980). These efforts ignore productivity aspects and the influences operating between water delivery and productivity. The result is a limited perspective of the system. Sometimes management improvements focusing on main system water control include the social-organizational subsystem. The social emphasis is on the farmers, and the organizational aspects are limited to the main system water control organization and perhaps farmer organizations. These are also limited perspectives.

The other subsystems of irrigated agriculture need to be explicitly considered or a boundary of control must be defined (for example, between the main system water delivery and the productivity subsystems). This boundary of control would define the constraints imposed on the main system delivery for effective management of productivity, and the corresponding constraints imposed on productivity by the defined main system delivery. Boundaries of control for organizations other than farmers and the irrigation department, for the economic subsystem, and for the remaining water control subsystems would also need to be defined. In addition, the resource conservation objective would still need to be achieved.

A review of numerous efforts in irrigation development has suggested that the on-farm water control subsystem is often ignored or neglected. This subsystem is relegated to the farmers for design and management (Lowdermilk, Freeman and Early, 1978). Engineers many times assume the farm water control system is simple because small flow rates are involved. However, observations of structures and field systems

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[7] The predictable boundary is a boundary of control. In water supply, supply of inputs and services, and supply of information, there is a level at which program decisions or, at least, policy decisions can be explicitly defined. Below this level, control does not exist, since what has been decided is not what is happening for various reasons. Improving management is a process of moving the boundaries of control to lower levels, such that good management is the result.

during diagnostic analyses in many countries suggest that structures and systems do not function as designed and have serious failures. Often, serious constraints to productivity exist in the farm water control subsystem that directly affect efficiency of water use and productivity of water used. This neglect has been a serious constraint to improving productivity in irrigated agriculture.

Farmers are the most important managers of the most important subsystem in irrigated agriculture. Farmers' roles in irrigation organizations and in the organizational coordination mechanisms of irrigated agriculture have been limited and usually ineffective. Laws and tradition constrain farmer roles, and irrigation authorities' perceptions of the appropriate roles of farmers and farmers' organizations in irrigated agriculture are limited. For example, farmers are usually perceived as not having significant roles in the management of the main system. In fact, in most irrigation systems diagnosed by the authors, farmers have had major roles in the distribution of water. Usually these are not *de jure* roles, they are *de facto* roles. Farmers typically install additional outlets, enlarge outlets, and open and close gates to increase and decrease the water flow; or they often extend or terminate the flow duration, with the result that adequacy and reliability of water supplies to some fields and farms are significantly increased.[8] Distributing water according to a plan cannot be achieved without the explicit cooperation of farmers.

Farmer requirements for water are often not clearly understood by engineers, because the limitations on productivity from undependable water supplies is often not fully understood. Repeated studies of irrigation projects (Clyma et al., 1983; Venkatraman et al., 1984; Alwis et al., 1982; Fowler and Kilkelly, 1988; Wattenburger, 1987) have shown that farmers do not risk substantial investments in agriculture when water supplies are undependable. Their management of productivity is not effective because the reduced investments lower potential and actual yields.

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[8] Farmer actions in the delivery of water do improve the performance of water delivery systems by several criteria. At least some farmers receive a more adequate and reliable water supply. However, because these efforts often maximize the benefits to a limited number of farmers, the result is inequitable water delivery. Because the interventions of many farmers produce a random effect, undependable water supplies result. Improved management is needed, but it can not be achieved without constructive farmer participation.

Farmer input to organizational coordination and management is critical if management is to be improved. Just as quality circles[9] have improved industrial productivity, farmer organizations that improve agricultural productivity are equally important and viable. The knowledge and understanding that farmers have on how to improve productivity should be systematically included in the management decision-making of organizations connected to irrigated agriculture.

3. Objectives and Subsystem Interrelationships

The interrelationships between system objectives and the subsystems of irrigated agriculture are important. These interrelationships are illustrated in Table 1. The productivity objective relates to the productivity subsystem, but it also must serve the overall purpose of creating yields that provide return on investment and achieve the purpose of irrigated agriculture. The return on investment (Table 1) relates to the economic subsystem, but also is an important measure of farmer well-being and a key factor in government decisions to invest or continue to invest in irrigated agriculture. Each investment in irrigated agriculture can be valued individually and collectively for its contribution to the total system for both the farmer and government.

Table 1. Interrelationships between system objectives and the subsystems of irrigated agriculture.

System or Subsystem	System or Subsystem Objectives or Emphases
Productivity	Achieve potential productivity.
Economic	Receive appropriate return on investment.
Water control	Achieve adequate, dependable and equitable water supplies.
Social-organizational	Achieve sufficient farmer involvement and organizational coordination.
Irrigated agriculture	Achieve sufficient resource conservation to sustain irrigated agriculture.

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[9] Numerous studies in industry have shown that encouraging workers to participate in groups in order to identify management needs and to recommend actions which will improve productivity has increased quantity and quality of production, reduced costs, and raised job satisfaction. Workers have knowledge of what they need, how activities can be accomplished better, and how organization can be improved. This example is directly relevant to farmer participation, participatory management in irrigated agricultural organizations, and diagnostic analysis team management.

Water control is an objective for the water control subsystem, but it must be guided by the potential productivity that can be achieved and by the amount of investment that is appropriate (Table 1). Thus, water control is also a necessary integrator of the productivity and economic subsystems.

The social-organizational subsystem emphasizes farmer involvement and organizational coordination as shown in Table 1. These emphases are not defined and achieved as measured levels of activity, but they are perceived as the amount or level necessary to achieve all four objectives. The social-organizational subsystem manages the irrigated agricultural system, but may also be considered as a series of subdivisions into the farmer, irrigation department, agricultural department, and many other smaller subsystems.

The resource conservation objective can be applied to each of the above defined subsystems, and it should also be continuously considered for the overall system of irrigated agriculture. Most importantly, if resource conservation is not achieved, then irrigated agriculture will only subsist or will disappear.

The value of using subsystems in considering irrigated agriculture are numerous. They allow careful specification of the subsystem, analysis and synthesis of alternative configurations, and the development of new approaches to management of the subsystem using the new knowledge gained. The key constraint in such endeavors is that the interrelationships of the subsystem under consideration and other subsystems of irrigated agriculture are not adequately defined and evaluated. If the interrelationships are not adequate, then the perspective of a single or a few disciplines will not effectively improve the performance of irrigated agriculture.

4. System Diagnosis Framework

A framework for diagnosis is presented in Figure 3. The diagnosis framework builds on management and system concepts to define an appropriate interrelated subsystem. This framework presents a structure and logic for accomplishing a diagnosis. System diagnosis starts with agreeing upon system management objectives. This agreement occurs within the diagnostic analysis team, and between the operational managers of the involved organizations and the diagnostic analysis team.

The team defines subsystem boundaries and their interactions for the system to be studied, as shown in Figure 3. The specific objectives for each subsystem are also established and agreed upon. These objectives are used to identify and agree upon the performance parameters to measure system performance. For example, water control may need to be evaluated for adequacy and equity of water supply. The team will need to identify the performance parameters for adequacy and equity, such as those suggested by Mohammed (1987).

The interaction between the inadequacy of the water supply and the productivity of crops grown is one example of subsystem interactions. Farmer actions to access a more adequate water supply may greatly affect

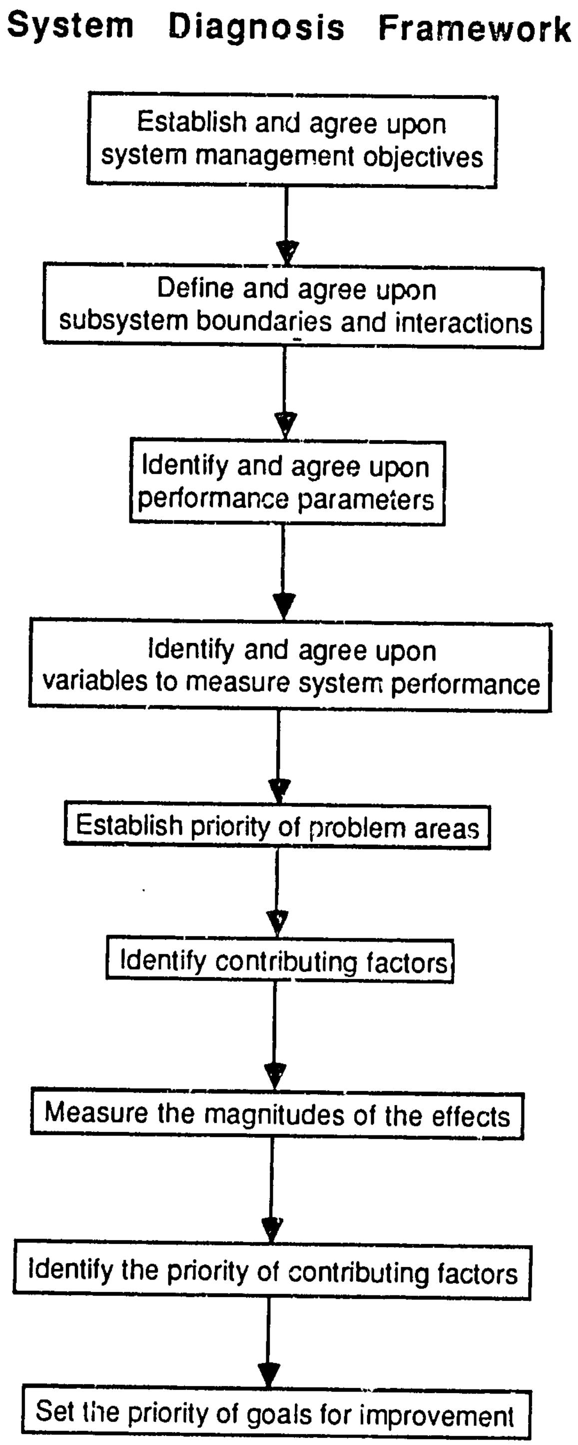

Figure 3. Diagnosis framework for analysis and synthesis of interdisciplinary understanding of the irrigated agricultural system.

the delivery of water and the social-organizational subsystem. These subsystem interactions build the team's interdisciplinary understanding of the irrigated agricultural system.

Figure 3 shows that the team needs to identify and agree upon variables to measure system performance. Measurements of system performance are compared to the potential or target performance for the system under the existing conditions. The target performance is established with the concurrence of the project operational managers. Judgments of high and low performance are based on the difference between the actual level of performance and the target performance.

Establishing the potential performance requires that the team conceptualize what a particular subsystem should be. This requires that the team use previous knowledge and experience, and understanding of the existing system, to develop a definition of the potential performance of the system. The target performance is less than the potential performance if existing conditions suggest that constraints exist which prevent the achievement of potential performance.

Priority problems are defined (Figure 3) where the difference between the measured performance and the target or potential performance are the greatest. Comparable measures of relative impact on improved performance across objectives usually are based on yield or, more appropriately, on improvement in return on investment. Where the goal is to make substantial improvements in the system, potential performance may be the relevant comparison since constraints caused by existing conditions may be the priority improvements to make. In other instances, constraints may need to be considered unresolvable for a time.

Areas of low performance constitute the priority problem areas. The magnitude of the low performance is confirmed by having different team members appraise the level of performance using their disciplinary or interdisciplinary observations. Areas of high performance are studied to ensure that the level of performance is maintained. Approaches that result in high performance also offer ideas for improving low performance.

Identifying the contributing factors is achieved through field studies of each area of low and relevant high performance (Figure 3). The difference between target or potential performance and actual performance is caused by contributing factors. Contributing factors are understood by first defining what the subsystem and its performance should be. This is a conceptual definition modified to consider the expectations of farmers and officials. Then, what causes a level of performance is defined by observing the actual subsystem.

An understanding of the causes is achieved by analyzing the subsystem in the field using disciplinary and interdisciplinary concepts to define the subsystem processes. The processes of the actual system are studied to understand the causes of low or high performance. An engineer can use the conservation of mass principle to identify seepage losses as an important factor in the inadequacy of water supplies at the tail of a system. The sociologist can use organizational theory to define and understand the interactions of farmers with the bureaucracy that delivers water supplies.

The magnitude of the effects (Figure 3) of contributing factors needs to be measured. Measurements are made in the field to determine the impact of a particular contributing factor on level of performance. A reduced flow at the field, for example, can be more carefully studied, and the factors that contribute to the low flow might be identified as seepage losses, spillage, stealing of water by other farmers, and inadequate delivery from the main system. The magnitude of the effect of these different factors can be determined explicitly. Let us assume that the team determines that the two most important factors are stealing water and seepage losses. These contributing factors are understood by applying specific concepts and principles from each discipline. The sociologist carefully studies water stealing and jointly establishes the magnitude of the effect of stealing water by working with the engineer, in terms of water diverted; with the agronomist, in terms of reduced crop yield; and with the economist, in terms of reduced income.

Identifying the priority contributing factors is done by considering the results of the subsystem studies (Figure 3). In considering the overall agricultural system, the team may find that inadequate and undependable water deliveries at the field level are affecting productivity, farmer incomes, and farmer willingness to improve management. Based on this information, the team decides that improving the delivery of water to the field should have high priority.

Priority goals for improvement are set (Figure 3) based on the priority contributing factors for each priority problem area. A goal for improvement is a statement of the condition under which the priority contributing factor will be resolved. In this example, the goals might be to reduce seepage losses by improving the watercourse delivery system and to reduce theft by helping farmers organize to enforce water rights for all farmers. These fundamental goals could be more specifically formulated by the organization responsible for implementing the improvement program. The responsible organization could set a specific goal of "reducing seepage losses in the canal to 15 percent," for example. This organization would then develop plans to accomplish this goal.

Contributing factors often affect performance in more than one area. For example, organizational constraints may affect main system delivery and on-farm delivery in much the same way by reducing the adequacy and dependability of water delivery. However, the magnitude of the effect and the actions contributing to the effect may differ. Similarly, one goal (for example, organizing farmers to participate more effectively in system management) may resolve several contributing factors.

The system diagnosis framework provides the structure and logic for the interdisciplinary team to use to understand each subsystem of concern using appropriate disciplinary and interdisciplinary concepts, but focusing on developing interdisciplinary understanding. While inadequate water supplies may frequently be related to seepage losses, supplies are often affected by organizational constraints, economic limitations of resources, lack of knowledge about crop water requirements, or other important factors. Thus, each discipline can bring the full power of disciplinary understanding to a particular contributing factor. Whether that particular factor is the focus of intensive study or not, however, is determined by whether or not the effect of the contributing factor is most important in terms of lowering system performance or assuring high performance.

The system diagnosis framework increases interdisciplinary understanding of the system and facilitates teamwork. It is a key concept of the diagnostic analysis methodology.

III. METHODOLOGY FOR DIAGNOSTIC ANALYSIS

A. INTRODUCTION

The methodology for diagnostic analysis is an intervention in an irrigated agricultural system. The purpose of diagnostic analysis is to initiate a process by which concerned organizations[10] will understand priority problems and causes of the problems in irrigated agriculture, and establish goals and strategies for improving system performance. The ultimate purpose of a diagnostic analysis is to involve these organizations in improving the management of irrigated agriculture. Thus, this new methodology facilitates organizational change by developing an understanding of the need for change and by initiating an organizational process that subsequently plans and implements the improved or changed management.

This section presents the essential processes of the methodology, starting with the context for a diagnostic analysis intervention, then the overall planning for diagnostic analysis using the team planning methodology, and finally the process of diagnostic analysis. The methodology integrates the management, system, and diagnostic framework concepts given in the previous section.

B. THE CONTEXT OF DIAGNOSTIC ANALYSIS

The diagnostic analysis methodology is applied where developing an understanding of the performance of irrigated agriculture will facilitate improving that performance. This understanding is needed for project designs, sector reviews, project evaluations, diagnostic analysis training workshops, senior officials workshops, and as a basis for improving the management of irrigated agriculture through a process such as implementation planning.[11] The methodology of diagnostic analysis focuses on defining areas of low and high performance so that improvements can be effectively implemented and good performance can be sustained.

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[10] Concerned organizations at least include irrigation and agricultural departments; credit institutions; agricultural extension; providers of seed, fertilizers, and other agricultural inputs; and farmer organizations. Other organizations or departments should be involved also if they have roles in irrigated agriculture.

[11] Using diagnostic analysis results to improve the management of irrigated agriculture through implementation planning should have prior commitment by key policy, executive, and operational managers. This commitment involves making organizational arrangements and providing funding to accomplish the improvement efforts developed in the implementation planning.

