Methodologies for Interdisciplinary Diagnosis of Irrigation Systems

Water Management Synthesis Project

WMS Report 93

METHODOLOGIES FOR INTERDISCIPLINARY DIAGNOSIS OF IRRIGATION SYSTEMS

Review and Analysis of the Methodologies Used for Irrigation System Diagnosis Under the Water Management Synthesis II Project

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PREFACE

The research reported in this document was conducted through the Triad Synthesis Program of the Water Management Synthesis II Project. This program was an effort to synthesize the understanding of personnel from the managing universities into an integrated perspective about important water management concepts, principles, and strategies for application in improving irrigation water management around the world. One part of this program was to synthesize our understanding about diagnosis of irrigation systems from project experiences. This report is a result of that effort.

We acknowledge the assistance of the Joint Project Management Team (Dr. Wayne Clyma, Dr. Walt Coward, Dr. Worth Fitzgerald, Dr. Jean Kearns, Dr. Jack Keller, and Dr. Richard McConnen) in formulating Triad Synthesis. The inter-university committee that assisted in the effort consisted of Dr. Mike Walter, Cornell University; Dr. Jack Keller, Utah State University; and Dr. Wayne Clyma, Colorado State University. These individuals provided on-going review and advice in the synthesis of experiences in irrigation system diagnosis. A workshop was held at Colorado State University to complete the final review of this paper. Additional individuals invited to provide a final review were Dr. Brad Parlin, Utah State University; Dr. Willard Schmehl, Colorado State University; Dr. Max Lowdermilk, Colorado State University; and Dr. Keith Wilde, Department of Agriculture, Canada. Their critique and helpful suggestions are gratefully acknowledged.

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I. INTRODUCTION

A. PURPOSE OF THE PAPER AND RESEARCH OBJECTIVES

This paper reports our research into the methodologies used for irrigation system diagnostic studies. These studies were conducted under USAID's Water Management Synthesis II (WMS II) Project.

The two main objectives of the research were:

* Develop an understanding of the diagnostic methodologies used by the WMS II Project to evaluate irrigation systems.

* Examine how these methodologies can be more effectively utilized in the future, and determine the requirements of a methodology in a particular situation.

A secondary objective of this research was to briefly capture the lessons that have been learned about irrigation system performance in developing countries through the application of these methodologies.

B. SCOPE AND LIMITATIONS OF THE RESEARCH

The scope of this research extends to three types of irrigation system studies made by the WMS II Project: diagnostic analysis workshops, irrigation sector reviews, and project design papers. The analysis of these three study types was combined because, to varying degrees, all are diagnostic in nature. All three study types seek to understand the existing state of an irrigation system, identify the system's strengths and constraints, and, if necessary, recommend improvements.

A major limitation on our research was that the WMS II reports on these activities did not record the methodologies used, except in the case of the diagnostic analysis studies. Such information would have lengthened the reports and might have been of little interest to the clients. Our identification of the methodologies used was limited to analyzing the content of the study reports and interviewing team members. As a result, information is limited on team building, activity sequence, selection of the methodology, and decision-making.

Some terms used in this paper require clarification either because they are not widely used outside the WMS II Project or because these terms have different meanings depending on the context of their use. We use the term "methodology" in its most comprehensive context. That is, a methodology is the system of principles and a process applied to a science or discipline. The principles include the analytical framework and logic inherent in the formation of knowledge. The process is the series of steps, or activities, followed in applying the analytical framework and logic to knowledge development.

The term "irrigation system" refers to different analytical units depending on the context of the analysis. An irrigation system may be an individual irrigation scheme, a sector such as the small-scale irrigation sector in Kenya, or a region. In the diagnostic analysis workshops, "system" usually meant one irrigation scheme. For our purpose, we consider that an irrigation scheme comprises a water source; delivery, application, use, and removal subsystems; and the cropping, socio-economic, and organizational subsystems. The irrigation system is the irrigated agricultural system. In sector review studies and project design papers, the irrigation schemes that were visited may have been referred to as "systems." Also, the sector or region itself may have been referred to as a system.

In WMS II Project, the term "diagnostic analysis" is used to refer to a methodology that has been extensively used to evaluate irrigation schemes and train professionals to study irrigation schemes in a workshop setting (Lowdermilk et al., 1983; Podmore and Eynon, 1983). These training workshops were called diagnostic analysis workshops. There may be a tendency to confuse the term "diagnostic analysis," referring to a particular methodology, with the general term "irrigation system diagnosis," which means any study or evaluation of irrigation system performance. System diagnosis, as used in this paper, refers to all irrigation system studies that use a diagnostic approach.

The information presented in this paper is organized into five chapters. Chapter II is a literature survey of the existing methodologies used in the WMS II Project for evaluating irrigation system performance. In Chapter III, we present the approach that was followed to synthesize information about selected WMS II irrigation system diagnostic studies. This includes a reference methodology that was used to review these case studies. In Chapter IV, we analyze the information collected as a result of the review of selected WMS II diagnostic studies. The purpose of this analysis is to develop guidelines that can be utilized in future studies of irrigation system performance. These guidelines, or recommendations, are outlined in Chapter V. The details of the case study reviews are given in Appendices A - F.

II. BACKGROUND OF IRRIGATION SYSTEM DIAGNOSIS

This chapter describes the types of diagnostic studies conducted under the WMS II Project. Most of these studies used the diagnostic analysis and rapid appraisal methodologies. Both methodologies are well documented, though a brief description is provided in this chapter.

A. TYPES OF DIAGNOSTIC STUDIES CONDUCTED BY WMS II PROJECT

The diagnostic studies conducted under the WMS II Project can be classified into three categories: diagnostic analysis workshops, sector reviews, and project design papers. The diagnostic analysis workshops identified the major constraints to optimum system performance and, in most cases, gave recommendations on how to alleviate the constraints. The purpose of diagnostic analysis workshops was to study and evaluate irrigation schemes while training professionals in irrigation system diagnosis.

Sector review studies sought to establish the existing state of a particular sector of irrigation in a country, and gave recommendations for further developing the irrigation sector. Project design papers were concerned with formulating projects to improve performance of one or more schemes, or of an irrigated agricultural sector.

The scope of the three study types and, to some extent, the methodologies used to fulfill the study objectives, are different. However, the three study types are similar in that they are diagnostic in nature. They seek to understand the existing state of irrigation and the potential that can be achieved, and to analyze strategies for achieving the potential state.

All WMS II diagnostic studies were conducted by teams of professionals representing disciplines such as rural sociology, irrigation engineering, economics, and agronomy. For diagnostic analysis workshops, the team generally followed the methodology of diagnostic analysis (Lowdermilk et al., 1983; Podmore and Eynon, 1983). The sector reviews and project design papers typically did not follow a standard methodology for the whole diagnosis. However, some teams (Laitos et al., 1986; Adams, 1983) used the methodology of rapid appraisal as part of the diagnosis. The rapid appraisal and diagnostic analysis methodologies are discussed in the following section.

B. DIAGNOSTIC METHODOLOGIES USED IN WMS II STUDIES

The two existing methodologies that have been extensively documented and used are rapid appraisal (Chambers, 1983) and diagnostic analysis (Lowdermilk et al., 1983). This section of the paper briefly describes each of these methodologies.

1. Diagnostic Analysis

Diagnostic analysis is an interdisciplinary methodology for defining the existing state of an irrigation system and identifying its strengths and weaknesses (Lowdermilk et al., 1983; Podmore and Eynon, 1983). The methodology is defined by Lowdermilk et al. (1983) as "an interdisciplinary method of examining both the values, that is [the] benefits and constraints, and [the] restrictions of a system." However, many diagnostic analysis workshops also have included recommendations for relieving constraints. The irrigation system may include one or more irrigation schemes.

Diagnostic analysis is one phase of a research-development process (Clyma, Lowdermilk and Corey, 1977) as illustrated in Figure 1. The diagnostic analysis phase consists of an interdisciplinary study involving the farmers and the interdisciplinary team to achieve an understanding of how the irrigation system is operating. The end product of a diagnostic analysis is an objective assessment of the most important problems. The second phase, development and assessment of solutions, utilizes applied research methods to identify and test useful solutions for farmers. Phase III, implementation, is undertaken to provide solutions for farmers and to improve the performance of irrigated agriculture.

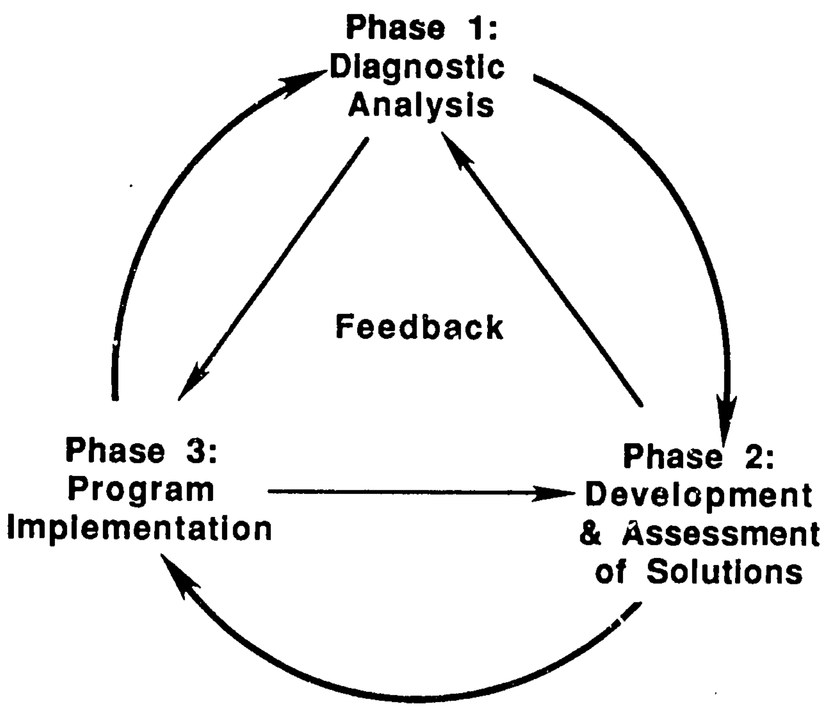

Figure 1. Research-development process (adapted from Lowdermilk et al., 1983).