1. Organizational Involvement

Organizational involvement includes gaining understanding about improvement needs, planning for improvements in the irrigated agricultural system, and improving management. These are actions requiring decisions made by the key organizations involved in irrigated agriculture. These organizations, therefore, are responsible for the overall planning and implementation of the diagnostic analysis methodology. This responsibility involves formally mandating the diagnostic analysis program at the policy and executive levels and obtaining commitment for involvement from operational managers. This involvement of stakeholders and clients[12] is shown in Figure 4 for the various phases of the methodology. Multi-organizational involvement in multiple levels begins with the diagnostic analysis so that the results will have credibility and acceptance within the responsible organizations. Ownership of the diagnostic analysis and implementation planning by the involved organizations is essential to the success of diagnostic analysis as an approach to organizational change to improve the performance of irrigated agriculture.

Prior experience suggests that more effective studies and results are obtained by using host country or expatriate consultants or a combination of both. Personnel in organizations related to irrigated agriculture usually are not sufficiently trained to conduct a diagnostic analysis. In addition, operational managers or a higher level of personnel would need to be responsible for the diagnostic analysis. These individuals usually do not have the time to train and implement a diagnostic analysis in addition to their regular duties.

Traditionally, diagnostic analysis teams have had a combination of host country and expatriate members (Figure 4), who have jointly shared responsibility for managing the diagnostic analysis workshops. Consultants contribute knowledge about the diagnostic analysis process and experiences from other systems or countries, and the irrigation project team members contribute knowledge about irrigated agriculture in their setting and specific disciplinary knowledge of their conditions. Involving project and related organizational personnel is an essential step in building understanding for making improvements.

It is necessary for key policy officials to mandate the study if the program is to succeed. This means involving host country Secretaries of agriculture and irrigation and related ministries as necessary. Key executives such as chief engineers and directors, and appropriate donor officials should be involved. Selected key officials are also

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[12] Stakeholders are all organizations (represented by an appropriate individual) that have a part in decisions made to improve irrigated agriculture. Because they have a part in these decisions, they should be involved in creating a common understanding of the problems. Clients are the farmers and the organizations directly responsible for the diagnostic analysis. Donor organizations that finance the diagnostic analysis or subsequent improvements are also clients.

Phase	Involvement						
	Team		Donor Officials	Host Country Officials			Farmers
	Expatriate	Host Country		Project	Province	Capitol	
I **Overall Plan**	▩	▩	▧	▧	▨	▨	
II **Entry**							
Information Input	▩	▩	▩	▩	▩	▩	
Replanning	▩	▩	▧	▧	▨	▨	
III **Rapid Diagnosis**							
Field Study	▩	▩		▧			▨
Replanning	▩	▩	▨	▧			▧
IV **Detailed Diagnosis**							
Field Study	▩	▩	▧	▧	▧	▧	▨
Analysis	▩	▩					▧
Synthesis	▩	▩					▧
Report	▩	▩					▧
V **Exit**							
Replanning	▩	▩	▧	▧	▨	▨	▧
Debriefing	▩	▩	▩	▩	▩	▩	▩

▧ Provides information for activity.
▨ Involved in activity.
▩ Participates in activity.

Figure 4. Involvement of key stakeholders and diagnostic analysis team in the diagnostic analysis methodology.

involved in identifying policy issues for consideration during the field studies and in giving appropriate input and guidance near the end of the study.

Operational managers and field personnel actively participate in the day-to-day field studies with the team. Interdisciplinary understanding is obtained by involving those organizations in the field studies which have the disciplinary expertise needed to do an appropriate study. The goal is to provide selected individuals in the key organizations with direct field experience and understanding so that the leaders of the organizations and the individuals involved feel they "own" the results of the study.

2. Key Outcome of Diagnostic Analysis

The key outcome of a diagnostic analysis is an understanding of the performance of the irrigated agricultural system and of the priority causes of low and high performance. Leaders and operational managers of the involved organizations need to understand the causes of low and high performance in order to know where to make improvements in facilities and management. When the leaders and operational managers of organizations have come to understand priority needs, some improvements have usually been accomplished. The structure for diagnostic analysis provides focused input to subsequent efforts by concerned organizations. They can then make needed improvements based on a common understanding of the priority areas.

C. DIAGNOSTIC ANALYSIS MANAGEMENT USING THE TEAM PLANNING METHODOLOGY

The diagnostic analysis methodology uses the management framework of the team planning methodology (Kettering, 1985; Levine, 1988) and a process for diagnosis. The management concepts and framework of the team planning methodology are continuously used to manage the overall diagnostic analysis methodology and accomplish its objectives. Key decisions that must be made before the overall planning begins are what type of diagnostic analysis to use (diagnostic analysis or rapid diagnostic analysis)[13] and what is the overall purpose of the diagnostic analysis.

Whether to use a diagnostic analysis or a rapid diagnostic analysis depends primarily on the amount of documentation necessary for organizations to accept and plan needed program and organizational changes. The amount of time and financial resources available also determine whether to use a rapid DA or a diagnostic analysis. Rapid DAs are appropriate for project designs, project appraisals, sector reviews, senior officials' workshops, and staff training, although longer diagnostic analyses may be considered necessary for some of these applications.

1. The Overall Management Plan for Diagnostic Analysis

The team planning methodology as applied to the diagnostic analysis methodology is presented in Table 2 as a series of phases. The team planning methodology, with its concepts for management and a framework for planning, is used to manage the overall process of a diagnostic

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[13] Diagnostic analysis includes both a rapid diagnosis and a detailed diagnosis, which is necessary to more carefully document the priority areas of high and low performance. The term "reconnaissance" conventionally has been used in diagnostic analysis to designate the initial review of field conditions to establish priority problems for further study (Lowdermilk et al., 1983). In this discussion, the term "rapid diagnosis" replaces "reconnaissance" in this meaning. (A diagnosis is the field study phase that uses field data to establish understanding of field problems.) Reconnaissance has also been used to designate a process equivalent to rapid appraisal (Chambers, 1983), meaning a diagnostic analysis that is accomplished in a few hours or days. In this discussion, rapid diagnostic analysis (rapid DA) is used as the term equivalent to rapid appraisal. A rapid DA has a rapid diagnosis phase and requires the same planning, team management, and organizational involvement aspects used to accomplish a longer diagnostic analysis.

analysis, including the involvement of clients and key stakeholders. Since the information used for decision-making evolves during a diagnostic analysis, replanning based on new information is a key feature of the overall process. A written plan is the key output of the team planning methodology. Replanning before beginning each phase provides an overall review of the remaining effort and a detailed plan for the next phase. Each plan is based on the specific information and input gained in that phase. The replanning concept may be new to some readers. Basically it signifies a flexible planning approach which encourages revision of earlier plans as necessary.

Table 2. The phases, focuses, and outputs of the management process for application of the diagnostic analysis methodology.

Phase	Focus	Outputs
I Overall Planning	Team understands context, agrees on purpose and outcomes, defines roles and responsibilities, and develops overall plan for managing intervention.	Overall plan; detailed plan for entry
II Entry	Team collects information for planning the diagnostic analysis, obtains guidance and a mandate for the intervention, and identifies issues and concerns for resolution.	Revised overall plan; detailed plan for rapid diagnosis
III Rapid Diagnosis	Team conducts rapid diagnosis and develops hypotheses of priority problem areas for detailed diagnosis.	Revised overall plan; plan for detailed diagnosis
IV Detailed Diagnosis	Team conducts detailed diagnosis of site to identify priority problems, contributing factors, and priority goals for improvement.	Diagnostic report with recommendations for improvement
V Exit	Review implications of diagnostic analysis results and recommendations for improving management through implementation planning.	Plan and support for implementation planning

The purpose and outcomes of diagnostic analysis are established and agreed upon early in the planning process. Diagnostic analysis as presented in this paper focuses on providing information for implementation planning. If diagnostic analysis was used for other purposes, then entry and exit activities would reflect this change in purpose and objectives.

The initial phase is the development of an overall plan for the intervention. The planning process involves the diagnostic analysis team and the key clients (Figure 4). At this time, the supporting concepts and processes for the methodology are reviewed and discussed. The form the methodology shall take for the particular diagnostic analysis is agreed upon, and an overall plan for accomplishing the outcomes of the diagnostic analysis is developed by the team. In addition, a detailed plan for accomplishing the outcomes for entry is prepared. Immediate next steps to continue the intervention are also planned. In addition, to prepare for Phase II (entry), a detailed plan outlining roles and responsibilities, activities to gather additional information, and needed guidance and input for the field study is a key part of the planning.

Entry is the beginning of the organizational involvement that is necessary if the diagnostic analysis is to provide the impetus for organizational change. Obtaining an organizational mandate for the study and the involvement of key personnel are essential parts of this phase. It is important to collect information from key informants about organizations, their roles in irrigated agriculture, and the problems considered a priority. Background data about the irrigated area to be studied is also collected at this time. Based on this updated information, upon arrival at the site, a plan for the rapid diagnosis (Phase III) should be completed during the replanning at the end of Phase II (Table 2).

The rapid diagnosis is completed as planned, using the diagnosis framework (Figure 3). If the total time of the field study is to be several days or weeks, one or two days will typically be allotted for the rapid diagnosis. Preliminary hypotheses of the key problem areas or areas of low and high performance should be formulated from the background information collected during Phase II. During the rapid diagnosis, frequent consultations about new problem areas should be conducted. The purpose of Phase III is to develop initial hypotheses regarding the priority problems areas and causes of low performance. These hypotheses will be accepted or rejected based on the results of the data collected during the detailed diagnosis in Phase IV (Table 2). The final output from Phase III is the plan for the detailed diagnosis.

The detailed diagnosis (Phase IV) focuses on collecting field data to define the areas of low performance and the factors which contribute to the low performance (Table 2). Some hypothesized low performance areas may not need extensive study to reject hypotheses formulated during the rapid diagnosis. New areas of low performance may be identified during the detailed diagnosis. Plans will need to be developed to collect data to accept or reject new hypotheses.

Formulating the hypotheses is a small group process accomplished by the interdisciplinary diagnostic analysis team. The team plans the interdisciplinary data collection, analysis, and synthesis. Interdisciplinary understanding is developed from the data collected to accept or reject a hypothesis after the data have been analyzed. Another purpose for formulating hypotheses before collecting data is to restrict data collection to a specific number of priority problem areas and contributing factors.

Phase V (Figure 4 and Table 2) provides the results of the diagnostic analysis to the key stakeholders, accepts their input and guidance for formulating final goals for implementation planning, and mandates the implementation planning process. A final report is submitted for use by the involved organizations to provide information for any follow-up needed before implementation planning is initiated, and for use by the involved organizations during planning and implementation of improved management.

2. The Team Planning Methodology for Managing the Diagnostic Analysis Team

The team planning methodology as applied to the diagnostic analysis methodology should be flexible to take into account the resources available and the purpose of the diagnostic analysis. A management professional should facilitate the overall planning process. A person with expertise in the team planning methodology should be one of the diagnostic analysis team members. This provides the management expertise needed in a diagnostic analysis.

The diagnostic analysis team members must be fully available and involved in the team planning for the overall plan. Key client involvement is also scheduled as needed. A written overall plan is the key output of the team planning methodology. The understanding that the team members and key clients gain about the purpose and outcomes of diagnostic analysis is a major benefit of the process.

D. IMPLEMENTING THE DIAGNOSIS PROCESS

The diagnosis process is the heart of the diagnostic analysis methodology. The diagnosis process is applied in Phase III for the rapid diagnosis and Phase IV for the detailed diagnosis (Figure 4 and Table 2) to develop an understanding of the irrigated agricultural system. The diagnosis process uses the supporting management concepts, the system concepts, and the diagnosis framework to measure system performance in order to understand the causes of low and high performance. This section presents how the management concepts, system concepts, and diagnosis framework are used in a diagnosis process. The key activities of the diagnosis process are also presented, and a schematic diagram of the diagnosis process is presented in Figure 5.

The interdisciplinary team formulates hypotheses regarding the areas of high and low performance and the priority contributing factors for each area of performance. For rapid diagnosis, the hypotheses are based on the information available from reports, and the input from donor and host country officials. For the detailed diagnosis, the hypotheses are formulated based on results of the rapid diagnosis.

The team uses the hypotheses to guide the data collection so that enough understanding is gained to accept or reject the hypotheses (Figure 5). When planning for data collection, the team agrees on which performance parameters to study, which variables to use to measure performance, and which individuals or teams should collect specific data. The diagnosis framework is the guide for this analysis (Figure 3). The team also plans the collection of data to confirm contributing factors and their magnitude. Provisions for necessary consultation during the field visit, especially during a rapid diagnosis, are also agreed upon.

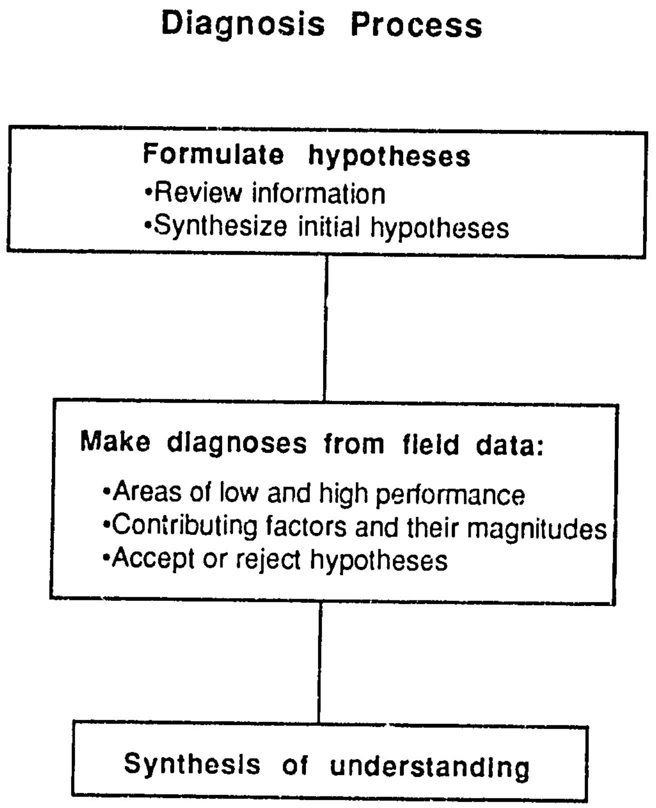

Figure 5. Diagnosis process for diagnostic analysis of irrigation systems.

The initial hypotheses usually are not sufficient to identify the priority areas for data collection. New areas of low or high performance most likely will be identified, or contributing factors may need to be rejected or added during the field study. Consultations regarding possible changes in the initial hypotheses are particularly important, especially during the rapid diagnosis. The team and subteams[14] should use the same process to reject a high or low performance area for further

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[14] Due to time constraints during a rapid diagnosis, plans to collect specific data may need to be changed or developed. A full team meeting is frequently not possible. Therefore, subteams, such as the agronomist and the engineer, the engineer and the sociologist, or the economist and the agronomist, may need to hold a short consultation and change the plan.

study and to define a new performance area. The contributing factors should also be rejected or added using the same process.

At the conclusion of the detailed diagnosis, data analysis is completed individually or jointly by team members. Consultations among team members should provide a growing, integrated understanding of system performance and the factors which contribute to performance.

An interdisciplinary team synthesis process should be used to formally accept or reject each hypothesis and priority contributing factor (Figure 5). The result should be a statement on the problem or the high performance area and the factors which contribute to the performance, including the magnitude of their effects. During the analysis and synthesis process, the team should consider the disciplinary and interdisciplinary concepts and processes that provide an understanding of the subsystem(s), the subsystem interactions, and the integrated system.

Overall priorities need to be established according to specific criteria. Effect on yield is often an important factor in establishing overall priorities. Farmers' and government officials' perceptions and concerns also play a role. Choosing available and visible solutions is useful because they may affect the initiation of a development effort. Farmers and government officials may benefit substantially from initial successes through visible solutions (Clyma, Lowdermilk and Corey, 1977). It may not be possible to resolve some problems or contributing factors, and these may need to be considered constraints. Usually, this decision should not be made by the diagnostic analysis team. It is an issue for policy decision makers in the involved organizations to make during the subsequent implementation planning.

Diagnostic analysis does not explicitly plan for the implementation of solutions. Instead, the synthesis of understanding (Figure 5) gained from the specific contributing factors gives the team insight from which they can recommend approaches to solutions. The process of understanding the cause by analyzing with farmers and officials what currently exists in the system and what should exist in the system is important when later considering solutions. The problems and their alternative solutions need to be defined and planned by the organization and personnel who will implement the solutions. An organizational mandate to plan solutions to the most important problems requires policy support. A process of involving the key personnel in irrigated agricultural organizations in a problem definition, problem-solving, and planning process is the heart of implementation planning (Jones and Clyma, 1988)[15] There is not sufficient time during diagnostic analysis to plan future activities, nor is this process the purpose of diagnostic analysis.

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[15] If solutions arrived at during implementation planning require additional data or some form of testing to evaluate alternatives, this additional data collection and testing should be an explicit part of the planning for solutions. Alternative approaches to defining solutions, including direct solutions, have been outlined by Clyma, Lowdermilk and Corey (1977).

E. IMPLEMENTING THE METHODOLOGY FOR DIAGNOSTIC ANALYSIS

The methodology of diagnostic analysis is presented in Figure 6. It includes the key concepts and the diagnosis framework, which are integrated to accomplish the diagnosis. The diagnosis process guides the application of the concepts within the overall management plan (Figure 6 and Table 2) for a particular diagnostic analysis. The concepts and process should be reviewed and agreed upon by the diagnostic analysis team during the overall planning. At the same time, the team should also review and agree upon the framework (Figure 3) and process for diagnosis (Figure 5) of the irrigation system. A preliminary review is all that is necessary to reach agreement during the overall planning. Agreements on the specific concepts and processes for each phase are agreed upon and planned during the replanning for each phase.

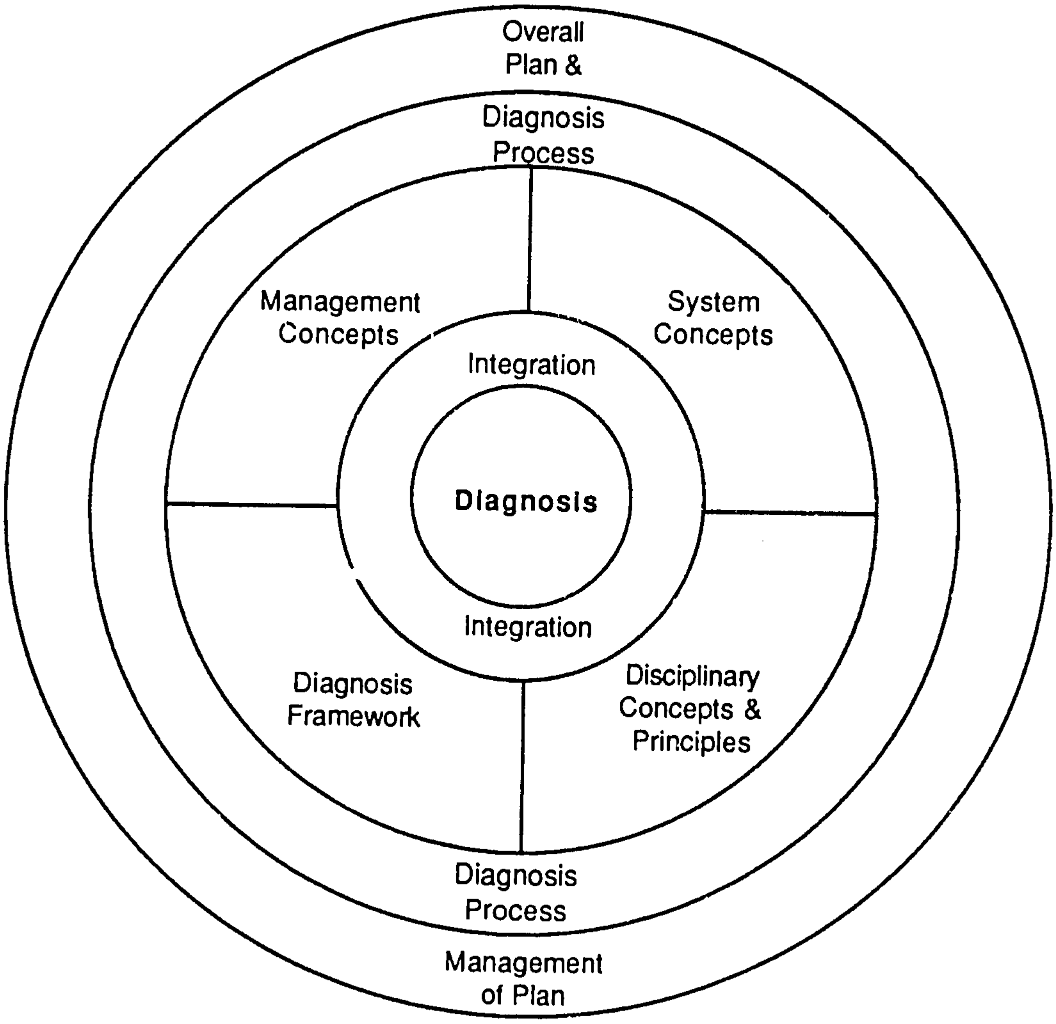

Figure 6. The methodology of diagnostic analysis.

The process the team will use to reach consensus on the concepts, framework, and process should be agreed upon for each new study. Thus, overall planning would provide agreement on the overall concepts, framework, and process. The planning for the rapid diagnosis would provide more specific concepts, a framework, and process; and planning for the detailed diagnosis would provide the most specific concepts, framework, and process. Day-to-day planning would revise and update the concepts and framework applied during the study. This flexibility in planning is needed given the dynamics of the diagnostic analysis process.

The logic followed in conducting a diagnostic analysis directly builds on the concepts for managing a system. The system objectives are established during overall planning and confirmed during entry (Table 2). These are reviewed and revised during replanning in each phase. The performance parameters and the variables to measure to determine performance are the next important decisions and are revised to become more specific as the planning evolves. Initially suggested during the overall planning, they are made more specific for the rapid diagnosis and again for the detailed diagnosis.

The overall management plan is the basis for implementing a diagnostic analysis (Figure 6). Whether the diagnostic analysis is a rapid DA, a diag-nostic analysis study, or a diagnostic analysis workshop will influence the priorities and time allotments for accomplishing the study. In this section, we discuss considerations concerning the diagnostic analysis study and then the rapid DA. A diagnostic analysis workshop implements a diagnostic analysis study, but accomplishes training goals at the same time.

1. The Diagnostic Analysis Study

The overall management plan for the diagnostic analysis study is developed using the team planning methodology (Kettering, 1985; Levine, 1988). The overall plan establishes the context in which the diagnostic analysis is to be accomplished. The planning can occur initially within the donor country if an expatriate team is involved, would occur at central headquarters in the host country if the host country is managing the diagnostic analysis, and can be held in abbreviated forms in both if there are joint teams involved in the study.

The team establishes roles and responsibilities, agrees on purpose and outcomes for the diagnostic analysis, and then plans how the diagnostic analysis will be accomplished. The concepts, framework and process for the diagnostic analysis are agreed upon explicitly as suggested previously. Roles and responsibilities are revised according to the plan. Monitoring and evaluation of the accomplishment of plan objectives and interim targets are also specified.

During the rapid and detailed diagnoses of the system (Table 2), daily analysis and synthesis of findings should be done on a preliminary basis. These results are discussed in the daily team meetings where next-day plans are finalized, logistical arrangements are considered and decided, and replanning is done if preliminary results suggest that the overall plan needs revision. Interdisciplinary analysis and synthesis of the preliminary data begins to build the understanding of the system and identifies key questions that each discipline and the team must address if the system is to be adequately understood.

As the detailed diagnosis approaches an end, the overall analysis and synthesis plan is developed and initiated (Table 2). This involves individual disciplinary analysis of data, joint analysis of some data between appropriate disciplines, and interactions among all disciplines to integrate the interdisciplinary understanding. When data analysis is complete, the team uses a small group structured process to systematically define problems. All disciplines should be present in each problem definition process.

Initially, brainstorming is used to define problems. Then the team uses the diagnosis framework to integrate contributing factors, identify and agree upon their magnitudes and priorities, and suggest strategies for resolution. This process is where interdisciplinary understanding is developed and the understanding needed to solve the problems is initially defined. In the authors' experiences, the understanding developed from the interdisciplinary interaction is unique to the diagnostic analysis process. The disciplines challenge each other to deepen their individual understanding and achieve a more effective interdisciplinary understanding than is possible with less structured processes.

The results of the team analysis and synthesis are captured on flipcharts. These are typed as the analysis and synthesis proceeds and are reviewed for clarity and completeness. Writing assignments are then defined. Selected individuals prepare sections of a final report for distribution to various audiences. Typical reports that should be considered are executive summaries for key policy administrators, descriptive summaries for technical leaders and executive administrators, and a detailed report to preserve the results of the study for interested water management professionals. Recommendations for future action come from the problem resolution strategies developed by the diagnostic analysis team.

An evaluation of the diagnostic analysis study should be completed at this time to identify gaps in the overall plan as it was initially developed. Suggestions for improving the diagnostic analysis process should be developed, and the next steps to take for any continuing studies should be identified. Debriefings with the key clients should be planned and implemented at the project site and at the project headquarters. Any next steps that follow the recommendations should be explicitly agreed upon. An implementation planning program should be identified and agreed upon, and the immediate next steps are planned for initiating the program.

2. The Rapid DA

A rapid DA may be the only study of the system that is permitted because of time and other resource constraints. The diagnostic analysis process is adapted in a rapid DA to reflect the limited time available.

A comparison of the activities for a diagnostic analysis study and a rapid DA is given in Table 3. The overall planning and entry phases have the same considerations. However, the specific outcomes and resulting activities are different to reflect the shorter time available. The rapid diagnosis (Phase III) is different in the rapid DA as compared to the diagnostic analysis workshop or study. Instead of replanning for a detailed diagnosis, the team would prepare reports synthesizing information and including recommendations.

The initial hypotheses developed for a rapid DA should be formulated as effectively as possible based on published information and interviews with knowledgeable personnel. The field visit should focus more on indicators of system performance and interviews with farmers and system personnel. It is important that the team members frequently consult each other to confirm their understanding of the priority problems and causes identified. The basic structure of the diagnosis process is maintained in a rapid DA, but the amount and quality of data on which to base conclusions are limited. The interdisciplinary analysis and synthesis process for a rapid DA is the same as for that completed after a detailed diagnosis.

The detailed diagnosis is not done in the rapid DA. Typically, detailed field studies extend from several weeks to a year. These detailed data provide a more definitive understanding of the needs for improvement. The exit phase (Phase V for diagnostic analysis and Phase IV for the rapid DA) is the same. Reports and planning for follow-up are equally appropriate.

The use of the data may suggest that a rapid DA is appropriate. Willingness of the concerned organizations to identify needs and to plan programs of change based on data from a rapid DA could make this data an appropriate input to implementation planning. Prior experience suggests that data need to be carefully documented if the organizational changes planned are to be substantial and significant.

Table 3. Comparison of activities for diagnostic analysis and rapid DA.

Activity/Phase	Diagnostic Analysis	Rapid DA
PHASE I: Overall Planning		
Understand context	X	X
Agree upon purpose/outcomes	X	X
Define roles and responsibilities	X	X
Establish overall plan	X	X
Plan next steps for entry	X	X
PHASE II: Entry		
Mandate for study	X	X
Information for planning	X	X
Guidance for issues/concerns	X	X
Replanning for Phase III	X	X
PHASE III: Rapid Diagnosis		
Form hypotheses		
-Review information	X	X
-Synthesize initial hypotheses	X	X
Diagnosis from field data		
-Areas of high and low performance	X	X
-Contributing factors and their magnitudes	X	X
-Accept or reject hypothesis	X	X
Synthesize understanding	X	X
Replan detailed diagnosis	X	
Prepare reports/recommendations		X
PHASE IV: Detailed Diagnosis		
Formulate hypothesis		
-Review information	X	
-Synthesize initial hypotheses	X	
Read diagnosis from field data		
-Areas of high/low performance	X	
-Accept or reject hypothesis	X	
Synthesize understanding	X	
Prepare reports/recommendations	X	
PHASE V*: Exit		
Review diagnostic analysis results/ recommendations	X	X
Implement planning mandate/input	X	X
Initial plans for implementation planning	X	X
Immediate next steps	X	X

*Phase V of the detailed diagnostic analysis is Phase IV of the rapid DA.

IV. APPLICATION OF THE DIAGNOSTIC ANALYSIS METHODOLOGY

A. INTRODUCTION

The purpose of this section is to describe the application of the diagnostic analysis methodology to an irrigation system. The application process follows the phases outlined previously for the overall plan for the methodology (Table 2) and focuses on a discussion of the application of the framework and process of diagnosis.

Before the decision is made to initiate a diagnostic analysis of an irrigation system, irrigated agricultural organizations will have collected some preliminary information and will have done some planning. Also, the purpose of the diagnostic analysis will have been agreed upon by the involved organizations and key clients. The structure of diagnostic analysis presented here assumes that the purpose of the diagnostic analysis results is to serve as input to implementation planning.

Once the decision is made to conduct a diagnostic analysis, the methodology of diagnostic analysis is applied in a sequence of five phases. The following sections discuss specific aspects of the application of the diagnostic analysis in these five phases (the overall plan, entry, rapid diagnosis, detailed diagnosis, and exit).

B. PHASE I: THE OVERALL PLAN

The team planning methodology is applied to diagnostic analysis as a structured, preplanned process to communicate the important aspects of accomplishing a diagnostic analysis study and to develop an overall plan. An infinite number of specific plans could be developed for diagnostic analysis. Thus, in application, the diagnostic analysis methodology assists in making the diagnostic analysis complete and helps the team build on prior experiences without limiting the specific innovations that the team may wish to implement.

A key aspect of overall planning is that the team must identify the purpose, outcomes, approaches, and concepts to be used in each phase of the diagnostic analysis. As each phase is planned in detail, the team must agree on how these concepts and approaches should be used to complete that phase of the diagnostic analysis. Planning the purpose and objectives of the diagnostic analysis and agreeing on approaches and concepts allows individual team members to contribute their knowledge and experience to each study.

1. Overall Purpose and Objectives

How the results of the diagnostic analysis will be used, and in what context, define the specific objectives to be achieved. The purpose of many WMS II and prior experiences with diagnostic analysis was to train personnel while conducting a study. These are conflicting objectives, and priorities must be established if either is to be successfully completed. In these past efforts, the highest priority was given to training objectives so that participating personnel would learn the concepts and the process well. A diagnostic analysis must be completed, however, if the process is to be learned. Thus, some compromise was made in the quantity and quality of data collected to ensure that the quality of training was adequate.

How the results of a diagnostic analysis will be used, and in what context, also determine the priority given to data collection as an objective and the length of time to allot for the diagnostic analysis. For example, if a major redirection of effort by concerned organizations is expected to result from a diagnostic analysis, then careful, substantive data must be collected. Further, a longer period of time will be required to collect the data -- perhaps a season or a year. On the other hand, sufficient understanding can be generated from a rapid DA to use for a project design. When training teams in field data collection and analysis and synthesis, usually two or three weeks are spent in the field.

How the results are to be used will also affect strategy because the understanding of the system gained must fit the anticipated use. The expertise of the personnel (expatriate and host country) influences how a diagnosis is conducted. Personnel with more experience and expertise may use more qualitative methods to understand the system, particularly if only a short time is available for the diagnosis.

Financial and logistical support are determined by the personnel defined, the organizations involved, the type of study to be conducted, the duration of the study, and how the results are to be used. If personnel are mandated by their organizations to conduct the study or participate in the training and are relieved of other duties, direct costs may be lower. If organizations make transport, facilities and equipment available, this lowers direct costs still further. Having these same organizations be responsible for logistical support will help to ensure that support is appropriate. Some expatriate assistance and specialized equipment will require additional financial and logistical support.

2. Overall Approach and Concepts

The team's agreement on an overall plan, including roles and responsibilities, is an important part of the plan. The team must understand and agree upon the disciplinary knowledge and skills expected of each team member and how each team member is expected to contribute to the study. Also, the team should begin to identify team management and interdisciplinary strategies. The team should review these agreements at least once during each phase, if not more frequently.

The team should review concepts and approaches used previously by the team members, and the purpose and objectives of the specific irrigation project should be tentatively identified and reviewed with key clients in subsequent phases. Approaches to disciplinary and interdisciplinary analysis and synthesis should be reviewed and tentatively planned. The team should agree on the role of farmers in the study and should establish guidelines for working with farmers.