To conduct a diagnostic analysis study in the field, researchers go through a process or set of activities. The general sequence of activities followed by many of the diagnostic analysis studies is given in Figure 2.

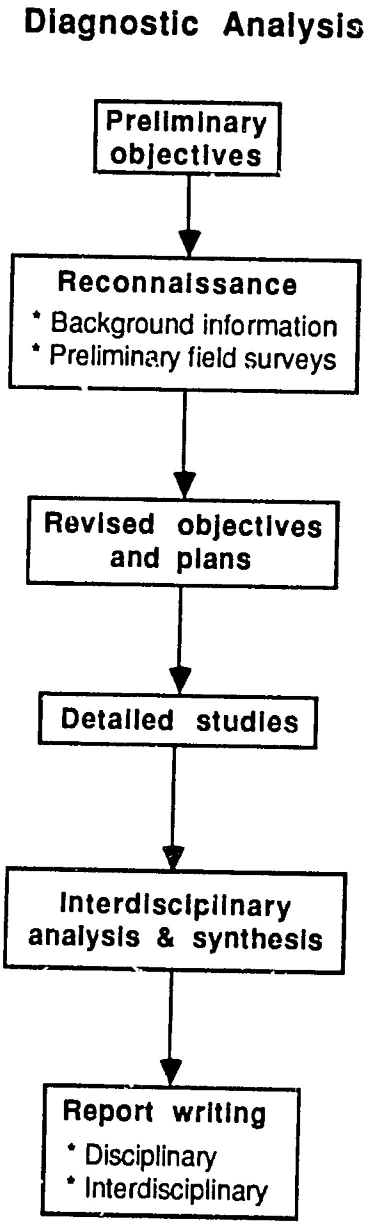

Figure 2. General sequence of steps followed by diagnostic analysis studies (Lowdermilk et al., 1983).

The diagnostic analysis methodology has its roots in the irrigation water management research conducted in Pakistan with the assistance of Colorado State University in the 1970s (Clyma, Lowdermilk and Corey, 1977). The methodology evolved from experiences in collecting and analyzing field data to understand existing system performance. Initially, these experiences were confined to farm-level analysis, but later, analysis of the water delivery system was included.

2. Rapid Appraisal

The rapid appraisal methodology, according to Chambers (1983), seeks to answer the question: How best to organize an irrigation system diagnosis to identify the optimal mix and sequences of actions which will improve system performance? Potten (1985) states that the aim of rural rapid appraisal is "to provide and analyze information on rural conditions as quickly as possible, and to be cost effective, avoid biases, and ensure the availability of results in a usable format."

To meet the cost-effective objective, rapid appraisal relies on qualitative principles (Potten, 1985). Therefore, the team should aim at levels of "optimal ignorance" and "appropriate imprecision."

Chambers (1983) suggests that the rapid appraisal team should include some combination of the disciplines of irrigation engineering, hydrology, agricultural engineering, agronomy, agricultural economics, sociology, and management science. Team members may have expertise in one or more of these disciplines.

De los Reyes (1980) designed a checklist for rapid appraisal of communal irrigation systems in the Philippines. The recommended information to be collected was as follows: identification of water supply and water rights, history of assistance received, land ownership, organizational aspects, opinions on assistance needed, water distribution, conflict management, irrigation fees, and maintenance procedures.

Yoder and Martin (1983) presented a checklist for information to be collected for a study of community-managed irrigation systems in Nepal. The list is divided into four sections:

1. General information: location, physical, population, ethnic groups, land holdings, tenancy, agricultural production, employment and migration, markets and prices, institutions, and development projects.

2. Organization: membership, social composition, official positions or roles, meetings, water allocation principles, water distribution, maintenance, conflict, conflict resolution, and organizational development.

3. Historical development of existing irrigation systems.

4. Technical information: water source, intake, distribution systems, soil types, provision for non-crop-related water

uses, physical constraints to increasing the irrigated area, and identification of local priorities and resources.

The above team composition and checklists reflect the most important disciplines and information to be gathered during a rapid appraisal. The checklists are procedures for ensuring completeness of data based on the experience of the authors, but these recommendations are not complete methodologies.

Laitos et al. (1986) outlined a rapid appraisal "methodology" (based on the reconnaissance step of diagnostic analysis) used to diagnose irrigation schemes in Nepal. The rapid appraisal was divided into:

* Entr gather information from written material, reports and studies; identify key informants.

* Initial walk-through: entire team walks through scheme exchanging observations and insights.

* Individual studies: direct observations, field measurements, and informal interviews (mostly qualitative in nature).

* Compare findings: compare and correlate data, and draw tentative conclusions (formal and informal meetings).

* Strengths and weaknesses: each team member reported impressions of the scheme's strengths and weaknesses.

3. Comparison of Diagnostic Analysis and Rapid Appraisal

Conceptually, the methodologies appear to be similar in that they both attempt to standardize irrigation system evaluation. Both recognize that irrigation system evaluation must draw upon many kinds of disciplinary expertise and local experience. Also, team members using either methodology interview key informants drawn from among farmers and the irrigation agency, in addition to their observations in the field.

The diagnostic analysis methodology has a well-developed conceptual base and a sequence of field activities to conduct the study (Lowdermilk et al., 1983; Podmore and Eynon, 1983). The rapid appraisal methodology emphasizes the procedures for collecting appropriate data with limited resources in order to analyze irrigation system performance. A form of rapid appraisal -- reconnaissance survey -- is used as a part of the diagnostic analysis methodology.

The differences between the two approaches to diagnosing irrigation systems appear to be in their emphases, not in their overall purpose. Both approaches are applied in the study of individual irrigation systems. Rapid appraisal has been more frequently applied to studies of irrigation sectors or a series of projects. Diagnostic analysis has been more frequently applied to studies lasting from one week to one season in length in individual irrigation schemes. Both attempt to look interdisciplinarily at the irrigation scheme. The diagnostic analysis defines the irrigation system as irrigated agriculture, and rapid appraisal frequently has looked largely at the water delivery system and the associated irrigation department and farmer organizations. The concepts, approaches, and procedures for diagnostic analysis have been more specifically defined than those for rapid appraisal.

III. RESEARCH APPROACH

In this chapter, we review the approach that was used to achieve the research objectives, including the selection of sample WMS II case studies, and the formulation and application of a reference methodology to these case studies. This reference methodology can be used to synthesize knowledge about other diagnostic methodologies or can itself be used for the diagnosis of irrigation systems.

A. SELECTION OF CASE STUDIES

In this research, we examined the methodologies used in various WMS II irrigation system diagnostic studies. The criteria used for selecting the case studies were the following:

1. The case study had to have been conducted under the WMS II Project.
2. The case studies had to represent a wide geographical distribution.
3. There had to be an equal proportion of diagnostic analysis workshop reports, project design papers, and sector reviews.

The WMS II studies selected and examined in this research are given in Table 1.

B. RESEARCH PREMISE AND METHODOLOGY

To synthesize information regarding the methodologies used in the case studies, we developed a **reference methodology**. As noted by Lenton (1986), there is a need for developing a methodology to formulate methodologies for irrigation system diagnosis. The central premise of the reference methodology is that a successful irrigation system diagnosis should be based on sound understanding of what good irrigation system management is expected to achieve. Then, the diagnosis must define the existing state of system performance. From the knowledge of existing and desired levels of performance, factors contributing to low performance can be identified, and strategies can be developed for system improvement.

The reference methodology is based on a methodology for diagnostic analysis defined more completely by Clyma and Lowdermilk (1988). The reference methodology consists of a diagnosis process, supporting concepts, and an analytical framework. The reference methodology (Figure 3) shows that diagnosis is accomplished through management and system management concepts, disciplinary process concepts, and the analytical framework.

Management in its simplest concept is the organization of people and resources to accomplish the objectives of a particular enterprise (Clyma, Lattimore and Reddy, 1982). The system management concepts acknowledge that irrigated agriculture is a system encompassing the water supply, the area under crop production, and the supporting facilities

Table 1. Summary of Water Management Synthesis II reports selected for examination.

Appendix*	WMS Report Number	Title of Report
A	40	Current Public and Private Sector Activities for Small-Scale Irrigation Development (Kenya) (Coward et al., 1986)
B	43	Rapid Appraisal of Nepal Irrigation Systems (Laitos et al., 1986)
C	25	Interdisciplinary Diagnostic Analysis of a Work Plan for the Dahod Tank Irrigation Project, Madhya Pradesh, India (Venkataraman et al., 1984)
D	33	Irrigation Systems Management Project Design Report: Sri Lanka (Skogerboe et al., 1984)
E	20	System H of the Mahaweli Development Project, Sri Lanka: 1983 Diagnostic Analysis (Jayewardene and Kilkelly, 1983)
F	32	Small-Scale Development: Indonesia/USAID (Walker and Coward, 1984)

* The reviews are included as appendices to this report; only the main points from each are included in the body of the report.

and organizations. This system is managed to produce food and fiber to improve the well-being of farmers. Understanding of the total system must integrate varying academic expertise and local experiences.

The analytical framework of the reference methodology is shown in Figure 4 and includes the structure and logic for acomplishing diagnosis. The analytical framework is based on the premise that system management, in the context of irrigated agriculture, must focus on achieving the purpose of irrigated agriculture. The purpose and defined outcomes of irrigated agriculture must be agreed upon and worked toward if management is to be improved.

The diagnosis process is presented in Figure 5 and includes the essential sequence for accomplishing a diagnosis. The logic followed in conducting a diagnostic study directly builds on the concepts and analytical framework. The concepts to be used in the diagnostic methodology should be carefully reviewed and agreed upon by the team. Then, the team must formulate an overall plan for the diagnostic study and establish roles and responsibilities. The reconnaissance study helps formulate initial hypotheses concerning irrigation system performance. The information obtained from the reconnaissance study is used to plan the detailed study of the irrigation system. Planning for the detailed study involves making decisions regarding data to be collected, how the data will be collected, who will collect the data, and coordination requirements in data collection. The results of the detailed study will confirm or reject the hypothesized problems and their contributing factors.