3. Planning for Phase II

A detailed plan for Phase II is developed during the overall planning phase. This plan should identify the purpose and outcomes for Phase II, the approach for collecting information, how to obtain input and guidance from the key clients, and a process for analyzing and synthesizing the information as it is collected in preparation for replanning Phase III.

Obtaining the agreement of the key clients regarding the planned outcomes for the diagnostic analysis is important. The team and the key clients should identify policy and program issues that need resolution at the field, operational management, executive, or policy levels. Each level in every involved organization may also have issues to raise that the team will need to consider in the field study. In addition, some issues may be raised in areas for which no organization has responsibility. For example, in many countries no organization exists that is responsible for dealing with on-farm water control or for farmer organizations. Individuals or organizations may be assigned these roles, though these assignments may last only for the duration of the study.

C. PHASE II: ENTRY

Phase II (Table 2) is structured to provide information about the diagnostic analysis to all involved organizations which may be significantly affected by the results. At the same time, desired involvement and information about irrigated agriculture, the organizations' roles and responsibilities, and any other issues of concern should be identified. Further, any personnel involved in the diagnostic analysis should receive a mandate for their involvement from each appropriate level within their organization.

The organizations responsible for the diagnostic analysis and its results must be identified and confirmed during the entry process. Decisions regarding the scope and depth of the study need to be made by the relevant organizations so that the results will be adequate for their needs. Whether to follow the diagnostic analysis with an implementation planning program or other alternative should be reviewed and confirmed, depending on the status of the agreement with the key clients. In many instances, knowledge of general problems may be sufficient to reach an agreement about follow-on programs at a general level. In other instances, the implications of the diagnostic analysis results to a program for management improvement may need to be discussed during the exit phase of the study.

General and specific information about the study site needs to be made available during Phase II. In previous diagnostic analysis workshops, formal lectures from key individuals from the related organizations have been given during the planning phase so that trainees could obtain relevant information and become involved. This strategy provides a basis for subsequent involvement if needed.

The focus of the above efforts is to collect, analyze, and synthesize relevant information, and make it available to the team and participants. Prior experience suggests that using small group processes to analyze and synthesize the information gained during entry, capture them on flipcharts, and type them in draft form for subsequent use by the team is an important strategy for accumulating and making relevant information available. Otherwise, information gained during the entry may not be processed or made available to all team members. Debriefing after each interview is an important activity for each interview team or individual.

The team will use this information to replan Phase III, the rapid diagnosis. The understanding of the objectives of the system under study also must be provided as input to the replanning. While information overload is one concern, the team and participants should not have to "re-invent the wheel." The goal is to provide specific information about all priority concerns identified in the overall plan in Phase I, as well as any important concerns identified during the entry phase.

Replanning Phase III involves reviewing the overall plan and developing specific plans for the rapid diagnosis. The diagnostic analysis team needs to provide time to review and agree upon the key management and water management concepts to be used. The knowledge and experience of team members, the diagnostic analysis manuals (Lowdermilk et al., 1983; Fowler, 1988), and the specific site conditions will influence these agreements. Another important aspect is to specifically plan the procedures for the rapid diagnosis by building on the general process of diagnosis and the diagnosis framework presented earlier. The specific plan for Phase III is a priority outcome of the replanning effort in Phase II.

The information provided in the next sections on completing the rapid diagnosis and the detailed diagnosis forms a more adequate basis for planning the rapid diagnosis. Because of the need to do specific planning for a specific study, the team should review the overall diagnostic analysis methodology to adequately plan each phase of the process.

D. PHASE III: RAPID DIAGNOSIS

1. Formulating and Testing Hypotheses

The diagnosis process (Figure 5) involves gathering information about an irrigation system to formulate tentative hypotheses of the areas of low and high system performance. Most studies of irrigation systems gather data too extensively and too intensively. The result is extensive amounts of data that do not address the problem areas. The purpose of the rapid diagnosis of the system is to confirm or reject these tentative hypotheses and formulate new hypotheses based on field observations. The purpose of gathering data to accept or reject the initial hypotheses is to focus the data collection effort in the detailed diagnosis (Phase IV, Table 2).

Previous information may indicate the potential problem areas for formulating the initial hypotheses. Problems from one system to another within a country and around the world are sometimes similar. However, the magnitude of the problem and the factors that contribute to the problem frequently differ from system to system. Thus, low productivity usually occurs in most irrigation projects, but the priority causes of it may be lack of credit, lack of knowledge about a specific production practices, inadequate and untimely availability of seed, and so on. The factor which is most important in a particular setting is often unique in terms of its priority and the way it combines with other factors.

When only a rapid DA is planned, then the initial hypotheses may need to be formed and accepted or rejected during the same field visit. This is accomplished by an early formation of the hypotheses and the subsequent gathering of data to accept or reject the hypotheses. A rapid DA team will usually collect indicative data to reach conclusions because of the time constraint.

The importance of formulating hypotheses and testing them is of value in addition to restricting and focusing data collection. Interdisciplinary interaction needs a firm basis on which to plan and build. Planning and interactions to identify initial hypotheses for areas of low and high performance develop interdisciplinary understanding. Data collected by each discipline individually or jointly is analyzed and synthesized by the discipline(s) and the team to contribute to the understanding needed to confirm or reject the hypothesis.

2. Using the System Diagnosis Framework in the Rapid Diagnosis

The system diagnosis framework (Figure 3) is the basis for guiding the team in identifying areas of low and high performance and in formulating hypotheses. The team should review the system objectives previously confirmed in the entry phase. For the particular system or subsystem studied, the team should define the objectives of the system or subsystem and identify and agree on performance parameters that will adequately measure system performance. Variables for measuring system performance (indicators, if a rapid DA is performed) are identified and agreed upon, and responsibilities are assigned for making measurements. This requires an interdisciplinary definition of the total irrigated agricultural system by the team. Table 4 gives some example performance parameters for the four objectives of irrigated agriculture and their related subsystems.

3. Defining Performance Parameters

Productivity may be measured in ratios of actual to potential yield, or the actual variation in yield may be used as an indicator for rapid DA. In some systems, variation in yield may be of critical importance. Careful consideration should be given to establishing potential yield since system constraints may limit even experiment stations yields. Potential yields can be defined in terms of the maximum yields achieved by farmers, average experiment station yields, or yields on other nearby irrigation systems. In many countries, the best farmers frequently have yields 50 percent higher than experiment station yields.

Resource conservation should be explicitly evaluated by measuring degradation of the soil, water, facilities, or other factors. The rate of deterioration is usually of importance. New projects may not have much effect in terms of waterlogging, but if the water table is rising rapidly, waterlogging and resulting salinity can be expected to contribute to low performance in the future. Suggested performance parameters are given in Table 4.

The profitability of investments in irrigation and on-farm facilities are important considerations in system performance. If farmers cannot make a profit, then an overall return on investment is not possible except through a direct or indirect tax. The problems that result in low performance often are the chief factors that contribute to low returns to farmers. One exception is when markets are a direct factor in low returns. The performance of farms in terms of net returns and appropriateness of investments are an important consideration.[16]

Much effort has been invested in defining performance parameters for the water control system, which includes the main and on-farm systems (Mohammed, 1987; Gates, Ley and Clyma, 1981). These suggested parameters (Table 4) vary for specific circumstances, such as continuous flow and rotation or demand systems. Other parameters may be appropriate.

The framework for diagnosing the performance of an irrigation system in achieving the emphases for irrigated agriculture is presented in Table 5. Farmer participation is important because farmers will be involved in the distribution of water -- whether for their own personal benefit or for the benefit of the group or project. Farmers will be involved in accessing agricultural inputs and services in a similar manner. Therefore, farmers should be involved in managing irrigated agriculture such that overall performance improves.

Evaluating the appropriateness of farmer involvement involves considering whether or not information or services are available to farmers in adequate quantity, in a dependable manner, through an equitable process (Table 5). When key decisions are made about issues related to inputs and services, are farmer concerns and needs identified and addressed? When the ability of farmers to make appropriate management decisions is constrained by a lack of information or services, then farmer involvement is not sufficiently emphasized.

Organizational coordination is viewed as an information flow system. Thus, equity, dependability, and adequacy of the information flow can be evaluated. Organizational coordination is important if the project is to be managed for a high level of performance. The key is to ensure that information for decision making and collaboration is gathered and made available so that appropriate decisions can be made. When poor management decisions are made, often the cause is a lack of information

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[16] Many irrigation systems are farmer owned and operated, not to mention millions of open wells and tubewells. Farmer returns on investment in these systems are often high compared to government-managed gravity systems.

Table 4. Framework for diagnostic analysis of irrigation systems with a management focus for system outcomes.

Key Management Outcomes	Subsystem	Performance Parameters
Productivity of agriculture	Field	Yield, cropping intensity, and variance in yield, cropped area
	Farm	Same as field subsystem
	System	Same as field subsystem
	National	Same as field subsystem
Resource conservation	Field	Salinity level, waterlogging, erosion, sedimentation, fertility, structural degradation, seawater intrusion
	Farm	Same as field subsystem
	System	Same as field subsystem
	National	Same as field subsystem; permanent (sustained) agriculture
Return on investment	Farm	Net returns
	Cooperative	Same as farm
	System	Return on investment
	National	Return on investment; social returns
Water control for - equity - dependability - adequacy	Main	Volume; flow and time for variance of outlet Qs; ratio of actual water delivered/scheduled delivery; ratio of actual supply/designed supply
	Farm	
	- delivery	Same as main subsystem
	- application	Defined efficiencies
	- water use	Stress index
	- water removal	Water content of soil and water level for optimum yield
	National	All of above; return on investment

or collaboration. Thus, a cause of low productivity may be poor coordination and not ignorance on the part of a farmer. Organizational performance should be reviewed in terms of whether or not decisions are made by the appropriate organizations to ensure good management. Many approaches to measuring performance are appropriate for organizational coordination.

Table 5. Framework for diagnostic analysis of an irrigation system with a management focus for the necessary emphases.

Key Management Emphases	Subsystem	Performance Parameters
Farmer participation - equity - dependability - adequacy	Farmer*	Information and services for decision-making and management
Organizational coordination	Farmer	Same as above
	Farmer organization	Same as above
	Irrigation Department - planning - design - construction - management	Information and decision-making for farmer involvement, agency technical decisions, and organizational coordination and management
	Agriculture Department - extension - on-farm water management - inputs - other services	Same as Irrigation Department
	Planning and development	Same as above
	Private sector - seeds - fertilizer - other services	Same as above

*Individual farmer decision-making is a key area for understanding. The farmer also represents the basic subsystem in the socio-organizational system. A sample of farmers is used to define this subsystem.

Additional performance parameters can be identified besides those listed in Tables 4 and 5. Additional suggestions for using these frameworks can be developed for each subsystem. Examples of the use of the framework for each of the subsystems in particular is given in Appendix B, which provides examples of how objectives, performance parameters, contributing factors, and magnitude are used in diagnosis.

4. Analysis and Synthesis of Information

Upon completion of the rapid diagnosis, disciplinary and interdisciplinary analysis and synthesis are initiated. If a detailed diagnosis follows the rapid diagnosis, analysis and synthesis in Phase III consists of accepting or rejecting the hypotheses defined for the rapid diagnosis. Subsequent efforts focus on developing an understanding in order to formulate the hypotheses to be tested during the detailed diagnosis. These hypotheses are the basis for replanning the detailed diagnosis (Table 3).

If only a rapid DA is to be completed, the analysis and synthesis is used to define the performance of the system, the priority contributing factors and their magnitudes, and recommendations for improvement. The analysis and synthesis efforts are the basis for distilling understanding from the rapid DA and for completing the diagnostic analysis reports.

5. Replanning Phase IV

Phase III ends with developing hypotheses of the priority problems and their priority contributing factors and magnitudes. Phase IV is replanned to reflect the specific data collection needed to accept or reject each hypothesis.

The hypotheses are developed as indicated in Table 6. This example is representative of a number of systems previously studied. Contributing factors may change from system to system, and their actual magnitudes may also change. The magnitudes would be estimated at this point based on limited measurements or approximate estimates of existing discharges. The causes are also just an initial identification.

The above process needs to be repeated for each hypothesis statement for each area of low or high performance identified during the rapid diagnosis. Note in Table 6 that watercourse losses were related to contributing factors that were defined by all team members but the main system engineer. Most likely, actual flows at the field also would be affected by main system management. Thus, another contributing factor to watercourse losses could have been the inadequacy and unreliability caused by variations in the flow measured in the distributary canal.

The replanning for Phase IV includes planning how each team member, individually and collectively, will collect data to substantiate or reject the hypotheses. Perhaps the engineer, agronomist, and economist will need to carefully coordinate data collection in order to document the effect of differences in water supply on yields and incomes. The engineer and sociologist may need to carefully coordinate data in order to develop an understanding of the knowledge and skill constraints limiting farmers in accomplishing adequate maintenance.

Table 6. Example hypothesis statement for verification during the detailed study.

Hypothesis: Watercourse losses are approximately 50 percent, with farmers at the tail receiving 20 percent or less of the head supply and the flow ranging from 0 to 5 times the average, resulting in an inadequate, undependable, and inequitable water supply.

Contributing Factors and Their Magnitude:

1. Seepage losses, leakage, and spills contribute 75 percent of the loss caused by inadequate maintenance.

2. Unauthorized use by upstream farmers constitutes 25 percent of the loss caused by conflict and inadequate cooperation among farmers.

3. Inadequate understanding of the magnitude of the loss and the causes contribute to farmers inability to cooperate to reduce the loss.

4. Inadequate knowledge and skills of farmers to do maintenance and to organize for cooperation, lack of a legal authority, and inadequate assistance in organizing contribute to farmers inability to organize to do maintenance.

5. At the tail, cropping intensities are one-half, yields are 50 percent, and incomes of farmers are one-fourth of farms at the head.

6. Some farmers are aware of the problem, most farmers are willing to work together to improve maintenance if benefits are sufficient, and some farmers are willing to organize if given appropriate and sufficient assistance.

7. Government agencies are unaware of the magnitude of the problem and have an inadequate understanding of the factors that contribute to the problem.

If time and resources are not available to obtain the thoroughly detailed understanding needed to provide a good basis for planning improvements, the first diagnostic analysis may have to settle for identifying general causes or contributing factors and their magnitude. For example, watercourse losses may be defined, but whether they are caused by seepage, spillage, or leaks may not be determined.

The replanning follows the team planning methodology to define context and goals and plan their achievement. The interdisciplinary analysis and synthesis follows the same process, which facilitates group interaction, agreement, and understanding.

E. PHASE IV: DETAILED DIAGNOSIS

During the detailed diagnosis, the team carries out the plan developed in Phase III. The methodology of diagnostic analysis is applied using the framework for diagnosis and the previously defined concepts. Examples of how the diagnosis is accomplished is presented in Appendix B. Each subsystem is diagnosed for low and high performance areas and the contributing factors. In the process, priority contributing factors are identified for each performance area.

As an example, watercourse losses may be identified as a priority contributing factor. Watercourse losses contribute to inadequate water control; are an important factor in the management decision-making of farmers, both as individuals and as an organization; and have serious impacts on the crops planted, the varieties used, the inputs provided, and the resulting yields and incomes attained.

During the detailed diagnosis, regular and frequent team meetings are conducted to review accomplishment of plans or to adjust plans as additional information is gained and better understanding is achieved. Some hypothesized problem areas may be rejected as a high priority and data collection stopped in that area. Priority contributing factors may be rejected, or new priority contributing factors may be added. Data collection for a particular contributing factor may be limited because of time constraints or other reasons. These decisions need to be made by the team.

The priority problem areas and priority contributing factors define what data are to be collected. Additional data in other areas are not collected unless the area is determined by the team to be a priority. As an example, if elevation and slope do not appear to contribute to watercourse losses, then the engineers need not survey the watercourse. If castes or family groups do not appear to be a basis for farmer conflict or cooperation, sociologists need not collect data on these relationships.

Upon completion of the detailed diagnosis, the team initiates disciplinary and interdisciplinary analysis and synthesis. The irrigated agricultural system was defined at the beginning, with purpose and outcomes agreed upon. Now, the performance of irrigated agriculture is defined based on the results of the field studies. The priority contributing factors are initially defined during a small-group brainstorming process involving the interdisciplinary team. Magnitudes are agreed upon based upon the specific data available.

Most professionals in irrigated agriculture have had limited experience in interdisciplinary analysis and synthesis of data. The authors repeatedly have been impressed by the understanding developed during interdisciplinary team activities, especially the synthesis process.

The understanding developed from the diagnostic analysis is used by the team to identify strategies for resolving the priority problems and contributing factors. These strategies become recommendations for resolving the problems to improve the performance of irrigated agriculture. The synthesis of strategies for resolving problems is accomplished immediately after the priorities for improvement are synthesized. Since these strategies are approaches to resolving the problems only, the team does not attempt to suggest detailed activities. Because of the knowledge and experience gained from the diagnostic analysis at this point, the team's purpose is to capture this understanding (in written reports) in order to plan approaches to resolving key problem areas. This completes Phase IV of the diagnostic analysis.

F. PHASE V: EXIT

The purpose of Phase V is for the team and the officials and concerned organizations to develop and agree upon plans for initiating an implementation planning process to improve the performance of irrigated agriculture in the study area. Findings and recommendations from the diagnostic analysis are reviewed. Information is prepared for briefings, and meetings are scheduled. How to initiate the next steps for implementation planning to improve the management of irrigated agriculture is planned.

The plan is a structure to provide to key officials a new understanding of the problems and specific factors that contribute to these problems. An understanding of the magnitude of the effect of contributing factors has been found to be an important emphasis in briefing senior officials. A plan for the scope, process, approach, and objectives of implementation planning is developed. Agreement to initiate the process is one outcome sought with key officials. The multi-organizational, multi-level briefing process involves the key policy, executive, and operational managers of the involved organizations. Key officials of the donor agencies are also involved. Responsibility for initiating implementation planning is established, and the plan for accomplishment is approved.

V. IMPLEMENTATION PLANNING FOR MANAGEMENT IMPROVEMENT

A. INTRODUCTION

Understanding the performance of irrigated agriculture and the areas of low and high performance is the best basis on which to improve the management of irrigated agriculture. Improvements in the system facilities and in management are based on the factors that contribute the greatest to low performance.

Improving management requires focusing on achieving objectives and investing resources in resolving constraints that inhibit desired performance. Program bias (e.g., investment in programs for small farms) and disciplinary bias (e.g., lining all the canals in a rehabilitation program) should not drive irrigation system improvements. Concern for improving the well-being of farmers is the ultimate purpose of achieving management objectives in the system. Implementation planning provides a way to fulfill this purpose.

This chapter reviews the needs for improving management, presents a strategy for organizational development that deals explicitly with needs for organizational change, and outlines an implementation strategy that builds on the diagnostic analysis results to improve the management and performance of irrigated agriculture. The knowledge gained by applying the diagnostic analysis methodology is of limited value unless problems are resolved. The major criterion of effectiveness is whether or not the performance of irrigated agriculture has significantly improved.

B. NEEDS FOR MANAGEMENT IMPROVEMENT

Management improvement has two aspects. One is the nature of irrigated agriculture as an organization in that its goal is productivity and the well-being of farmers. Clyma, Lattimore and Reddy (1982) described this circumstance as follows:

> "Irrigated agriculture as a business around the world allows one and usually several organizations to supply inputs; another organization to do development research; another to provide resources to purchase production inputs; and still another to provide information on knowledge and skills for production procedures (which may conflict with what inputs are supplied and/or recommended from research). The farmers (as labor) are usually inadequately and unreliably rewarded, and totally unorganized. No means or power is given to farmers (labor) to improve any of the previous inadequate conditions. Farmers are issued instructions or directives as if they were the employees of each individual organization, when by right and circumstance they are managers themselves with vested management rights to decisions. Thus, management of irrigated agriculture as a business is difficult because of the many organizations and their operating procedures.

> Management in its simplest form is the organization of people to accomplish stated objectives using a defined procedure according to a specific plan. In irrigated agriculture, usually a half a dozen or more organizations are involved and each has its own and differing objectives. The farmers, the primary participants in the process, usually are not members of these organizations nor organized themselves and do not have the same objectives. Though farmers are not a part of any of the organizations, they are assumed to be directed by all of them. They also are not knowledgeable about, nor have the skills for, the often conflicting procedures assumed for them by each organization. The actions of farmers are frequently not according to any of the differing plans of the organizations. Thus, management is most lacking from water management in irrigated agriculture."

With the above circumstances prevalent in irrigated agriculture, is it unexpected that irrigated agriculture's productivity is so low in most countries of the world? Industrial experience has shown that productivity and the quality of production can be increased by using a participatory style of management. Participatory management can work in irrigated agriculture, too. Individuals who perceive a problem as being only the farmers' problem or who perceive the farmer as the problem do not understand the role of management in irrigated agriculture. If any other business was managed as irrigated agriculture typically is managed, it would not survive. Does this explain why so many farmers largely subsist?

A number of challenges must be met if the management of irrigated agriculture is to be improved. Jones and Clyma (1988) suggested some important challenges as follows:

1. Understanding actual field conditions and problems and linking improvement efforts to those conditions.

2. Improving the equity, dependability and adequacy of main system deliveries and on-farm water control through system improvements and improved management as a necessary condition to improving productivity.

3. Increasing the productivity of irrigated agriculture by enhancing the specific conditions of the factors of production through effective research and improved public and private efforts in supply of inputs and extension.

4. Resource conservation to ensure the sustainability of irrigated agriculture.

5. Improving access to credit and markets, and the return on investment to farmers and governments.

6. Managing the improvement process and the integration of agricultural development efforts through organizational coordination, including farmer organizations.

7. Improving the roles and responsibilities of farmers in the planning, design and implementation of improvement efforts and in improving system management where government has traditionally controlled roles.

8. Addressing specific technical issues to improve systems and their management and providing expert technical assistance in a way that builds on and supports the expertise of local resources.

9. Obtaining the support and guidance of policy and upper management levels for implementing improvements; particularly those that involve politically sensitive issues such as water policy enforcement and coordination among different agencies.

10. Addressing the needs of the different kinds and sizes of systems within different environments and institutional contexts.

A management improvement process that successfully addresses the above challenges is needed. Diagnostic analysis provides information on the factors that contribute to many of the above challenges. Improvement in management, however, requires organizational development, which will equip organizations to plan and implement improvements in management.

C. ORGANIZATIONAL DEVELOPMENT FOR CHANGE

Organizational change needs to focus on addressing the priority problems faced by farmers that constrain productivity and farmers' well-being. Organizational change for the sake of change, or for the purpose of some outside organization that believes change is needed for good and well-defined reasons, is fraught with difficulties. Change that is initiated to more effectively address well-defined and agreed-upon problems is more likely to succeed.

Experiences from diagnostic analysis workshops and field studies in a number of countries have shown the power of the understanding generated from diagnostic analysis. It can often initiate changes in understanding, in actions, and in organizations. Yet, a major constraint to actual improvement in management identified by diagnostic analysis participants was the inability to create a multi-organizational, multi-level consensus about problems and the need for change.

Organizational change can involve creating new organizational roles, responsibilities, and relationships with other organizations, and developing new emphases and actions to accomplish new objectives. Individuals will need to acquire new knowledge, skills, and perhaps attitudes through training. If too great a gap develops between the new directions and the requirements of individuals, then management performance will be limited. Thus, organizational development may require new forms of action training (Kettering, 1985).

An approach for accomplishing such training is elaborated in Appendix C. The approach uses the results of the diagnostic analysis to assess the training needs of the involved personnel. Then the types of specific training needed are identified. Integrating the trained personnel back into their positions is also included in the planning.

In addition to defining new roles and responsibilities for related organizations and the individuals involved, improvements in management will involve defining new goals to address the priority problems faced by farmers, and providing new facilities. Implementation planning provides a way to meet the challenges and needs for improving management in irrigated agriculture.

D. IMPLEMENTATION PLANNING

Implementation planning was developed to improve the management of irrigated agriculture in the Command Water Management Project in Pakistan (Jones and Clyma, 1988). Implementation planning builds on the results of a diagnostic analysis study and uses the concepts and approaches of the team planning methodology. Essentially, implementation planning is used to assist irrigated agricultural organizations in implementing an action training process to develop an inter-organizational management plan.

Implementation planning is accomplished using outside (host country and/or expatriate) consultants experienced in management and water management. The implementation planning assistance team uses the team planning methodology to develop an overall plan for the effort. The implementation planning process is summarized in Figure 7 and Table 7.

The overall plan is developed in a team planning meeting (Levine, 1988). Input and guidance for the planning are obtained as preliminary work through a short visit with the key personnel related to the irrigation improvement effort (Table 7). Information about logistical arrangements, identification of personnel for participation, and scheduling of facilities is done to evaluate alternatives during the planning. In Phase II (entry), the team provides information on the overall plan, receives further input, and obtains a mandate for participation of key personnel from the involved organizations. Phase III involves two workshops. The first workshop focuses on defining and agreeing upon the priority problems to be addressed in the second workshop, which does the planning.

The involvement of personnel in the implementation planning process is illustrated in Figure 7. The results of the diagnostic analysis are input to the planning. The key personnel are the field and operational managers for planning. The field personnel have the field knowledge and experience and the operational managers are the individuals responsible for day-to-day management of activities. The input and ownership on the part of the executive personnel are obtained through their involvement in structuring the planning and in reviewing the results of the planning. Policy level involvement is through a mandate obtained in the beginning and their review of the results of the planning.

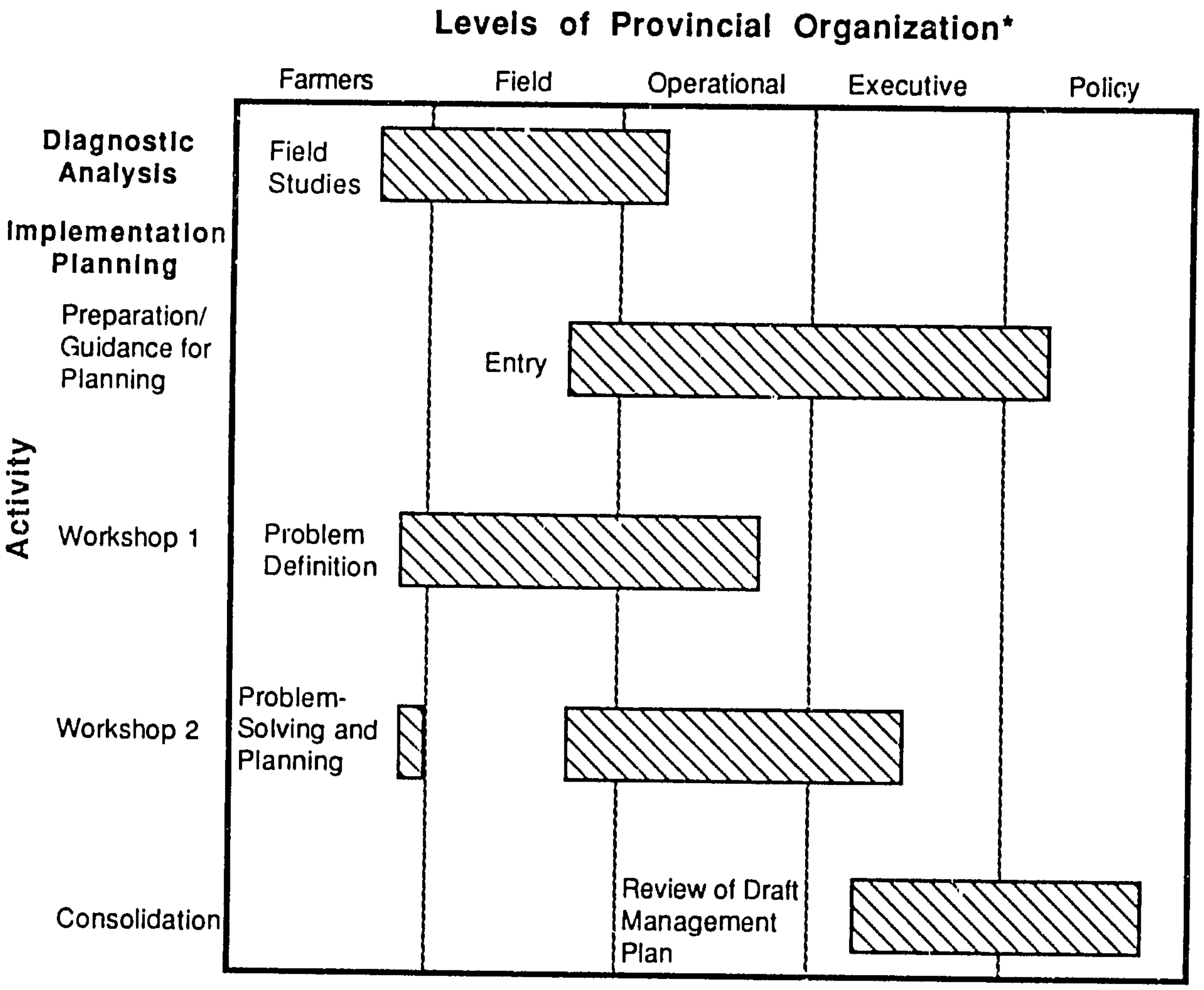

Figure 7. Involvement of farmers and the levels of provincial irrigation-related organizations in the diagnostic analysis/implementation planning process.

Table 7. Stages of the management intervention through implementation planning (IP) (modified from Jones and Clyma, 1988).

Stage	Focus	Participants
Diagnostic Analysis (DA)		
Diagnostic analysis workshop (5 wks)	DA concepts, skills, & practice	Organizational staff and consultants
Diagnostic analysis of subproject (6 wks)	Identify priority problems, their contributing factors, and their magnitude	Field personnel and managers, farmers, input suppliers, consultants
Implementation Planning (IP)		
Pre-program visit for IP Program (1 wk)	Initial planning for IP; information gathering and briefing of provincial organizations	Project staff, multi-levels of key provincial organizations, 2-3 members of IP team
IP team planning meeting (4 days)	Prepare IP team and plan IP program	IP team, donor and host country representatives
Phase I: Entry (1 wk)	Present IP, identify key concerns, obtain input of officials, final planning for workshops	Project staff, multi-levels of key provincial organizations, IP team
Phase II: Management Planning (1-1/2 wks) (1-1/2 weeks)	Workshop I: Problem Definition. Review project context, goals, and structure; starting with the DA, gain understanding of priority problems	Field and operational managers, representatives of all involved organizations, farmers, IP team
	Workshop II: Problem Solving and Planning. Complete draft manage-	Operational managers, farmers, executive personnel, IP team
Phase III: Consolidation (1 wk)	Return to key policy officials with draft plan; obtain policy-level input and decisions; "next steps" planning	Policy and executive levels of key organizations, project staff, IP team

Workshop II (Figure 7 and Table 7) involves the key implementing organizations related to irrigated agriculture in a problem solving and planning process in order to develop an inter-organizational management plan. These participants will delineate long-term purpose(s) and objectives, intermediate goals for several years, and short-term objectives for the next six months to one year. Roles and responsibilities are defined, including organizational and individual responsibilities for each activity. A plan for monitoring the plan and the management of the irrigated agricultural system is also developed.

This draft plan is reviewed by policy and executive officials in Phase IV. These officials provide guidance for finalizing the plan and make decisions about key aspects of the plan. The operational managers then prepare the "next steps" for completing and initiating the implementation of the plan.

The implementation planning process is currently being applied in one state in India, is being used to initiate an Irrigation Advisory Service in Egypt, and is being considered for application in Sri Lanka. The approach is applicable to any situation where improving the management of irrigated agriculture is a priority and has organizational commitment. Implementation planning is not a recipe for planning and improving management. Implementation planning is one approach for improving the management of irrigated agriculture.

VI. REFERENCES

Alwis, J.; L. Nelson; H. Gamage; R.A. Nandasena; R.E. Griffin, K. Yoo; A. Ekanayake; M. Haider; L. Wickramasinghe; L. Dunn; M.A.W. Bandaranayake; J.M. Reddy; W.R. Laitos. 1983. System H of the Mahaweli Development Project, Sri Lanka: 1982 Diagnostic Analysis. WMS Report 16. Water Management Synthesis II Project, Colorado State University, Fort Collins.

Bottrall, A. 1983. An approach to evaluating the organisation and management of large irrigation schemes. In: Singh, K.K. (ed.). Utilization of Canal Waters: a Multi-disciplinary Perspective on Irrigation. Central Board of Irrigation and Power, New Delhi, India.