As the detailed study approaches an end, the overall analysis and synthesis of data is initiated. This involves individual discipline analysis of data, joint analysis of some data, and interactions between all disciplines to integrate the understanding.

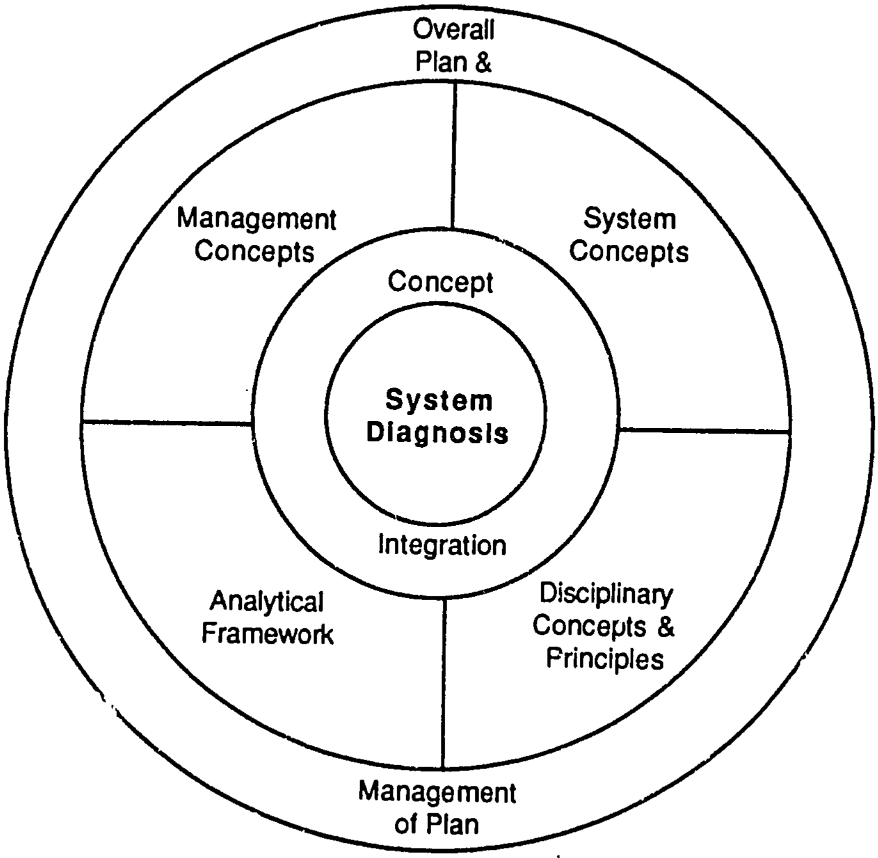

Figure 3. Conceptualization of the reference methodology (Clyma and Lowdermilk, 1988).

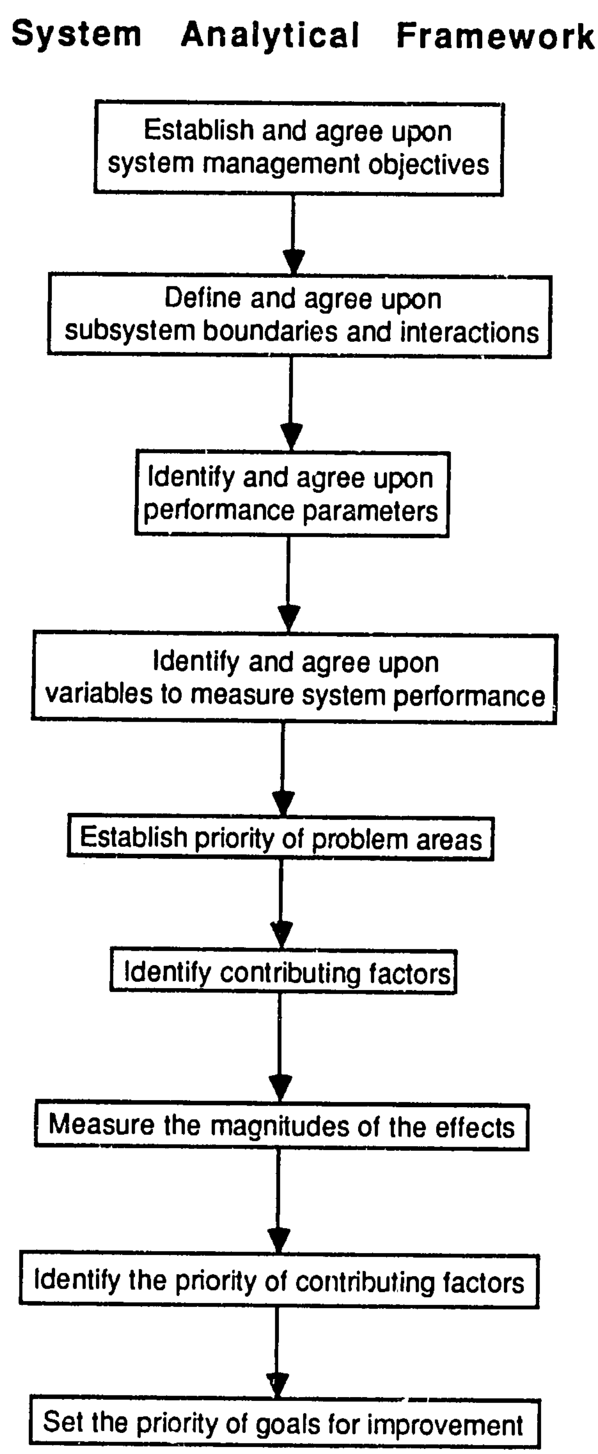

Figure 4. Outline of the analytical framework (modified from Clyma and Lowdermilk, 1988).

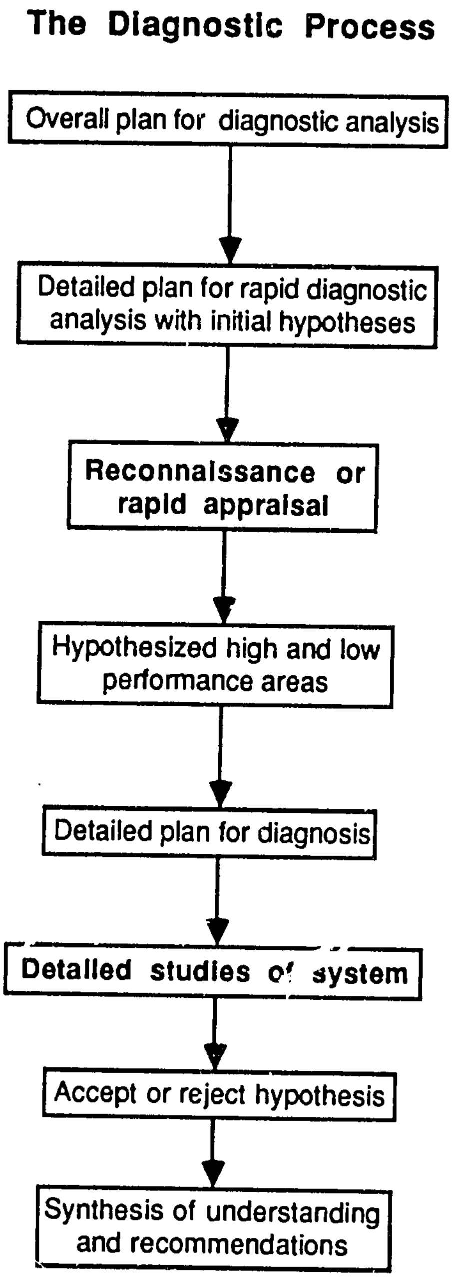

Figure 5. Diagnosis process for diagnostic analysis of irrigation systems (Clyma and Lowdermilk, 1988).

1. Analytical Framework

The analytical framework of the reference methodology, as outlined in Figure 4, is based on the logic that a system diagnosis must begin with understanding the overall goals and objectives toward which the system is managed. After understanding system objectives, the diagnostic methodology should establish whether or not the objectives are achieved by comparing the **actual performance** with the **desired performance** of the system. If the objectives are not achieved, the **contributing factors** causing the low performance need to be identified. **Recommendations** could then be made for irrigation system improvement.

After the overall goal and system objectives are identified, the diagnostic methodology should evaluate system performance by identifying the performance indicators and measuring the relevant variables (Figure 4). When actual system performance is compared to the desired system performance, the methodology can then be used to identify the contributing factors that should be addressed to improve performance.

The central concept of the analytical framework is illustrated in Figure 6. This concept is that irrigation systems are managed with certain objectives in mind to achieve the overall goal of farmer welfare. The primary goal of irrigated agriculture should be to increase farmer welfare, though irrigation sectors are frequently expected to fulfill other goals. The key management objectives are water control, productivity of agriculture, resource conservation, and return on investment. These objectives are achieved with effective organizational coordination and farmer participation.

We analyzed the diagnostic methodologies used in the case studies using the above framework. In the process, we learned about the various elements of the analytical framework. The results of this analysis are presented in Chapter IV.

2. Process for Conducting a System Diagnosis

To evaluate the performance of irrigations systems using the analytical framework, the team needs to undertake a series of activities. These activities constitute a process for applying the analytical framework. While exact content of these activities might vary depending on the nature of the system diagnosis, the process includes a number of activities which are common to many diagnostic studies. The activities forming the diagnostic process may be as follows:

* Hold team meetings to define study objectives, plan and formulate diagnostic methodology and assign roles for various team members. Inclusion of host country and donor agency officials is highly desirable in this phase of the diagnostic study.

* Plan for reconnaissance study or rapid diagnostic analysis.

* Conduct reconnaissance study of the irrigation system, including literature survey and meetings with key officials and system

users. Analyze data for initial findings, and formulate hypotheses concerning irrigation system performance.