Chambers, R. 1983. Rapid appraisal for improving existing canal irrigation systems. Discussion Paper Series No. 8. Ford Foundation, Delhi, India.

Clyma, W. 1986. Irrigated agriculture: a comparative analysis of development concepts. In: Nobe, K.C.; R.K. Sampath (eds.). Irrigation management in developing countries: current issues and approaches. Westview Press, Boulder, CO. pp. 19-46.

Clyma, W; G.L. Corey. 1974. The importance of farm water management in Pakistan. Field Party Report #2. Water Management Research Contract/Pakistan, Colorado State University.

Clyma, W.; S.R. Katariya; L.J. Nelson; S.P. Tomar; J.M. Reddy; S.K. Bakliwal; M.I. Haider; U.R. Mehta; M.K. Lowdermilk; W.R. Laitos; R.R. Mehta. 1983. Diagnostic analysis of farm irrigation systems on the Gambhiri Irrigation Project, Rajasthan, India: Volumes I-V. WMS Report 17. Water Management Synthesis Project, Colorado State University, Fort Collins.

Clyma, W.; D. Lattimore. 1987. Irrigation system rehabilitation: need for pre-rehabilitation studies. In: Fowler, D. (ed.). International Conference on Irrigation System Rehabilitation and Betterment, Volume 2: Papers. Water Management Synthesis II Project, Colorado State University, Fort Collins. pp. 341-351.

Clyma, W.; D.L. Lattimore; J.M. Reddy. 1982. Irrigation water management problems around the world. Paper prepared for presentation at the Ninth Technical Conference on Irrigation, Drainage, and Flood Control. U.S. Committee on Irrigation, Drainage and Flood Control. October 20-23, 1982, Jackson, MS.

Clyma, W.; M.K. Lowdermilk; G.L. Corey. 1977. A research development process for improvement of on-farm water management. Water Management Tech. Report No. 47, Colorado State University, Fort Collins.

Clyma, W.; M.K. Lowdermilk; D. Lattimore. 1981. On-farm water management for rural development. Agricultural Engineering. 62(2):-14-15.

Clyma, W.; M.K. Lowdermilk; E.V. Richardson; W.R. Schmehl, M.D. Skold; D.K. Sunada. 1981. An agricultural development model for Egypt. Paper No. 81-5025. ASAE. St. Joseph, MO. 21 p.

Egypt Water Use and Management Project (EWUP). 1984. Improving Egypt's irrigation system in the old lands: findings of the Egypt Water Use and Management Project. Engineering Research Center, Colorado State University, Fort Collins. 68 pp.

Fasso, C.A. 1987. Rehabilitation and modernization of irrigation and drainage projects for improving water management. Proceedings of Thirteenth International Congress on Irrigation and Drainage, Casablanca, Morocco. p. 195.

Fowler, D. (ed.). 1988. Diagnostic analysis of irrigation systems, Volume 2: evaluation techniques. Water Management Synthesis II Project, Colorado State University, Fort Collins.

Fowler, D.A.; M.K. Kilkelly (eds.). 1988. Diagnostic analysis of four irrigation schemes in Polonnaruwa District, Sri Lanka: interdisciplinary analysis. WMS Report 61. Water Management Synthesis II Project, Colorado State University, Fort Collins.

Gates, T.; W. Clyma; T.W. Ley. 1981. Systems analysis for improvement of surface irrigation. Paper No. 81-2073. ASAE. St. Joseph, MO. 29 p.

Haider, M. 1987. Proceedings of International Conference on Irrigation System Rehabilitation and Betterment. Water Management Synthesis II Project, Colorado State University, Ft. Collins. p. 1.

Jayaraman, T.K.; M.K. Lowdermilk; W. Clyma. 1982. Command area development authorities for improved water management. Water Management Synthesis Report No. 3, Colorado State University, Fort Collins.

Jones, A.L.; W. Clyma. 1988. Improving the management of irrigated agriculture: the management training and planning program for Command Water Management, Pakistan. WMS Professional Paper 3. Water Management Synthesis II Project, Colorado State University, Fort Collins. pp. 13-16.

Kettering, M.H. 1985. Action training for development management: learning to do and doing to learn for stronger development programs. Development Program Management Center, USDA, Washington, D.C.

Korten, F.F. 1982. Building national capacity to develop water users' associations: experience from the Philippines. World Bank Staff Working Paper No. 528.

Levine, D. 1988. The team planning methodology: shaping and strengthening development management. Development Program Management Center, USDA, Washington, D.C.

Lowdermilk, M.K.; W. Clyma; L.E. Dunn; M.I. Haider; W.R. Laitos; L.J. Nelson; D.K. Sunada; C.A. Podmore; and T.H. Podmore. 1983. Diagnostic analysis of irrigation systems, Volume 1: concepts and methodology. Water Management Synthesis Project, Colorado State University, Fort Collins.

Lowdermilk, M.K.; D. Freeman; A. Early. 1978. Farm irrigation constraints and farmer's responses: comprehensive field study in Pakistan. Water Management Technical Report 45, Volumes I-VI. Colorado State University, Fort Collins.

Nelson, L.J.; M.K. Kilkelly; S. Hettige; M.A.W. Bandaranayake; J.W.D. Somasundra; K.A.V.S. Imbulana; I. de Silva; R.A. Mohammed; W.R. Laitos. 1988. Diagnostic analysis of four irrigation schemes in Polonnaruwa District, Sri Lanka: interdisciplinary report. WMS Report 61. Water Management Synthesis II Project, Colorado State University, Fort Collins.

Mohammed, R.A. 1987. A theory for monitoring an irrigation conveyance system. Colorado State University, Fort Collins. 182 pp. [Dissertation]

Oad, R.; P.G. McCornick; W. Clyma. 1988. Methodologies for interdisciplinary diagnosis of irrigation systems. WMS Report 93. Water Management Synthesis II Project, Colorado State University, Fort Collins.

Oram, P.; J. Zapata; G. Alibaruno; R. Shymal. 1979. Investment and input requirements for accelerating food productions in low-income countries by 1990. Research Report 10. International Food Policy Research Institute.

Planning Commission - India. 1986. Sixth five-year plan (1980-1985). Government of India.

Shaner, W.W.; P.F. Philip; W.R. Schmehl. 1982. Farming systems research and development guidelines for developing countries. Westview Press, Boulder, CO.

Skogerboe, G.V.; J.D. Brewer; F.B. Brown; A.C. Early; R.J. McConnen. 1984. Irrigation systems management project design report: Sri Lanka. WMS Report 33. Water Management Synthesis II Project, Colorado State University, Fort Collins.

Uphoff, N. 1984. Experience with peoples' participation in water management: Gal Oya, Sri Lanka. In: Garcia-Zamor, J.C. (ed.). Participation and Development Planning and Management: Cases from Asia and Africa. Kumarian Press, West Hartford, CT.

Venkatraman, K.N.; L.J. Nelson; J.C. Uttamchandani; J.M. Reddy; W.R. Laitos; T.S. Sheng; P.C. Stanbury; A.G. Madsen; C.W. Honeycutt. 1984. Interdisciplinary diagnostic analysis of and workplan for Dahod Tank Irrigation Project, Madhya Pradesh, India. WMS Report 25. Water Management Synthesis II Project, Colorado State University, Fort Collins.

Wade, R.; R. Chambers. 1980. Managing the main system: canal irrigation's blind spot. Economic and Political Weekly. 25(19):A107-A112.

Wattenburger, P.L. 1987. Command Water Management, Punjab: Pre-rehabilitation diagnostic analysis of the Niazbeg Subproject. WMS Report 52. Water Management Synthesis II Project, Colorado State University, Fort Collins.

Yoder, R.; E. Martin. 1983. Identification and utilization of farmer resources in irrigation development: a guide for rapid appraisal. Nepal Irrigation Research Project, The Ford Foundation, 55 Lodi Estate, New Delhi, India.

VII. APPENDICES

APPENDIX A

THE PURPOSES OF IRRIGATED AGRICULTURE

Irrigated agriculture is engaged in by farmers for their own benefit and to improve their well-being. In individually managed irrigation efforts, the farmer analyzes the costs and benefits resulting from irrigation and invests accordingly. In this instance, the financial analysis of the appropriateness of irrigation should be based on the costs and benefits to the farmer. In an economic analysis, there also may be substantial benefits to government from rural development, increased food security and food production, and increased foreign exchange; and there may be environmental degradation and increased demands for some inputs with a resulting increase in imports.

Government may engage in irrigation development with any or all of the above purposes in mind and may also use irrigation development as a resettlement process. In the instance of individual private development, there is no doubt that farmers pay the costs and derive the principal benefits. Government development efforts often involve irrigation projects, but the multiplicity of objectives may result in poor economic decisions about who pays the costs and who derives the benefits.

Government rural development efforts may restrict the size of farm or the supply of water to the extent that farmers' returns are reduced. Government may then assess the farmers the full cost of the investment and require that payments be large enough for the government to recover the full costs. When this results in farmers being unable to pay, then irrigation projects are judged to be uneconomical. In reality, the financial returns to irrigation may be substantial, but the constraints imposed by rural development or other objectives may make the costs of irrigation greater than the returns to individual farmers.

When evaluating irrigation projects, the costs associated with objectives other than development of irrigated agriculture and the well-being of farmers should be determined and carefully evaluated. When evaluating the performance of irrigated agriculture, the financial benefits to farmers of irrigation should be carefully evaluated to determine the priority costs and benefits to understand which returns are attributable to irrigation. Rural development or other government objectives should also be evaluated in terms of costs and benefits. When the costs reduce the benefits to farmers and constrain irrigated agricultural performance, this condition should be documented and the information provided to government. The problem can be resolved by changing policy, or the existing policy can be considered a constraint.

When evaluating the economic performance of the irrigation project, conclusions about the economic and financial feasibility of the project should be clearly stated in terms of irrigation development objectives and rural development objectives. Statements about the economic and financial performance of the project without considering the costs and benefits of other objectives should not be made.

For diagnostic analysis, it is important to evaluate the financial feasibility of irrigation for the farmers. When other constraints are identified (such as export policies or rural development costs) that reduce farmer returns, then a careful economic analysis should document these constraints and relate improvement plans to appropriate policy actions - either as constraints or as policy changes for improving the performance of irrigated agriculture.

The important consideration is that diagnosis of irrigation systems should focus on farmer well-being. Consideration of return on investments should include a financial analysis of the farm system and the irrigation project. Other economic constraints may be identified and documented. However, for rural development, food security, or other purposes to be successful, the purpose of improving farmer well-being must be served.

APPENDIX B

APPLICATION OF DIAGNOSTIC ANALYSIS TO THE IRRIGATED AGRICULTURAL SYSTEM

INTRODUCTION

Diagnostic analysis of an irrigated agricultural system is accomplished by an interdisciplinary team which applies the concepts and processes previously defined in this paper. The key subsystems in irrigated agriculture were previously defined in Chapter II. This appendix covers the application of the diagnostic analysis methodology to these subsystems.

A careful disciplinary and interdisciplinary analysis of causative factors and their magnitude, combined with an interdisciplinary synthesis, is an important aspect of the diagnostic analysis process. Experiences in Pakistan[1] and elsewhere suggest that changes in attitudes and behaviors take place in those who are involved in the process.

The measure of low performance is the basis for establishing the priority problem area. Therefore, the performance variable or indicator needs to be comparable to some potential level of performance for a given context. For example, equity of water distribution could be very low, but still have a limited effect on yield if the water supply was adequate for overall crop production. Other factors, such as non-availability of credit for inputs may have a higher impact on productivity and farm income than equity of water supply. Thus, each objective can be evaluated in terms of how it affects productivity and farmer well-being.

Causes of low performance are of interest for several reasons. The causes or contributing factors represent an important part of diagnosis in that taken together for a particular problem, they represent the interdisciplinary definition of a problem. For example, the problem may be low productivity of wheat. The factors which contribute to this problem may be unreliable water supply, inadequate water supply, inadequate credit, inadequate use of inputs, waterlogging and resulting salinity, inadequate information from extension, and inadequate prices for the product.

It may be that an unreliable water supply is the priority contributing factor, and the farmer is unwilling to deal with other factors due to perceived high risks and poor returns. This does not mean that

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[1] Jones, A.L.; W. Clyma. 1988. Improving the management of irrigated agriculture: the management and training program for Command Water Management, Pakistan. WMS Professional Paper 3, Water Management Synthesis II Project, Colorado State University, Fort Collins.

only water supply requires problem definition and resolution. Other problematic factors critical to improving yield need to be resolved to ensure that productivity does increase. Improving credit availability, providing more water, improving extension, or changing the government purchasing system for wheat might be the most important cause to resolve first. For example, waterlogging may only affect a small part of the area and may not require immediate action.

The concept of contributing factors allows a team to develop an interdisciplinary definition of a problem and identify the key factors requiring planning to resolve the problem. A contributing factor of undependable water supply may result in a goal statement of "provide a dependable water supply." The specific contributing factors to the problem area become objectives or actions under an objective that deal with resolving the contributing factor that is causing the undependable water supply. Plans are then made that will achieve that goal. The improvements to the system and the management to achieve that goal are the basis for systematically improving the performance of the system.

The application presented here is based on knowledge and understanding from previous experiences. The suggestions offered regarding performance variables, performance indicators, contributing factors, and how to measure the magnitude of contributing factors are not intended to be exhaustive or restrictive. They are intended to provide more information about how to apply the methodology of diagnostic analysis and to give specific suggestions for how to accomplish the diagnosis.

The methodology is applied to the productivity, return on investment, water control, and social-organizational subsystems. Objectives for analyzing system performance are presented and discussed. Resource conservation is also presented as an overall objective appropriate for application to all the subsystems. Evaluation of the performance of farmer involvement and organizational coordination is also discussed.

THE PRODUCTIVITY SUBSYSTEM

Productivity directly affects farmer well-being. Therefore, it often becomes the criterion for judging the magnitude and priority of contributing factors. Concentrating on individual farm and field productivity during a diagnostic analysis focuses the management objectives on system purpose and the factors that constrain system performance.

Important management decisions are made by farmers and the organizations which provide the agricultural inputs and services which directly affect productivity. Therefore, the factors which contribute to reduced productivity are of central importance in a diagnostic analysis.

Measuring the performance of productivity is time consuming and expensive. The timeliness required to accurately measure yield is often a constraint on scheduling a diagnostic analysis. Nevertheless, measuring yields and identifying the key factors which contribute to a particular yield level is a key part of the diagnosis. Table B1 identifies the major variables for measuring yield characteristics and some of the indicators of yield which can be used to complete a diagnosis analysis or rapid DA

Table B1. Variables and performance indicators for measuring the performance of productivity.

Subsystem	Variables Measured in Detailed Diagnosis	Indicators Observed in Rapid Diagnosis
Field	Crop yields	Crop differences suggesting low or high yields.
		Crop differences caused by differences in fertility, planting or seeding practices, or water control.
		Changes in inputs or management practices; variations in yield.
	Cropping intensity	Changes from head to tail in system.
		Changes due to timely availability of water, inputs or services.
		Changes due to reliability of water supplies.
	Crop or variety grown	Changes in crop types or varieties with location.
	Quality of yield	Size or appearance of yield products.
		Marketable sugar or other measures of quality.
Farm	Same as for field given above	
	Crop diversification	High quality or high yield crops nearest water supply.
		Crop rotation excludes sensitive or high water demand crops.
		Fraction of area in key crop
	Marketable surplus	Estimated value
System	Same as field and farm given above	
National	Same as field and farm given above	
	Export/import ratio	

without taking yield measurements. Farmer interviews, indirect observations, and other indicators are all important aspects of measuring yield performance.

During a diagnostic analysis, potential or target yields for a project or an area need to be determined. While experiment station yields are useful, good farmers frequently have yields that exceed experiment station yields by 50 percent. Thus, good farmer yields may be a better indication of potential yields in the study area.

Yields at the head of the system are often used as measures of potential yield under the assumption that water supplies are adequate and reliable at this position, and will not limit yields. However, limitations in the farm irrigation system, farmer knowledge, and availability of agricultural inputs and services often seriously limit yields at all locations. Thus, yields at the head of the system may not automatically be a good indicator of potential yields.

Current and past cropping intensities are often good indicators of system constraints, though a combination of factors may result in the given or measured cropping intensity. The type, variety, and quality of crop are also good indicators of system constraints. A change in variety may reflect non-availability of seed, inadequate credit, inadequate information, or changes in water supply. Almost all diagnostic analysis studies have found that cropping patterns change as the adequacy and dependability of water supplies improve.

Water control is often the most powerful variable in these studies. For example, farmers may plant sensitive crops nearest the water supply. They may also give priority to irrigating the sensitive crops. Other management practices such as input use, weed control, and higher yielding varieties may be reflected in the higher priority crop. These practices may contrast with the management of additional crops under other important constraints.

Table B2 suggests some factors which contribute to low crop productivity and some ways to measure their magnitude. The factors that contribute to low productivity are often complex and interact with other contributing factors. For example, aspects of water control often directly affect productivity. A lack of resource conservation can create conditions that result in sustained low productivity. Investment decisions about inputs and services usually directly affect potential or actual yields. Thus, the productivity objective integrates the other objectives and correlates strongly with most factors measured.

Management practices often combine with other contributing factors to affect productivity. Yet these practices may be symptoms of the problem, rather than a more direct cause. For example, farmers may not control weeds because they expect that water supplies will be short and investment in weed control will not pay. Every diagnostic analysis conducted to date has shown that undependable water supplies drastically affect input use and management of crops.

Table B2. Factors contributing to low system performance for productivity, and suggested measures for identifying the magnitudes of the factors.

Problem	Contributing Factors	Magnitude
Inadequate agricultural production	Same factors as main and farm water control system	
	Low levels of input use	Interview/observations
	Use of varieties with lower yielding potential	Interview/observations
	Poor management practices in seeding, weed control, timing of fertilizer, pest control, and timing and amount of irrigations.	Interview/observations
	Inadequate information; inadequate services, such as credit; inadequate inputs, such as seeds and fertilizer; and inadequate knowledge and skills.	Interview/observations
	Low cropping intensities	Measurements, interviews and observations

THE ECONOMIC SUBSYSTEM

The returns that farmers achieve are often the direct measure of farmer well-being. Family and social considerations may often require that the farmer incur more costs or receive less returns. The returns on investment are the primary means for measuring levels of performance that integrate the effects of contributing factors. Returns are also used to eliminate solution alternatives because they reflect combinations of costs and benefits.

The current world economic situation has increased the emphasis on ensuring that projects pay the recurrent costs of irrigation. While capital costs may not always be included, a yearly management cost is more frequently required. In Chapter II and Appendix A, the purposes of irrigation projects were reviewed. The primary concern was that farmers may be asked to pay an inordinate share of the costs to achieve national or regional purposes for irrigation projects. Government policy on subsidies and pricing is often complex and creates a hidden tax on the farmer. Therefore, careful analysis of the benefits that farmers and government receive from irrigation is necessary.

The variables used to measure investment performance and some appropriate indicators for use in rapid DA are given in Table B3. Returns to head and tail farmers, good managers and poor managers, and farmers who have made investments to improve production and those who have not are some of the factors to compare. Land values may also indicate the costs of poor water control (e.g., a comparison of land values for head and tail farmers, or with and without tubewells), and differences between rainfed and irrigated conditions.

At the farm level, net farm income per hectare is a measure of how well an irrigated agricultural system is performing. Variations in net returns between irrigated and non-irrigated farms, and farms with poor and good water control are important indicators of levels of performance. In a rapid DA, time may not permit a detailed analysis of farm returns. However, returns on the primary crops can be estimated, and stability of farm incomes may be an important indicator of the value of irrigation. Labor productivity for a crop can be estimated or measured during a detailed study where labor constraints have been identified. Farmer investments in pumps, tractors, and land leveling to improve productivity can be estimated or measured. Use of improved seeds and fertilizer may need to be estimated for some farms. The effect of government policies on net incomes due to terms of trade and subsidies may also need to be evaluated.

During the diagnostic analysis, a complete financial analysis should be done for selected farms with important characteristics. The primary variables to identify for a given farm cannot be listed here, but location is frequently important. Dependability of water supplies is also often a priority factor. Other important factors may be identified by the interdisciplinary team. This financial analysis is needed to assess the overall benefits to farmers from irrigated agriculture. Where differences are small, a careful study is needed to isolate priority contributing factors. Where differences are large (no water at the tail of a distributary, for example), then estimates of the importance of water control can be made.

The suggested contributing factors and methods to measure their magnitude are given in Table B4. In many instances, the major contributing factor is the one identified as causing low performance in another objective. For example, inadequate water control at the tail, caused by large watercourse losses, may create several magnitudes of difference in net returns between head and tail farmers. Another important consideration when assessing economic productivity is that the marketing of goods (marketing margins) and the prices which farmers obtain (terms of trade) are often influenced by a variety of factors. In one diagnostic analysis, the prices received by farmers for an important crop was less than 20 percent of its retail value. Transport, price information, and inadequate coordination among farmers contributed greatly to the low price received.

Table B3. Variables for measuring investment performance and indicators of performance.

Subsystem	Variable Measured in Detailed Diagnosis	Indicator Observed in Rapid Diagnosis
Field	Net returns	Estimated yield and net returns and variations between units
	Land values	Variation before and after an improvement; degree of water control (wells, closeness to source)
	Enterprise return	Estimated yield and return
Farm	Net farm returns	Estimated yield and net returns for major crops and yearly variations
	Land values	Sales of land over time
	Farm value	Farm facilities and land value estimates
	Labor productivity	Changes in returns to units of labor as a ratio
	Investment return	Value of pumps, land leveling, tractor or tractor plowing
	Financial analysis	None
System	O&M* cost/ha	Relative level of system repair
	Water revenue	Farmer perceptions of costs and benefits
	Marketable surplus	Changes over time; ratio to O&M
	Financial analysis	None
	Economic analysis	None
National	Financial analysis	None
	Economic analysis	None
	Pricing policies	None

O&M = operation and maintenance

Table B4. Factors contributing to low system performance for returns on investment and measures of magnitude.

Probem	Contributing Factors	Magnitude
Inadequate return on investments	Same factors as other objectives	
	Pricing policies of government	Returns with and without policy
	Inadequate marketable surplus	Consumption/ marketable surplus ratio
	Inadequate markets and marketing mechanisms	Consumption/ marketable surplus ratio
	Inadequate price for goods sold	Farm price/ market price ratio
	Inadequate knowledge of market demand for alternative crops	Key import items
	Inadequate cooperation and coordition among farmers	Potential/actual goods marketed
	Inadequate coordination between farmer organizations and government	Potential/actual goods marketed

THE WATER CONTROL SUBSYSTEM

The framework can be applied to the water control subsystem as an extended example of analysis. The initial effort further defines the variables to measure in order to compute the suggested performance parameters. Table B5 provides the suggested variables for measuring the identified performance parameters (page 41). These variables would be measured during detailed diagnosis to define system performance.

In many instances, time only permits a rapid DA. Usually, actual measurements cannot be made during a rapid DA. In those instances, an indicator of performance should be sought that can be rapidly and visually observed. For example, Table B5 suggests indicators for levels of performance for each of the subsystems. As an example, farmers are often reliable sources of information about undependable and inadequate water supplies. Crop conditions are also good indicators of undependable and inadequate water supplies. Major differences in flow in the canal and watercourse with distance indicate inequity. No water at the tail is an obvious indicator of inadequate and inequitable water supplies. Changes in types and quality of crops grown also are good indicators of inequity when the crop water requirements change drastically.

Table B5. Measuring main and on-farm system performance.

Subsystem	Variables Measured in Detailed Diagnosis	Indicators Observed in Rapid Diagnosis
Main	Q at control points Duration & frequency of Q	Implied variations in Q at control points: *Official schedule vs. observed schedule or farmer report
	Planned Q	*Flow less than planned, crop stress, farmer complaints
On-farm delivery	Q at farm or field	Variable or reduced flow at field, water loss evident, farmer conflict
Water application	Water applied, water required	Unlevel fields, too much water applied, non-uniform crop symptoms, crop stress
Water removal	Soil water content	Standing water, salinity, crop symptoms

Q = flow rate

During the field study (rapid diagnosis or detailed diagnosis), the causes of the problem or the factors which contribute to the problem are identified. Some commonly encountered contributing factors or causes are given in Table B6 for the main system. The infinite variety of combinations of priority contributing factors is one reason why irrigated agriculture is difficult to manage and why there are often failures when improvements are attempted.

The contributing factors in Table B6 are often observed in irrigation projects. Unregulated water abstractions by farmers are frequently unauthorized and commonly unrecognized by the official management of the system. Measurement of discharge is usually not practiced and if practiced, measurements are not used for management. Usually a plan for managing the distribution of flows is developed, but no measurements are taken to ensure that the planned flows are actually distributed. Contributing factors affecting dependability and adequacy are usually related. Adequacy is sometimes related to a lack of understanding by engineers of the crop water requirements.

Table B6. Factors contributing to low performance in main systems.

Problem	Contributing Factors	Magnitude
Inequity	Unregulated farmer abstractions	Head/tail Q
	No farmer organizations to decide joint actions	Interview
	Unplanned seepage losses	Measured/planned Q
	Improperly regulated flow at control points (divisions/checks)	Measured/planned Q
	Unregulated inflow supply	Measured/planned Q
	Uncoordinated design of canal and outlets	Measured/planned Q
	No explicit measurement of discharge	Measured/planned Q
	No management plan including monitoring and evaluation for management	Measured/planned Q
Undependability	Same factors and magnitudes as equity	
	Management not following plan	Measured/planned Q
	Inadequate communication to farmers	Measured/planned Q
Inadequacy	Same factors and magnitude as equity	
	Flows not regulated to meet crop needs	Actual/required Q

Q = flow rate

Commonly encountered factors contributing to low system performance in the on-farm water control system are given in Table B7. On-farm delivery is usually directly affected by the main system management. Farm deliveries often are undependable because of seepage losses from the channel or unauthorized abstractions by other farmers. The result is that farmers do not collectively manage (operate and maintain) the farm delivery channel. Unlevel fields and inadequate farmer knowledge and skills result in poor field applications of water. In many countries, it is thought that farmers practice level basin irrigation when in fact, wild flooding, with resulting poor water management, is the common practice. This often leads to drainage problems because excess applications of water and upward flow from groundwater result. Other factors exist which may be identified during a diagnostic analysis.

The factors which contribute to inequitable water supplies often have social, organizational, and economic roots. Cropping patterns and profitability often influence farmer decisions to modify the planned distribution of water in a canal system. The results of the interdisciplinary analysis of the field conditions provide the team with the knowledge and understanding needed to synthesize the factors which cause particular problems.

THE SOCIAL-ORGANIZATIONAL SUBSYSTEM

The major emphases for the social-organizational subsystem were provided initially in Chapter II and in more detail in Chapter IV. Freeman[2] has suggested a number of considerations necessary for effective organization of irrigated agriculture. The investigators of the social-organizational subsystem, however, do not attempt to define specific social norms or organizational arrangements for effective performance of irrigated agriculture. Instead, the diagnosis is used to identify the process and rationale that individuals and organizations use to make key decisions. Their expectations or goals in making the decisions are also identified, and the results of the decisions are evaluated in terms of system performance or factors that contribute to system performance. Adequacy of decision-making is thus determined and areas of decision-making needed to improve system performance are identified.

Farmer involvement has an individual dimension, which is decision-making, and a collective dimension related to how farmers organize for system management. Farmer decision-making is a complex process, which takes place in a social environment. Social norms, knowledge, skills and information play a part. The individual and collective goals of a farmer or farm family also play a part. It is necessary to understand this environment in order to understand decision-making.

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[2] Freeman, D. 1988. Linking main and on-farm systems in order to control water, Volume 1: designing local organizations for reconciling supply and demand. WMS Report 69. Water Management Synthesis II Project, Colorado State University, Fort Collins.

Table B7. Factors contributing to low performance of farm water control system.

Problem	Contributing Factors	Magnitude
Inadequate, undependable and inequitable delivery of water	Inadequate water control from the main system	(See Table B6)
	Uncoordinated design of canal and outlet	Measured/planned Q
	Inadequate planning, design and construction of watercourse	Head/tail Q
	Inadequate operation and maintenance	Head/tail Q
	Inadequate farmer involvement	
Inadequate water application	Inadequate water control from main and watercourse	(See delivery above)
	Unlevel fields	Field elevation
	Inadequate technical assistance to farmers	Yields/efficiency
	Inadequate farmer knowledge and and skills	Yields/efficiency
	Improperly planned, designed and constructed fields	Yields/efficiency
Inadequate water use for crops	Same factors and magnitude as delivery and application	
Inadequate water removal	Same factors and magnitude as delivery and application	
	Soil conditions that restrict flow of water from root zone	Yields/crop conditions
	Groundwater flow into root zone	Yields/crop conditions
	Excess surface flows from rainfall or irrigation not removed	Yields/crop conditions

Q = flow rate

Farmer decisions are conditioned by tradition, which can be defined as a combination of social norms and knowledge. Tradition plays an important part in agricultural and irrigation practices. Effective farmer decision-making requires motivation or incentives. The level of incentives needed for a given positive decision is the basis for changing farmer decision-making. For example, how much additional water needs to be delivered to farmers to interest them in participating in collective maintenance?

A farmer makes decisions about what to plant and when; when, how, and how much to irrigate; and how much and when to add agro-chemicals.

The success of these decisions in the aggregate helps to determine the level of system performance.

The diagnostic analysis team needs to identify key decisions farmers have made in managing productivity. For example, there are cases where high yielding varieties are available, but farmers in a particular system have largely planted traditional varieties. Why? Farmers may have chosen traditional varieties because of lack of information, lack of credit to make the purchase, non-availability of seed, home consumption needs, or an undependable water supply. Table B6 provides an example of an analysis of key management decisions by farmers.

Preliminary information suggests that an undependable water supply is a priority contributing factor to low productivity and low performance of the water control system. The farmer makes a number of decisions that relate to undependable water supply. The crop he grows, the variety he selects, the weeding practices he uses, the fertilizer he applies, whether or not he obtains extra-legal water from the distributary, when he irrigates, and whether or not he would consider using a pump may depend on the water supply.

While such a decision-making process may not relate to such a priority factor frequently, several diagnostic analysis studies have shown the pervasive effect of an undependable water supply. However, keep in mind that decisions could be related to other factors operating in the system. For example, farmers' choice of which variety to plant could relate to adequacy of information, availability of seeds at the proper time, availability of credit, and home consumption needs of the family, as well as dependability of water supply.

Careful analysis of factors which contribute to farmer decision-making about system management, and measuring the magnitude of the results of key decisions are important parts of the diagnosis process. Usually a majority of, if not all, disciplines are involved in defining the decisions and contributing factors. Measuring the effects that decision-making has on system performance is an important contribution to understanding and identifying key contributing factors. Diagnosis may provide a strategy for changing farmers' decisions and their involvement in management.

The organizational decision-making of farmers is another important area of farmer involvement. Investigation of organizational decision-making is restricted to priority contributing factors for low or high system performance. Table B9 provides an example analysis of farmers' organizational decisions regarding maintenance of a watercourse, involvement in operation and maintenance on a distributary, and involvement in improving the management decisions of a service organization (extension information or credit, for example).

The factors that contribute to the success of each decision accumulate as the complexity of the decision-making increases. Internal farmer organizational decisions (Table B9) are less difficult than multi-organizational decisions with irrigation or extension, for example. The diagnosis process can answer questions and determine the contribution of a

Table B8. Example of key decisions for farmers in managing the productivity process.

Subsystem or Objective	Decision	Contributing Factors	Magnitude
Productivity			
Crop	Grow fodder or rice	Is the water supply adequate and dependable?	Design/Actual Q
Variety	Grow improved or traditional variety	Expected return* Alternative: a. information b. availability c. credit d. home consumption	Return with or without variance
Cropping Practices			
Planting			
Weeding	Good/limited/none	Expected return*	Return with and without weed control
Pest control			
Fertilizer	None/some/adequate	Expected return*	Return with/without fertilizer
Water Control			
Distributary	Obtain extra-legal flow	Inadequate and undependable water supply*	Design/actual Q
On-farm delivery	Maintain watercourse	See crop above	Q with and without maintenance
Field	a. When?	a. When available	Applied/required Q
	b. How much?	b. Decided by tradition	Applied/required Q
	c. How?	c. Decided by tradition	Applied/required Q
Investment			
Pump	See crop above	If credit and return expected	Financial analysis
Land leveling			
Seeds			
Resource Conservation			
Salinity	Control for crop growth	Expected return and if excess water supply available	Return with and without salinity

*See also the information given with crop productivity above.