* Hold team meeting to analyze initial findings and plan for the detailed field study. Discuss the analytical framework of the methodology and process for collecting the data.

* Conduct detailed field study using the analytical framework to guide data collection and documentation.

* Analyze data to synthesize information about the irrigation system performance and strategies to improve system performance. Prepare report on the diagnostic study.

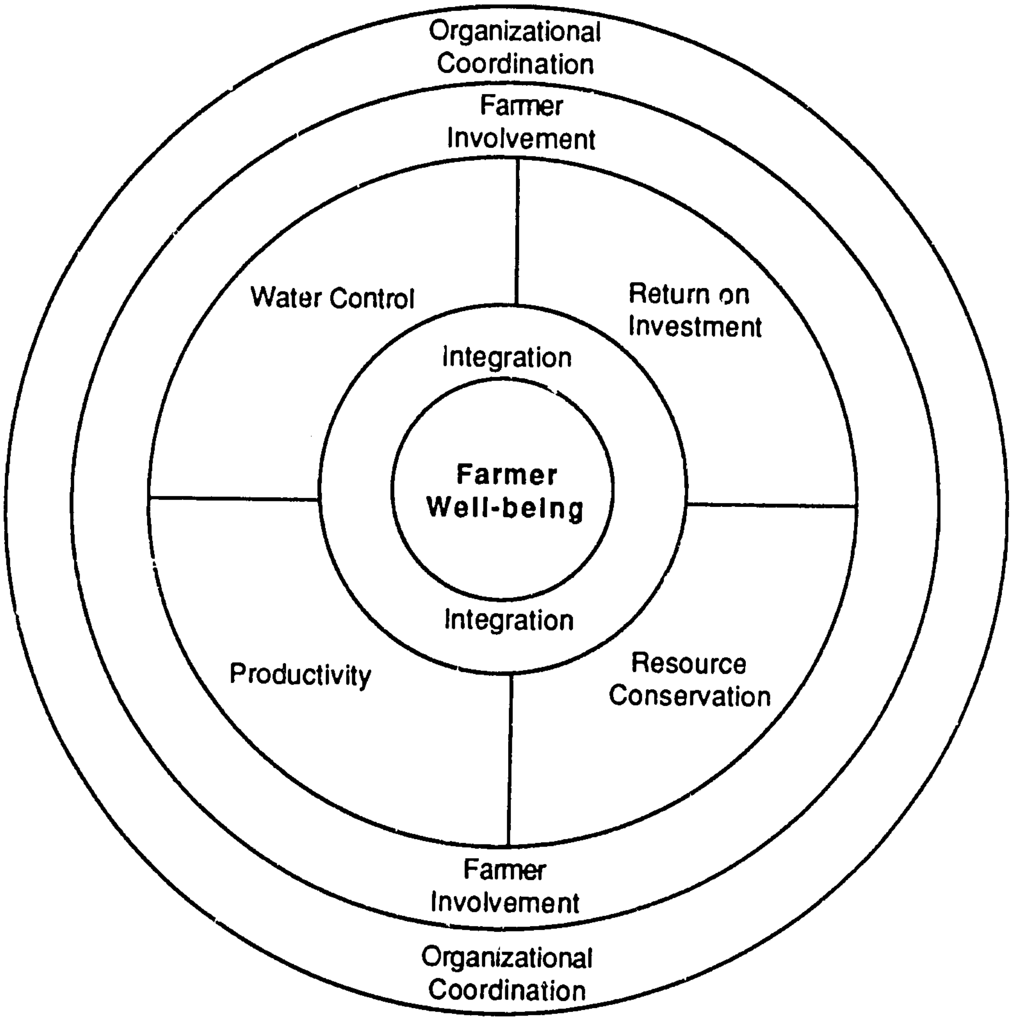

Figure 6. Central concept of the analytical framework (Clyma and Lowdermilk, 1988).

IV. ANALYSIS AND DISCUSSION

In this chapter, the results of our review of the case studies are presented. In the review process, we followed the analytical framework of the reference methodology to synthesize information about the diagnostic methodologies used by the WMS II teams. Also, this information is used to analyze and clarify components of the reference methodology so there are useful guidelines for future diagnostic studies. The format of this chapter follows the logical progression of the analytical framework, which is identification of goals and management objectives, evaluation of system performance, and formulation of improvement strategies. This discussion is followed by an analysis of the process for conducting a system diagnosis.

A. GOALS AND MANAGEMENT OBJECTIVES

Most of the case studies assumed that the primary goal of irrigated agriculture is to increase farmer welfare through increased agricultural productivity. This premise is correct, particularly at the irrigation scheme level. To sustain farmers' support and participation, individual irrigation schemes must increase farmer welfare. However, at regional or national policy levels, there may be other goals for developing irrigated agriculture.

The case studies present examples of the diversity in goals toward which irrigation systems may be developed. For the Kenyan sector review (Coward et al., 1986), the team considered rural development as a goal for developing irrigation schemes. In the Indonesian project design study (Walker and Coward, 1984), population transmigration from Java to the outer islands was considered a goal of the irrigation development project. Another goal for developing irrigation systems frequently mentioned by policy makers is to earn foreign exchange by growing cash crops that have an export value (for example: cotton and tobacco).

While these goals are legitimate for managers at the national or sectoral levels, managers must insure that the goal of farmer welfare is not compromised in the pursuit of these goals. For example, to broaden the participation of the rural population in irrigation schemes, it may be desirable to limit landholding size. An irrigation scheme diagnosis may conclude that farmers cannot make an adequate return on their investment while paying recurrent costs to the system because landholdings are too small (Zimbabwe Joint Workshop Team, 1988). In that case, policy makers would need to revise development plans so that the goals of increased farmer welfare and rural development become congruent.

In achieving the goal of improving farmer welfare, several factors must be considered; namely, the sustainability of the system, improvement of the public good, and prevention of negative externalities. As such, we can describe good irrigation system performance as achieving the overall goal of increased productivity through certain management objectives. An example of key management objectives as presented by Clyma, Lattimore and Reddy (1982) is the following:

* resource conservation to ensure a productive future.
* positive return on investment in irrigated agriculture.
* water control to insure dependability, equity, and adequacy of irrigation water supply.
* increased productivity of agriculture.
* appropriate farmer involvement in system management.

Specific objectives or subsets of the above may be identified in a particular study of an irrigation scheme, sector, or irrigation development project. Based on our review of the case studies, the above objectives define what must be achieved by system management to increase farmer welfare through increased agricultural production. If some of these key management objectives are not achieved at the irrigation scheme level, then the goal of increased farmer welfare may not be obtained.

We can present some evidence from the case studies to analyze the observation made above. In Kenya, the sector review studies (Coward et al., 1986) indicate that agricultural production may be increased through large-scale irrigation schemes controlled by government agencies. However, the participation of farmers regarding choice of crop, input use, crop management practices, and crop marketing is nonexistent. The study questions whether or not such development strategies can be sustained over the long run. Since the management objective of farmer participation is not achieved, the overall goal of farmer welfare may not be obtained.

Another example is provided by the diagnostic analysis workshop conducted in Bangladesh to study tubewell irrigation systems (Karim et al., 1983). The study clearly showed that the management objectives of water control and farmer participation were not achieved. The benefits of irrigation were captured by a few rural elites which decreased the welfare of other farmers. A primary reason for the inequity was that national policies, in some cases, do not prevent a dominant landowner from assuming sole control of a tubewell.

The two examples above are biased towards farmer participation in irrigation scheme management. This was done intentionally to defend, if necessary, the position of including farmer participation as an objective. Many of our colleagues have suggested that farmer participation is a means for achieving specified management objectives. With this suggestion in mind, we no longer include farmer participation and organizational coordination as management objectives (Figure 5). Rather, these can be conceptualized as important means for achieving the management objectives.

Similar examples can be given to illustrate the importance of achieving other key management objectives or subsets of the objectives. Resource conservation is particularly important for two reasons. First, in the rush of increasing production, important resources such as land and water are often degraded. Second, resource conservation is the category of objectives which was not explicitly addressed in any of the six case studies.

From the evidence presented above we conclude that an appropriate strategy for conducting an irrigation system diagnosis is to clearly identify the goals and objectives toward which the irrigation system is managed. In developing countries, differences may exist regarding the goals and objectives for developing the irrigation systems between policy makers at the national level and farmers at the scheme level. A successful irrigation system diagnosis should analyze the causes of such differences and suggest strategies for making the national goals congruent with the scheme-level goal of increased farmer welfare.

Though irrigation systems are developed to fulfill multiple goals, increasing farmer welfare should be the primary goal at the scheme level. This is necessary for sustained farmer participation in the management of irrigation schemes. Because improving system performance will depend on increased farmer welfare, the success of achieving other goals, such as rural development and earning foreign exchange, will depend on achieving the goal of increasing farmer welfare. Therefore, in system diagnosis, the focus is on factors that constrain improved farmer welfare.

B. ANALYSIS OF SYSTEM PERFORMANCE

After identifying goals and management objectives, a diagnosis team should analyze system performance to see whether or not the objectives are being achieved. This is done by comparing actual system performance with potential or desired performance.

The management objectives mentioned above may specify the desired level of system performance. For example, the management objective of increasing agricultural productivity may establish yield levels that can be attained. The desired level of system performance can also be determined by considering the performance of irrigation schemes in favorable conditions, such as on research farms.

For each management objective, **performance parameters** exist that describe how well a system is meeting an objective. For example, equity, adequacy, and reliability of water delivery can indicate how well the objective of water control is being met. Rapid appraisals may not provide time and resources for measuring the system performance in attaining an objective. Thus, **performance indicators** may provide a basis for understanding the level of system performance. Performance indicators qualitatively measure yield levels or other performance levels.

For each performance parameter, **variables** can be identified and measured to assess the level of performance. For instance, the adequacy of water delivery to a particular farmer can be assessed by measuring the flow onto the farm during an irrigation delivery. The desired performance could be indicated by the farmer's perception of his water needs or by an assessment of crop water needs.