Table B9. Organizational decisions and their contributing factors for farmer involvement.

Decisions	Contributing Factors
(1) Maintenance of community watercourses	Is the water supply reliable and at least minimally adequate? Is there an organizational capability to make decisions and control "free riders"? Is there knowledge of the need, and knowledge and skills to accomplish the job? Are the benefits to all obvious to all?
(2) Involvement in maintenance of the main system distributary	Same as above. Does the responsible organization look to the farmers to help decide priorities and implement activities? Is there a mechanism for organizations to make decisions and carry them out? Does the quality of the result of the decisions provide benefits to involved organizations?
(3) Involvement in establishing the nature of the service, defining the needs, and assessing the results	Same as 1 and 2 above. Can the farmers assess their need for the service? Can the farmers monitor and evaluate the results? Can the service organization assist the farmers to carry out their role without controlling the role?

factor in a decision. Physical measurements can document the need for maintenance (for example) and evaluate the results of the maintenance accomplished.

Decisions about management of a system by an irrigation department may not involve farmers because the department does not recognize the need to involve farmers. Also, the organizational capability to adequately deal with a farmer organization may not exist. If a farmer organization does exist, case 2 in Table B9 provides a basis for analyzing the decision-making for farmer involvement with maintenance of the main system as an example.

Organizational coordination for management decision-making is the other major emphasis for irrigated agriculture. Because of the focus on priority problem areas, not all decisions are considered. Only key decisions that have had major impact on system performance are identified and analyzed to determine if the needed coordination existed. In instances where coordination is effective, the focus is on understanding key factors which contributed to the success of the coordination effort. In instances where coordination and decision-making was ineffective, the factors which contribute to this inadequacy are analyzed.

As an example of organizational coordination, Table B10 illustrates organizational management of the decision to schedule and release seasonal water supplies for rice irrigation. The irrigation department evaluates the water supply, selects a date to begin water releases for land preparation, and schedules a flow release for a duration to irrigate an area for growing rice. The length of the growing season for rice is an important factor in this decision. Thus, the irrigation department needs to coordinate with extension so that extension will provide timely information to the farmers about which rice variety to use and why it should be used. Furthermore, seed suppliers will need to provide an adequate supply of seed in time for planting. Since seed must be purchased, often at a premium price, timely credit must be available to farmers that need it. Research to develop and test the seed for appropriateness for the area will have to be completed before it is recommended for use.

Table B10. An example of multi-organizational decision-making with irrigated rice.

Decisions	Contributing Factors
Plan and management of seasonal water releases for rice irrigation	Is each organization capable of participating in a decision?
	Is there a mechanism available for the organizations to make decisions?
	Does each organization understand its role and responsibilities?
	What was the quality of the result?

Not a small part of this decision-making is the farmer and his organization. Purchases of seed are individual decisions, but the decision to provide water for a short-season variety of rice only would be a collective decision, since farmers who decide to plant long-season varieties will not have water to complete the seasonal irrigations. Also, the area that can be planted to short-season varieties may be larger than the area that can be planted to long-season varieties.

The process for making the above decisions can be examined, and the results of each decision made by each participating organization can be documented. The results of the collective decisions can be measured in terms of irrigated agricultural production. Actions taken that reduce the effectiveness of the result can also be evaluated. The results can be used to identify factors which contribute to reduced performance. With this understanding, plans can be developed to improve the coordination process by resolving the key contributing factors causing less effective performance.

A diagnostic study provided understanding for almost exactly the above scenario[3], although there were additional complications. Even so, the need for coordination and the limitations of the process that had been used became very clear to the organizations involved as a result of the diagnostic analysis. A new mechanism for coordinating activities has evolved since the diagnostic analysis, and perhaps the diagnostic analysis contributed to defining the organizational mechanisms needed to accomplish the improved decision-making.

In the diagnostic analysis case study mentioned above, irrigation department releases did not follow their prestated plan. Releases of water for land preparation came earlier than farmers desired and precious water was wasted. Farmers made a number of decisions that reduced potential and actual yields. Information was not provided to farmers about a number of important choices, and extension was not involved in the decision-making. Reduced rice yields for the season were the result.

RESOURCE CONSERVATION

The management of an irrigated agricultural system must ensure the sustainability of the system. Thus, resource conservation must be sufficient to sustain the system. Traditionally, resource conservation has been neglected. Oad, McCornick and Clyma[4] found that the only system objective not explicitly considered by a series of diagnostic studies was that of resource conservation. Only when the very existence of irrigated agriculture is threatened does controlling adverse effects seem to receive high priority.

Resource conservation is an objective rather than a subsystem. As an objective, it applies to all the subsystems of irrigated agriculture. Productivity must not be achieved at the expense of fertility, salinity control, or other conservation issues. Return on investment must assure

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[3] Alwis, J.; L. Nelson; H. Gamage; R.A. Nandasena; R.E. Griffin, K. Yoo; A. Ekanayake; M. Haider; L. Wickramasinghe; L. Dunn; M.A.W. Bandaranayake; J.M. Reddy; W.R. Laitos. 1983. System H of the Mahaweli Development Project, Sri Lanka: 1982 Diagnostic Analysis. WMS Report 16. Water Management Synthesis II Project, Colorado State University, Fort Collins.

[4] Oad, R.; P.G. McCornick; W. Clyma. 1988. Methodologies for interdisciplinary diagnosis of irrigation systems. WMS Report 93. Water Management Synthesis II Project, Colorado State University, Fort Collins.

farmers will be involved in an irrigation project and that the organizations can maintain an adequate level of services. Water control to prevent waterlogging, control salinity, and prevent erosion are all important. Organizational sustainability of farmers and government are also of concern. This section presents several examples of the application of the resource conservation objective to a number of subsystems.

Suggested variables and indicators for evaluating irrigation system performance in resource conservation are given in Table B11. The variables for measuring performance and the indicators of performance are the same for the farm and the field, and much the same for the irrigation system as a whole.

Poor water control, which results from excessive use of irrigation water on fields, is a major factor in creating waterlogging and salinity. Many of the contributing factors for inadequate water control contribute to inadequate resource conservation. When adequate water control is achieved, resource conservation usually will improve. Even so, explicit attention to the resource conservation objective is still highly necessary.

An important concept about irrigation system diagnosis should be illustrated here. A symptom of a problem is not the cause of a problem, but the symptom of a condition in one subsystem may be the cause of a condition in another subsystem. Eliminating the root cause is usually an effective first step in solving a problem.

For example, a high water table is a symptom of inadequate water control (a condition). Excess water is being supplied by the irrigation delivery system, and overirrigation (a cause) in fields may be the major contributing factor for the high water table. Controlling the high water table by improving drainage typically increases the amount of overirrigation: the symptom is being treated, not the cause. A more effective strategy may be to control overirrigation by improving the ability of the farmers to irrigate their fields. This high water table may also cause salts (the symptom) to accumulate in the top portion of the soil. Lowering the water table will help to control salinity. However, a more effective approach may be to control the water table by reducing the overirrigation (the root cause).

Some factors which contribute to inadequate resource conservation are shown in Table B12 with suggestions for measuring their magnitudes. The magnitude of the effect identified helps to determine the priority given to a factor. As an example, measuring the magnitude of contributing factors to waterlogging may require measuring the desired or design discharge or volume that is supplied to a field, farm, or area. This measurement can be compared with the volume of water contributed from subsurface groundwater flow or the overirrigation of fields. When considering whether or not preventing waterlogging is of higher priority than resolving unreliable water supplies, the magnitude of the effect of these conditions on yields may need to be compared. There may be a serious inequity that results from selected farms or fields becoming

Table B11. Measuring system performance for the resource conservation objective.

Subsystem	Variables Measured in Detailed Diagnosis	Indicators Observed in Rapid Diagnosis
Field	Water table level	Absence of or stunted plant growth; salt accumulations at soil surface; standing pools of water; abandoned wells
	Salinity level	Visible surface salts; limited or stunted plant growth
	Channel/field erosion	Observation of soil loss
	Sedimentation	Soil accumulations in channels and fields
	Soil degradation	Physical condition of soil; hard, blocky structure; sealed soil surface with standing water
	Nitrate leaching	Yellow plants where over-irrigation is prevalent
	Fertility depletion	Plant condition and declining crop yields each year
	Seawater intrusion	Salty groundwater; declining groundwater levels; soil and plant indications of salinity
	Degradation of facilities	Non-functioning facilities
Farm	Same as for field	Same as for field
System	Same as for field	Same as for field
	Watershed degradation	Erosion of watershed; sediment deposits
	Quality of return flow	Salinity or fertility in return flow
	Flooding	Evidence of flood damage, standing water, and erosion

waterlogged and going out of production. The long-term implications of waterlogging and resulting salinity may suggest that controlling waterlogging should have a higher priority. For this reason, establishing priorities requires careful consideration of the important factors which affect the achievement of project management objectives.

Table B12. Factors contributing to low performance in resource conservation and variables for measuring the magnitude of the contributing factor.

Problem	Contributing Factors to Problems	Magnitude
Waterlogging	Inadequate design of canals, control structures and outlets	Design/actual Q Actual/needed slope; Actual/needed elevation
	Excessive surface water contributing to groundwater	Water level rise from surface water
	Subsurface groundwater inflow	Gradient into/upward in area
	Overirrigation of fields	Needed/actual water applied; actual/desired water levels
	Same factors for main and farm water control systems (Tables B2 and B3)	
Salinity	Excessive salinity in soils	Actual/required soil salinity
	Excessive salinity in groundwater	Actual/required water salinity
	Overirrigation in fields	Needed/actual water applied; Actual/desired water levels
Erosion	Excessive channel or water surface slope	Actual slope/design slope
	Improper field design or inadequate field water control	Actual slope/design slope; Actual field Q/design field Q

Q = flow rate

SUMMARY

Application of the methodology for diagnostic analysis involves using the concepts and diagnosis framework in the diagnosis process. Disciplinary and interdisciplinary concepts are applied in the analysis of subsystems to understand performance and the factors that contribute to performance. The interactions between subsystems are numerous and multi-faceted, and careful interdisciplinary efforts are needed to understand each subsystem and the system as a whole. The suggested variables for measuring performance, indicators of performance, contributing factors, and means for measuring the magnitudes of contributing factors are intended to assist a new diagnostic analysis team to more effectively diagnose an irrigation system.

The evaluation of performance as related to farmer involvement and organizational coordination were suggested to give a simple example of a complex process. Creating an understanding of the need for involvement and more effective coordination to improve system performance is a priority objective of diagnostic analysis. Without this understanding, farmer involvement and organizational coordination will not be accomplished. Examples of inadequate decisions and coordination are numerous from field studies of irrigation projects.

The diagnostic analysis methodology is expected to continue to evolve. It is hoped that these improvements in concepts and approach will improve the performance of diagnostic analysis teams and the understanding gained from diagnostic analyses. The continued improvement of the process will build on these and other experiences and will continue to improve the management and performance of irrigated agriculture.

APPENDIX C

TRAINING STRATEGY FOR ORGANIZATIONAL CHANGE

Organizational change is often slow and difficult, but a strategy for change can build on the use of diagnostic analysis and implementation planning. The action training implied in the involvement of organizations in diagnostic analysis creates an understanding of the need for change. The diagnostic analysis methodology provides specific data about the actual performance of the irrigated agricultural system and the organizations responsible for managing the subsystems. This information establishes the need for change.

Implementation planning takes the needs identified from the diagnostic analysis results and defines the goals and activities for how the needs will be met in terms of system improvements and improved management. These activities are the basis for defining new roles and responsibilities for organizations and the responsibilities assigned to specific individuals. These new responsibilities are a specific answer to a need for organizational change.

The above approach to organizational change is embodied in an action training approach that involves the individuals and organizations in identifying needed improvements, planning how to implement the improvements, and then implementing the actions that will result in improvements. The approach builds on previous experiences in water management research, irrigation development, and water management training. The approach allows the involved organizations to plan and develop needed organizational changes and to assess the training needs that are necessary for organizational change. This process involves all levels in an organization. Such changes must have the support of the organization from the operating level to the policy level if they are to be implemented. Management and water management specialists can facilitate this process.

To accomplish organizational change, specific training is provided to develop the knowledge and skills identified to be a part of the new roles and responsibilities during implementation planning. Diagnostic analysis and implementation planning are coupled with a training process to provide the specific knowledge and skills identified during the training needs assessment. A structured process of training is shown in Figure C1.

The training assessment and planning builds on the implementation planning to assess the training needs for the management plan and to identify specific strategies to accomplish the training objectives. Phase II of the training cycle consists of planning and implementing training programs that accomplish the training goals. Phase III involves designing a plan for re-entry of the trainee and integrating the individual into the new role and responsibilities. Future diagnostic analyses or replanning efforts identify any new roles and responsibilities and further training needs.

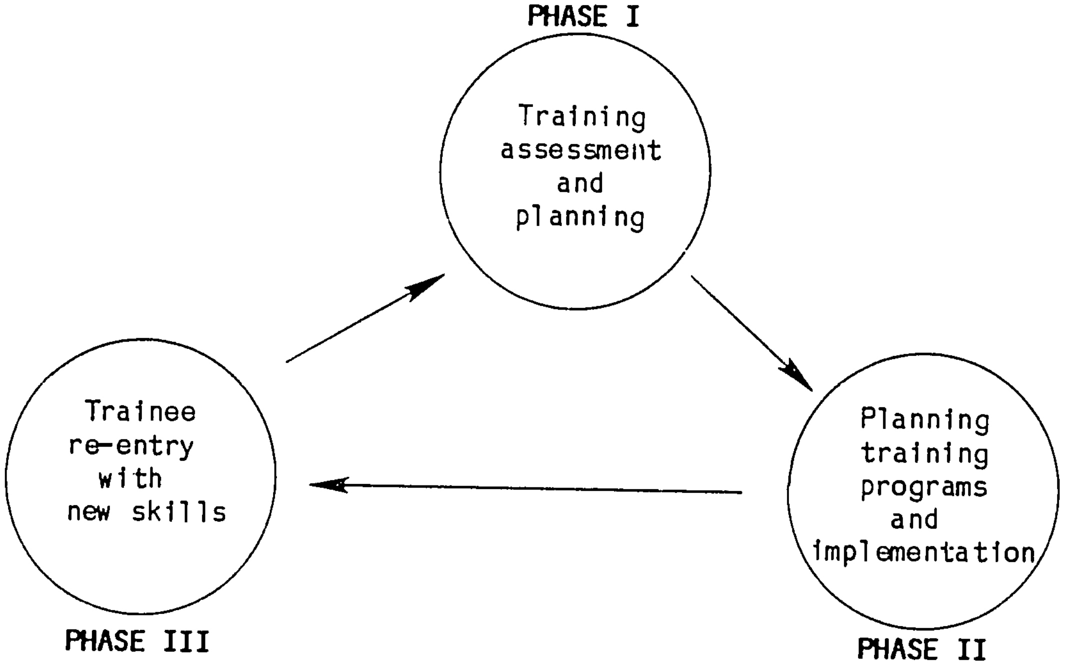

Figure C1. A training strategy for organizational change to complement diagnostic analysis and implementation planning.

Some of the key results expected from the process in Figure C1 include 1) identified policies to support professional development, 2) systematic procedure for monitoring and evaluating process steps and obtaining feedback to improve each step, 3) improved management relative to training, 4) improved job performance, and 5) improved performance of irrigated agriculture through professional development.

Specific outcomes to be achieved by such an approach are as follows:

1. Organizations will have reached a common understanding of the needs required to improve the performance of irrigated agriculture and will have identified attitudes, staff knowledge, and skills needed to achieve this objective.

2. Organizations will have identified the existing staff capabilities, and defined training needs required to close the gaps.

3. The results will enable organizations to develop training plans to meet the high priority needs identified and to initiate priority training activities.

4. On-the-job training plans will have been developed and implemented to enable trainees to begin using new skills.

5. Employee performance and satisfaction will have been evaluated and improved performance measured.

6. Monitoring and evaluation by the appropriate unit, with the assistance of consultants, will ensure that the above steps are accomplished, that feedback is provided for further improvements, and that data is collected and assembled in a current, active data base.

7. Needed policies to support the irrigated agricultural organizations will have been developed.

8. A strategic plan for achieving professional development in the involved organizations will have been completed, including implementation plans.

The strategy of integrating an on-going training program with the evolving management plans ties the capability for change to the planned change. The result should be improved performance for personnel and irrigated agriculture.