The difference between actual and desired system performance begins to establish the priority problem areas where performance is low. Once a priority problem area is established, then the factors that cause or contribute to the low performance are identified. The magnitude of the effect of each contributing factor can usually be identified. The resolution of the priority contributing factors solves a priority problem. Recommendations are formulated by establishing goals which result in the resolution of one or more related contributing factors.

The suggested subsystems and performance parameters for each management objective represent suggested approaches for each objective. The team should identify and agree upon the particular management objectives, subsystems, performance parameters or indicators, and variables to be measured for their particular diagnostic analysis study. These suggestions should be added to and accepted by the team based on their own experience and understanding of a particular irrigation scheme.

One example of a combination of the elements in the analytical framework is presented in Table 2. For convenience, the contributing factors and recommendations are not listed. Examples of these components are discussed in the reviews of the WMS II diagnoses (Appendices A-F) at the end of this paper.

Note that the performance variables are not included in Table 2. It is difficult to be general about system performance variables because by definition they are locality-specific. The performance variables to be measured depend on the system objectives and performance indicators, and they must be identified and measured in that context. However, given the extensive experiences of WMS II Project, it is possible to extract some lessons or guidelines that apply to performance indicators and variables in several developing countries.

1. Analysis of Actual Performance

The first set of guidelines for analyzing actual performance concern the **identification** of performance indicators and variables for evaluating irrigation system performance. Identifying correct performance variables is a complex process that must have input from various disciplines concerned with irrigated agriculture.

This is particularly correct when these variables are measured through interviews with key informants. For example, during the diagnostic analysis workshop for the deep tubewell irrigation systems in Bangladesh, it was consistently mentioned that the tubewell discharge was about 2 cfs (Karim et al., 1983). What was being referred to was the design discharge, not the actual discharge. The actual discharge measured in five tubewell irrigation systems was about half the design discharge.

Not only does this cross-checking of indicators identify errors in the data, it is also used to reinforce conclusions. For example, in the Nepal rapid appraisals (Laitos et al., 1986), the team identified equity of water supply as one of their performance indicators. The team was able to make some flow measurements to establish the level of equity of water supply during one irrigation. Then, crop yield data from the farmers' and system records was used to verify the inequities of water supply. This is an example of how variables from two different disciplines can be used to establish the performance indicator if the team members maintain good interdisciplinary communication.

Table 2. Examples of the analytical framework elements used by the reference methodology.

Management Objectives	Subsystem	Suggested Performance Parameters
Water control	National Main scheme Unit command Farm Field	Equity Reliability Adequacy
Productivity of agriculture	Field Farm Scheme National	Yield Crop intensity Cropped area Variability of yield
Resource conservation	Field Farm Scheme National	Erosion Sedimentation Fertility Waterlogging Salinity Structural degradation Seawater intrusion
Return on investment	National Scheme Cooperative Farm	Costs and benefits Social returns
Effective organization and coordination	Irrigation dept. Design Construction Agricultural dept. Extension OFWM Seeds Fertilizer Mechanization Planning & development Private sector Seeds Fertilizer Other services Farmer organizations Other organizations	Technical ability of personnel Communication between organizations Accountability Incentive/sanction structure Tenancy patterns Conflict management

In assessing the water control within an irrigation system it is important to establish the amount of water supplied, the spacial variation of supply, and the timing of the supply, especially its reliability. The amount of water and the necessary timing depends on the demand patterns within the irrigation system. The diagnostic team must understand the pattern of demand within the system. This requires knowledge concerning cropping patterns, soil properties, and farmers' water management practices within the irrigation system. To recognize the need for this information and to collect it requires cooperation within the team.

The uncertainty present in identifying the performance variables may be one reason why evaluation studies collect large amounts of "data." At the beginning of a diagnosis, the team members are not sure what performance variables need to be considered in a particular sector or irrigation scheme. A logical response is to collect as much data as possible. As the team members gain more experience and knowledge about the system, they sort available data to identify the variables that, when measured, can state the system performance. Team members may discard some of these data during their analysis phase as it becomes clear which data explain system performance and which do not.

The second set of guidelines relate to **measuring** irrigation system performance variables. In diagnostic analysis studies, the team members have the opportunity and time to collect data on individual irrigation schemes. Many of the system performance variables are actually measured in the field. This is particularly true for variables such as crop yields, water supplies, and water demand.

Comparatively, the team members on a sector study or project design have limited time for measuring performance variables in individual irrigation schemes. As a result, we saw more emphasis on collecting secondary data to evaluate system performance. Also, most of the performance variables were measured using interviews with key informants rather than direct measurement of the variables in the field.

From the reviews of the case studies, we conclude that identifying and measuring performance variables requires sound interdisciplinary experience and expertise. The team needs to identify performance variables, separate them from other data, and measure the variables in a time-effective way. This is a valid reason for requiring that some of the team members have previous experience in the social and economic aspects of irrigated agriculture in the country.

2. Analysis of Desired Performance

To evaluate whether or not an irrigation scheme or the irrigation sector is achieving its objectives, it is necessary to establish a desired level of performance. Many times the desired level of performance is defined in the system objectives. For example, system management may specify target yield levels and the command area that is to be irrigated as agricultural productivity objectives. The small-scale irrigation projects designed in Sri Lanka, Indonesia, and Nepal specified target command areas to be irrigated by the project schemes (Skogerboe et al., 1984; Walker and Coward, 1984; Laitos et al., 1986). The Indonesia project considered cropping patterns as well as irrigated area (Walker and Coward, 1984).

If the desired level of performance is not specified in the objectives, then it must be determined by the team. The desired level of performance can be established by comparing units within an irrigation scheme (tertiary units in Indonesia and watercourse commands in India and Pakistan), irrigation systems within a sector, or irrigation systems in different sectors (large-scale and small-scale irrigation sectors). The level of performance obtained under controlled conditions, such as at research farms, is also used as a measure of desired performance.

In sector review and project design studies, the teams do not have enough time to compare units within each irrigation scheme visited. As a result, the methodology for evaluating desired performance seems to be to compare different irrigation schemes to each other. Therefore, the sampling procedure for selecting irrigation schemes to compare is critical. According to the case studies and interviews with team members, there was considerable input to the selection process from local professionals in government agencies and in the USAID mission. Some of the criteria commonly used were whether the irrigation schemes were "well managed" or "not so well managed", had adequate water supply or had low water supply, had monocropping or diversified cropping, were small or large, and were government-managed or farmer-managed.

When selecting sample irrigation schemes, the tendency was to select irrigation schemes within the sector being studied. This was particularly true for the project design studies. The irrigation project studies in Sri Lanka, Indonesia and Nepal almost exclusively visited small irrigation schemes (Skogerboe et al., 1984; Walker and Coward, 1984; Laitos et al., 1986). However, it can be informative to understand other sectors of agriculture as well, such as large irrigation schemes managed by government agencies and large private estates. In Kenya, for example, the team studied irrigation schemes managed as private estates, and large government-managed irrigation schemes (Coward et al., 1986).

To conclude this section on system performance analysis, some guidelines concerning the **documentation** of the WMS II diagnostic methodologies are reiterated. During this research, we observed that the WMS II Project reports seldom stated the logic used to identify system performance indicators and the methods employed to measure the performance variables. Typically, the reports reviewed the irrigation sector and then proceeded to the design of the project (or to recommend strategy in sector reviews).

There are good reasons why the logic of the methodologies used in the WMS II activities was not stated. The project design or sector review reports are bulky enough without adding statements on methodologies. Also, some experienced team members indicated that this would be unnecessary detail.

There are equally important reasons why the process should be documented. If a team does not consciously formulate and state the methods used to determine the performance indicators to measure, it is probable that the team members do not have a common understanding of their roles in the study. Also, if the methodologies are not documented, they cannot be repeated by other teams in similar situations.

C. FORMULATING IMPROVEMENT STRATEGIES

The last phase in an irrigation system diagnosis is to formulate strategies for improving irrigation system performance. This phase includes identifying strengths and constraints based on the evaluation of system performance and recommending actions that will remove the constraints and improve irrigation system performance.

The review of the WMS II case studies revealed an emphasis on identifying the system constraints. However, in some cases, both strengths and constraints are analyzed. This observation is supported by the sector review studies conducted in Kenya and Nepal (Coward et al., 1986; Laitos et al., 1986). The Kenya study identified the successful role of women's groups in developing and managing small-scale irrigation schemes, and the irrigation sector review in Nepal identified system strengths for the purpose of selecting irrigation schemes to be included in a future project.

The identification of system constraints is well documented in most of the WMS II case studies. Broadly, these constraints may be classified into two categories: system constraints that are specific to particular irrigation schemes, and constraints that are more general. The general constraints appeared in most of the case studies. For policy purposes, this category of constraints is important. Some examples of general constraints are as follows:

* Inadequate farmer participation in system management.
* Limited technical capability in the government irrigation agency.
* Poor communication between farmers and the government agencies.
* Inadequate coordination among the agencies serving irrigated agriculture.
* Poor state of the physical control structures.

Note that most of these constraints are organizational in nature. That is, the constraints arise because of poor management of the organizational relationship between farmers and the agencies serving irrigated agriculture. Often, an informational gap exists between the management objectives of the farmers at the scheme level and the agency policies at the national and regional levels. As a result, national policies and plans may deter individual schemes from achieving the goal of increased farmer welfare. As mentioned earlier, the case studies in Bangladesh and Kenya convincingly support these observations (Karim et al., 1983; Coward et al., 1986).

There are other determinants of the constraints mentioned above, such as degree of organizational coordination and technical capability. In developing countries, multiple organizations or government agencies play important roles in developing irrigated agriculture. However, the patterns of coordination between the organizations are not well articulated, which confuses the management of irrigation systems. Almost all case studies, particularly the India diagnostic analysis report and the

Indonesian project design paper, emphasized the lack of coordination between departments (Venkataraman et al., 1984; Walker and Coward, 1984).

The lack of technical capabilities refers both to inadequate interdisciplinary perspectives in irrigation system design and lack of disciplinary knowledge. Irrigated agriculture is a complex social activity, and designing irrigation systems requires local experience and academic expertise. These considerations are particularly relevant to small-scale, community-managed irrigation schemes, which is pointed out in the Indonesia, Kenya and Nepal reports (Walker and Coward, 1984; Coward, 1984; Laitos et al., 1986).

After identifying strengths and constraints, the diagnostic methodologies develop recommendations to remove the constraints. From our review of the case studies, we found some site-specific recommendations. However, many recommendations were common to all the case studies.

The main recommendations concern the organizational interaction between farmers and the irrigation department. Most of the case studies recommended strengthening or creating water users associations and enhancing staff levels and the technical capacity of the irrigation department, especially in the areas of operation and maintenance. In the case studies reviewed, this usually included introducing operation and maintenance plans.

The Indonesian case study (Walker and Coward, 1984) is an interesting example of a designed attempt to reduce the involvement of government agencies in the management of irrigation systems. This was achieved by limiting the development role of the irrigation department to augmenting water supplies in small rivers. The development and management of small irrigation schemes on these rivers was to be the responsibility of the farmer groups. The farmer groups may ask for technical assistance from the irrigation department, if necessary.

Rehabilitation and improvement of physical facilities was a common recommendation. Inadequate maintenance of the irrigation control structures seems to be a common problem. Increasingly, the irrigation agencies lack the financial resources to properly maintain the irrigation facilities. Many studies recommend involving farmers in the operation and maintenance of irrigation facilities, particularly at the tertiary level of the irrigation systems. However, it is not clear whether or not the farmers perceive the need for the structures and the benefits of maintaining them.

D. PROCESS FOR CONDUCTING IRRIGATION SYSTEM DIAGNOSIS

We previously listed a set of activities that an irrigation system diagnosis might follow (page 14). These were to hold a preparatory meeting with the team to define study objectives and roles, formulate a methodology, meet with key informants and conduct a reconnaissance survey, plan field visits and data collection procedures, conduct a detailed field study and collect data, and analyze and document findings. In this section of the report, we consider the implications of the pre-diagnosis process on the diagnosis and discuss the overall structure of the diagnostic process.

1. Pre-diagnosis Phase

From our analysis of the six case studies, we realized that the methodologies the teams used were influenced by the process which initiated the diagnosis. The funding agency and the host government were the major players in identifying the need for the diagnosis and defining the system to be evaluated. They also influence the membership of the teams. Although not strictly part of the diagnosis, we considered it important that this process be better understood. Not only does the pre-diagnosis process define the time frame, the limits of the system, and the team membership, but it also defines the objectives of the team for the diagnosis.

In some of the case studies, the USAID mission involved the intended team leader at an early stage. This was especially true for the sector reviews and the project design papers. The team leaders were also able to choose the individual team members from guidelines given by the mission. This involvement of team members in the pre-diagnosis process could be interpreted as part of the preparatory team meeting to define roles. However, this involvement goes beyond the definition of roles. It defines the scope and time available for the diagnosis. The distinction between the pre-diagnosis process and the beginning of the process listed above can become indistinct. Where the scope of the diagnosis is not particulary clear, as in the Kenyan study, it is advisable to include experienced team members in the pre-diagnosis process as early as possible.

All of the case studies showed that professionals from the host government departments were included on the teams. Also, the sector reviews and the project design papers included representatives from the USAID mission and local professionals who were not associated with the government departments. Including government and mission representatives on a team added authenticity to the team's findings. The inclusion of in-country professionals, whether associated with government departments or not, greatly facilitated the team's ability to identify and interview key informants and to access secondary data sources. Their language capabilities were also an added asset.

2. Diagnostic Process

To manage and conduct a diagnostic study, the team must plan and implement a process. This process consists of a number of activities or phases designed to apply the analytical framework to evaluate irrigation system performance. The process involves team members, farmers and professionals from different agencies. A general conceptualization of the process, including various phases and people to be involved, is shown in Table 3.

In reviewing the case studies, we found it difficult to identify the methodologies that the various diagnostic teams followed. This is not to say that definite methodologies were not followed. However, no documentation of the process for formulating and applying the methodology was provided. We recommend that in future studies, an effort is made to formulate the diagnostic methodology in team planning meetings and that the team document their methodology.

Table 3. Conceptualization of the process for applying the analytical framework in an irrigation system diagnosis (adapted from Clyma and Lowdermilk, 1988).

Phase	Involvement			
	Team	Donor Agency Officials	Host Country Officials	Farmers
1. Initial Planning				
Entry meetings	*	*	*	
Objectives of study	*	*	*	
Scope of study	*	*	*	
Roles and responsibility	*			
Formulation of methodology	*	*	*	
2. Reconnaissance study				
Initial findings	*			*
Replanning for detailed field study	*			
3. Detailed field study				
Sample selection	*			*
Data collection	*			*
Analysis of data	*			*
Findings	*	*	*	*
4. Formulation of improvement strategies	*	*	*	*
5. Plans for implementation	*	*	*	

The team planning meetings are important for all the team members to understand and agree upon the study objectives and scope of the study. This understanding should involve donor agency and host country professionals. Almost all six diagnostic studies had detailed meetings with donor agency officials and host country officials at national, regional, and local levels.

In initial team planning meetings it is also important to be clear about the roles and responsibilities of various team members. From the review of case studies it appears that various team members assumed certain roles based on their academic expertise. To ensure an interdisciplinary diagnosis of the irrigation system, it is essential that the role of each team member should be discussed and defined in the team planning meetings in accordance with the objectives of the study.

After formulating their diagnostic methodology, the team should conduct a reconnaissance study. The purpose of this phase is to collect information that confirms or rejects the initial hypotheses, or suggests additional hypotheses. The resulting hypotheses will be accepted or rejected based on the data collected during the detailed study. For example, the team initially hypothesizes that some farmers are illegally obtaining water from the delivery system (taking water at a place or time not sanctioned by system managers). The team identifies possible causes and effects to investigate during the detailed study. One possible cause the team identifies is that construction changes varying from the system design have caused some farmers to lose access to canal water. During the detailed study, the team will determine the relationship between this and other possible causes and farmers taking water illegally from the system.

Also during this phase, the team can identify performance parameters and variables to be measured during the detailed study. The main sources for obtaining the necessary information during the reconnaissance study are interviews with key officials and farmers, field observations by the team members, and surveying the existing literature. Based on the findings of the reconnaissance study, the team plans the detailed study and data collection.

In the detailed study, the team applies the analytical framework for the purpose of evaluating irrigation system performance. The team members collect data regarding various performance parameters by measuring appropriate variables. Identifying the correct performance indicators and variables is critical to the success of this phase. To a large degree, the success of the detailed study depends on the effective involvement of local officials and farmers, and the quality of information from the previous two phases of the diagnostic process. Also during this phase, as with the other phases, the team members must constantly share information with each other to continue the interdisciplinary analysis.

The analysis of data and synthesis of results is primarily done by the team members, but it is good practice to check the findings before making final recommendations. The project design study in Indonesia (Walker and Coward, 1984), the Nepal rapid appraisals (Laitos et al., 1986), and the Kenya sector review (Coward et al., 1986) consulted with local officials and farmers before making their final recommendations. An effective way to accomplish this is to hold a one-day seminar at the end of the detailed field study. The participants can be officials from various government agencies, donor agency officials, selected farmers, and team members.

This short seminar at the end of the field study is reported to be helpful in identifying strategies for improving irrigation system performance. These improvement strategies can then be critically analyzed by the team members, along with some key officials from the donor agency and host country agencies.

V. FINDINGS AND RECOMMENDATIONS

In this chapter of the paper we summarize our major findings and give recommendations for future irrigation system diagnostic studies.

A structured process for undertaking an irrigation system diagnosis needs to be clearly agreed upon by the interdisciplinary team at the outset. Most study results suggest that some areas of irrigation system diagnosis were considered by individuals on a team, but were not clearly a part of the team effort. The team whose members understand and agree upon the diagnostic methodology to use will reap several benefits: consensus on the direction the diagnosis should take at all stages, better understanding of the individual team members' roles, an improved interdisciplinary diagnosis of the system, a stronger and clearer report, and a record of a repeatable logic.

This study presented a reference methodology that can be used to select or formulate methodologies for irrigation system diagnosis. The reference methodology can itself be used as a diagnostic methodology to evaluate irrigation systems. The analytical framework for the reference methodology is to define system objectives, measure actual system performance and compare it with the desired performance, identify factors contributing to low performance, and then identify the factors most in need of improvement. A suggested process for applying the analytical framework was given.

An irrigation system diagnosis should be approached with the view that the overall goal of irrigation schemes is to improve farmer welfare through increased agricultural production. The goal of improving farmer welfare can be achieved if schemes are managed according to a set of objectives. The general management objectives are water control, agricultural productivity, resource conservation, and return on investment. These management objectives must be achieved within the context of effective organizational coordination and farmer participation. All these objectives are essential for obtaining and sustaining the overall goal of improved farmer welfare.

After identification of goals and management objectives, the diagnosis should analyze the system performance to see whether the objectives are achieved. This can be done by comparing the actual system performance with the desired system performance. Often, the desired level of system performance is derived from the management objectives.

To evaluate actual and desired system performance, the irrigation systems diagnosis must identify performance parameters which, when measured, can describe whether or not the system is achieving the management objectives. If the objectives are not achieved, the diagnosis should identify factors that contribute to low performance. Strategies can then be formulated and implemented to remove these contributing factors to improve system performance.

Most of the constraints to improved irrigation system performance mentioned in the WMS II case studies are organizational in nature. Some examples are inappropriate management of the organizational relationship between farmers and the agencies serving irrigated agriculture, lack of coordination between the agencies, and lack of effective farmer participation in the management of irrigation systems. Some studies mentioned constraints of a physical nature, such as poor state of the control structures, lack of measuring structures in the delivery system, and inadequate technical abilities of the irrigation department engineers.

To apply the analytical framework in a particular irrigation system diagnosis, the team needs to agree upon a process or a set of activities. The process should begin with team planning meetings to understand the study objectives, formulate their methodology, and assign roles and responsibilities. This planning phase is then followed by a reconnaissance study of the irrigation system. The information collected from the reconnaissance study should be used to plan the detailed field study. Involvement of local officials and farmers is essential for correct identification and measurement of performance indicators and variables.

From the experiences of WMS II diagnostic studies, it is recommended that the team hold a short seminar (one-day duration) at the end of the field study phase. The participants of the seminar may include key officials from the government agencies and farmers. The purpose of the seminar is to discuss and analyze the major findings of the field study with the participants before making final recommendations.

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VII. APPENDICES

APPENDIX A

WATERING THE SHAMBA: CURRENT PUBLIC AND PRIVATE SECTOR ACTIVITIES FOR SMALL-SCALE IRRIGATION DEVELOPMENT IN KENYA WMS REPORT 40

OBJECTIVES

The team identified the Government of Kenya (GOK) national objective, or overall goal, as being to increase agricultural production. The system (or sector) objectives for small-scale irrigation were those defined by the Irrigation and Drainage Branch (IDB) of the Ministry of Agriculture and Livestock Development, which is the public entity charged with small-scale irrigation development. These objectives were identified by the team to be the following: keep the cost of irrigation development to an absolute minimum through low-cost technology and farmer involvement, involve farmers in planning and constructing "their" systems, emphasize the organization of farmers into water users' associations, limit the agency's role to technical design and construction.

Comparing the system objectives with the key management objectives discussed in the procedure for this study (p. 12), we see that farmer involvement was heavily emphasized by the government institution. None of the other four key objectives were directly addressed as objectives of the government.

The team objectives were stated in the report as being to:

* Analyze experiences of GOK, donors, non-government agencies, and local entities in the design, operation, and management of small-scale irrigation schemes in Kenya.

* Assess economic viability of small-scale irrigation schemes in Kenya.

* Develop guidelines and recommendations for USAID.

* Recommend areas and mechanisms for USAID.

The team gave economic aspects of small-scale irrigation development as one of their objectives, which corresponds to the generic management objective of "positive return on investment." Although not stated as objectives, the team does address the objectives of increased production and water control.

From analyzing this report, we conclude that explicitly, by implication in their methodology, or by consideration of the system objectives, the team considered all of the key management objectives with the exception of resource conservation. In discussions with team members we were told that resource conservation was considered by the team. However, the relative importance given to each objective is unclear and whether each team member was aware of all the objectives or not is uncertain.

This team apparently addressed each of the key objectives at some point in their diagnosis, but whether or not they examined them as a team is unclear. Also, it is not clear how the team compared the different objectives of the different role players with the overall objectives for the system.

PERFORMANCE

Water Control

The team used the performance indicator of reliability in the main system to evaluate these small-scale irrigation schemes. This indicator was applied to the diversion structures on the rivers. The team also applied the indicator of equity to main system and on-farm delivery. Adequacy was addressed by the engineer when he assessed the "water use efficiency" of the on-farm application system.

It was interesting to note that the individual water control performance indicators identified in the framework were applied to different subsystems. The adequacy indicator was measured at field level and was then used to assess the main system. Equity was assessed by the delivery to groups and to individual farmers.

Reliability was measured by using the likelihood of the diversion structure failing as the performance variable. Equity was assessed by determining the users' emphasis on equity, the existence of water users organizations, and the existence of control structures at different levels in the schemes. Therefore, equity was measured indirectly by asking the users and by observing the existence of physical structure to implement equitable water distribution. This would be expected where the team was spending only a few hours at each scheme.

"Water use efficiency," the term used in this report, was assessed by observing the field application systems. For example, the team observed small basins with furrows and ridges in one scheme where vegetables were grown. This suggested to the team that the farmers were using water efficiently. Also, the team noted the relative importance of the crops grown. This variable could be used to measure the water control available to the farmers, assuming that crops of high value require greater water control. However, crops grown could also be affected by factors other than water control. The report comments that availability of other inputs, such as labor, may be the constraint. This demonstrates that certain variables that the team used as performance indicators may need further investigation before final conclusions can be made.

Again, the above variables are indirect measurements of performance. Because the measure is indirect, the probability that the factors are interrelated are increases.

Productivity of Agriculture

The discussion of agricultural productivity was limited in this report. The only performance indicators addressed were the value of the different crops and their relative importance in the whole farming system.

By implication, it appears that the team used the market value of crops as a performance variable. Also, they must have used the farmers perception of the relative importance of crops. The team mentions the inadequate data available concerning the farming systems and the outputs. With limited existing data and limited time available for field visits, it was necessary for the team to use indirect measurements to establish scheme performance.

Resource Conservation

Resource conservation was not directly addressed in the report. However, erosion on the river beds and sedimentation in the irrigation systems were two performance indicators discussed in reference to water control. Fertility and waterlogging were also discussed.

Sediment load in the rivers was a performance variable addressed in the report. Waterlogging and erosion (performance variables) were observed by the team members. Note that performance indicators and performance variables, as defined in this study, can be the same thing. This happens when performance indicators can be directly measured.

Return on Investment

The team used the performance indicators of economic and financial viability and applied them to the government, the small-scale irrigation sector, existing schemes, farmer cooperatives, and individual farmers. These indicators were also applied to the private sector concerned with small-scale irrigation.

Some of the data reported were rural incomes (with and without irrigation), potential for increased production, projected rates for irrigation development, required inputs, and market availability. These variables were applied at government, sector, scheme, water users organization, farmer cooperative, or farmer level. These data were used to assess inputs to and outputs from various levels of the sector. Because of the general nature of the information provided in the report, it was difficult to separate specific variables. The listed data were drawn from throughout the report and are not a complete list of the variables used by the economist on the team to assess the return on investment.

Effective Organization and Coordination

Irrigation and Drainage Branch (IDB). The IDB is within the agricultural department. There is also an irrigation department within the Department of Natural Resources, but it is concerned with larger schemes. Therefore, IDB was considered to be the irrigation department in this case, as it is the organization concerned with developing small-scale irrigation within the country.

The team considered the following performance indicators identified in the reference framework: farmer involvement, technical ability, organizational coordination, and system management objectives attained. Being a sector review it is logical that the team consider the main government department concerned with this sector.

To assess the coordination between various organizations, and the coordination and technical ability within these organizations, the team used the following variables: relationship between the farmers and the irrigation department, education levels of the irrigation department staff, department experience with irrigation, appropriateness of development targets, rate of development, and roles of professional staff in small-scale irrigation development. Most of these variables were measured indirectly, using interviews with different key informants in the sector.

Agricultural department. The local representatives for the irrigation department are located in the district agricultural offices. The role of the agricultural department appears to be carried out by the irrigation department personnel. From the report and discussions with team members, it appears that the team looked at extension. However, the indicators applied were unclear. They did note that the lack of organizational coordination between the different agencies was a major constraint caused an inefficient use of staff, and that the lack of qualified personnel caused a low development rate in small-scale irrigation. This suggests that the team looked at the performance indicator of technical competence within the agricultural department.

Planning and development. The team did address the national plan for small-scale irrigation system development. The performance indicator used here was the rate of small-scale irrigation development by the IDB. The variable concerned with this would be the land area in small scale irrigation schemes.

Private sector. The team assessed the "agribusiness linkages". These were the private sector's ability to provide the required services for small-scale irrigation development. These services included crop marketing, equipment supply, fertilizers, credit facilities, and seeds. From the report it appears that the performance indicators considered were the technical ability of the private sector, its coordination with the other organizations involved - particularly the farmer cooperatives - and the needed coordination achieved.

It is interesting to note that some of the areas considered for assessing the performance of the private sector are the same as those considered for the "return on investment" objective. This would be logical, as the outputs from the private sector become inputs for the return on investment.

Farmer organizations. The farmer organizations considered by this team are the water users organizations (WUOs) and the farmer cooperatives, which were within the organizational structure of the WUOs. The performance indicators that appear to have been applied to the WUOs and the farmer cooperatives were farmer involvement, technical ability, organizational coordination, management objectives attained, and needed coordination achieved. The team analyzed at these farmer organizations in depth.

The performance variable used for farmer involvement was the farmers' presence in the organizational structure of the WUOs. Performance variables used for organizational coordination were water allocation procedures, maintenance arrangements, financial management, legislation, discipline and enforcement, and resolution of conflicts.

DESIRED PERFORMANCE

The only reference made to desired performance in the report was the rate of development of small-scale irrigation, which was estimated from the limited data available and a "conservative" estimate of what it should be. It may be because the team relied on experience that they did not discuss explicit values for desired performance.

CONSTRAINTS

Of the constraints identified by the team, most related to the key management objective of effective organization and coordination. The main constraints identified were the lack of a national plan for small-scale irrigation development, lack of professional manpower in the irrigation department, poor funding to public agencies, poor credit facilities available to the private sector, WUOs not able to deal with the new developments in their schemes, slow rate of development, and poor training.

There were a few constraints identified that do not tie into the previously defined performance indicators. These constraints are those which related to the limitations of the diagnosis rather than the system. For example, the report mentions a lack of data on the farming systems involved. This limited the team when trying to evaluate the system, but does not necessarily limit the system itself.

The report identified a lack of research and unresolved land issues as constraints to small-scale irrigation development. These do not follow from the performance variables considered above. However, by implication, it appears the team did consider land tenure and research as performance indicators. Land tenure could come under the key objective of effective organization and coordination. Research could be considered a part of the sector's technical ability. That is, it would also come under the key objective of effective organization and coordination. However, fitting the key logic to such levels in the system is probably not productive at this stage.

RECOMMENDATIONS

The recommendations given by the team were at two levels. Individual chapters gave recommendations on how to relieve the constraints identified in that chapter and the executive summary gave recommendations for the USAID Mission.

Training farmer leaders and securing land rights are two examples of the recommendations given in each chapter. These recommendations followed from the constraints identified by the team, which in this example were the WUOs' inability to deal with new developments and the unresolved land issues, respectively. This and the discussion on how the team appeared to arrive at the constraints demonstrates the teams use of a methodological approach to arriving at their recommendations. However, one recommendation in the individual chapters did not appear to fit the methodological structure, that of developing "multifaceted strategies for clan-based systems," which was essentially improvement of the supporting infrastructure for subsistence irrigation systems. This recommendation did not appear to follow from any of the constraints identified by the team.

The five recommendations given in the summary were for implementing a small-scale irrigation intervention strategy, and appeared to follow from the constraints identified. For example, the recommendation that the Mission make additional funds available to the Government of Kenya for small-scale irrigation development fits with the identified constraint of scarce public funds. However, one recommendation that was not supported by previously identified constraints, was that the USAID Mission assist the IDB in designing and testing a pump program for small-scale irrigation development. The information collected did not support this recommendation.

APPENDIX B

RAPID APPRAISAL OF NEPAL IRRIGATION SYSTEMS
WMS REPORT 43

OBJECTIVES

This diagnosis comprised separate rapid appraisals conducted on 17 irrigation schemes in Nepal. These schemes included ten farmer-managed sites, six government managed (DIHM), and one "hybrid."

The team objectives were to provide the USAID Mission and His Majesty's Government of Nepal (HMG) with relevant information on potential target sites for the Irrigation Management Procedures (IMP) Project. This information would be used to select the sites for the project.

The objective of the Irrigation Management Procedures (IMP) Project in Nepal, as identified by the team, was to determine what lessons can be learned from farmer-managed schemes to aid in the management of government-managed schemes. The implication was that farmer-managed schemes are doing better organizationally. This discussion of objective suggests that organization and coordination were considered in this report.

The team listed seven criteria they used to select sites for diagnosis. Three of these criteria were control of water source, potential for expanding command area and cropping intensity, and potential for increased crop production. From this list, we deduced that the team considered the management objectives of water control and productivity of agriculture.

For this study, where we are interested in the methodology used by the team, it is unnecessary to examine each rapid appraisal in detail. By examining two of the rapid appraisals (one farmer managed and one DIHM managed) in detail and using information from the others we were able to identify the methodology used for the site visits. The team produced a report on each scheme visited. As it was the same team conducting each diagnosis, a similar methodology was assumed to be used in each case. If a major step in the methodology was missing from one diagnosis but not others, then it could be implied that the team did not consider it important for this particular scheme. However, if excluded from all rapid appraisals, then it could be argued that the team overlooked this particular part of the performance assessment.

The team appeared to consider, both directly and by implication, four of the five key management objectives. The objective not covered in the team's general overview was the conservation of resources. However, this objective appears to have been considered by the team when looking at individual schemes. This will be discussed below.

PERFORMANCE

Water Control

Adequacy was a performance indicator considered by the team. It was applied at field level where the team used the water needs of the crops grown as the desired performance and an estimate of the water available to the crops as performance indicator. The field application practices were observed in order to estimate the performance variable of water applied. Adequacy was also determined at farm level with the farmers perception of adequacy used as the performance variable. The desired performance in this case would be farmers satisfaction with adequacy. Adequacy was also applied at the system level where the team examined the adequacy of the available water in the reservoir and adequacy of the main canal to deliver the required water. The desired performance was an estimate of the temporal and spacial water needs of the crops. The variables used were the cropped area, the consumptive use of the crops with time, estimated efficiency of the system, estimate of the canal capacity, and an estimate of the reservoir capacity over the year. The team observed excessive water being applied to the fields and water being allowed to spill from the distribution channels back into the river. These were used as performance variables relating to more than adequate water supplies in parts of the system.

Adequacy was used in terms of the original design by this team. To describe it as a performance indicator could cause confusion. It is a measure of the desired performance of the original design. It could also be a measure of the technical competence of the irrigation department, but it does not appear to be the case in this diagnosis. It could be interpreted as an input variable used to determine the constraints on the necessary water control. Whatever the case, the information is of a qualitative nature which depends on the observations and experience of the team members.

The team asked farmers and government officials whether the scheme was equitable or not. These were performance variables relating to the performance indicator of equity. We can imply from this that equity was considered at farm (impressions of the farmers) and system level (impressions of the government officials). The team also used the observed water wastage in certain distribution channels and fields to compare with the observed inadequate supplies at other locations. The performance variables are the water use, volume delivered to fields, and volume delivered to delivery channels. In this case the desired performance would have been equal water delivered. From this we can see that equity was applied at the farm, the field channel and the distributary level.

The performance indicator of reliability is also applied by the team. They used the variables of farmers' perception of reliability and the cropping patterns to assess this. The desired performance for the cropping patterns was the crops the design supply was intended for. That is, if a particular field was supposed to get enough water to produce paddy yet the farmer was growing wheat, then this was taken as a measure of unreliable water supply. The desired performance for farmer perception of reliability would have been the farmers being satisfied with the reliability of supply.

From the above paragraph we can see that reliability was applied by the team at the farm level. However, this information was also assessed at field channel and distributary level.

Productivity of Agriculture

Yield data and farmer reports were available at government managed schemes. It appears that yield was used as a performance indicator at the scheme level where the team examined the yields from different varieties. The desired performance was the higher yielding varieties in the system extrapolated over the whole system. The variables were the yields at farm level and the cropped area.

The spacial variation of yield was also used as an indirect measure of the equity of water supply in the water control objective. This makes yield a difficult term to define in the key logic, in this case. It is a performance indicator at the scheme level, which is measured by taking the yields at farm level. It can, therefore, considered as a variable as well. Also, it is an indirect measure, or variable, for the equity indicator. These different definitions of the one term may cause confusion. It is interesting to note that this multi-use of data appears to become less common as the measuring intensity increases. That is, where the teams have more time to directly measure performance variables, such as in the case of the diagnostic analysis workshops, the variables become more specific to one indicator.

Cropping intensities was another performance indicator used by the team. The relevant variables were crops grown and cropping patterns. It appear that the desired performance was the highest intensity identified within the scheme.

The area under irrigation was an important performance indicator in this diagnosis. The team appears to have used the area cropped before government intervention as a measure of the desired performance. The main variable appears to be the irrigated areas reported by the farmers. This could also be used to assess the technical ability of the irrigation department in their intervention strategies. Whether or not this was the case is not apparent in the report, however, it is worth noting that the necessary data to make performance assessments of the irrigation department was being collected for other purposes.

When considering the objective of productivity of agriculture it is striking that the team gives what appears to be minor consideration to the performance indicator of cropped area as this was a major goal of the IMP project.

Resource Conservation

The performance indicator of erosion was examined by the team in relation to the main system canal. Here the team noted that the estimated canal flow velocity was too fast for long term stability of the canal.

The desired performance was taken as one meter per second and the performance variable was the estimated velocity of flow.

Erosion was also considered in terms of landslides. The desired performance was the absence of landslides, and the variables were the physical evidence that landslides had occurred and reports from key informants that landslides occurred.

Degradation of the physical system was used in the context of a performance indicator by this team. Assuming that the physical structures are a resource that the system needs to conserve then this comes under resource conservation. The desired performance used by the team appears to be the original design. The variables used were signs of deterioration of structures, adjustable components state of repair, and visible signs of excessive canal seepage. In this study the "measurements" were qualitative and related to the whole system. In the case of the farmer managed scheme much of the main system comprised natural stream beds and the source was a naturally occurring spring. Therefore, the term "original design" is not appropriate for the whole system. The team can still consider the components of the system that were installed by the farmers to improve control. This indicator would also have to consider the adequacy of the original design in order to decide when a structure was a resource or maybe even a hindrance to water control. The adequacy of the original design is discussed under the water control objective.

The team also examined the indicator of fertility. It is unclear what variables they used to assess this. Constraints were identified as lack of manuring practices and the loss of fertilizer due to high rates of percolation.

Deep percolation at field level and canal seepage/spillage within the main system are two other resource conservation performance indicators considered by the team. The variables used for deep percolation were water supplied to the field and water required in the field according to the DIHM estimates. The desired performance would have been minimal deep percolation. The variables used for canal seepage were water losses along lengths of canal and observed evidence of waterlogging due to canal seepage. Spillage was also assessed by observation.

Another resource conservation issue identified by the team was the loss of land due to the expanded capacity of the reservoir. The reservoir already had the extra capacity but it had not been used as 250 ha of land would be lost. This land is the constraint to improved water supplies and appears to have been identified through the water control objective rather than resource conservation. It must relate to the performance indicator of adequacy.

Return on Investment

This objective was not covered in the report and does not appear to have been considered by the team.

Effective Organization and Coordination

Irrigation Department (DIHM). On the farmer managed schemes there is no input by the DIHM, therefore, the following discussion is concerned with the DIHM managed schemes.

The team appeared to only consider the role of the DIHM in operation and maintenance of the irrigation scheme. Little if any references were made to the design and construction role of the DIHM.

A performance indicator used by the team was the ability of the DIHM's representatives to operate the system. [What was the performance indicator]. The desired performance were the specified roles of the DIHM representatives. The variables concerned appear to be the farmers' perception of what the DIHM representatives actually did and the state of repair of the system. The DIHM representatives were concerned with the control of water within the branch canal and this is where the team looks at DIHM involvement in the scheme.

The team also assessed the performance indicator of inter organizational coordination where they assessed the coordination between the DIHM and the farmers. The variable used was the presence of conflicts and the desired performance was the absence of conflicts. The information was collected by interviewing both parties. In the particular scheme we are considering the team did not report the existence of meetings between farmers and DIHM representatives. However, it appears that this may have been excluded from the report because the meetings did not occur on this scheme due to the lack of water users' associations. Looking at reports from other schemes the team have implied the existence of these meetings. It appears that meetings between farmers and DIHM was used as a performance variable to assess the coordination between the two organizations.

Agricultural Department. The indicators of interorganizational coordination and farmer involvement were both assessed using the existence of meetings between the two parties as a performance variable. The team also used the availability of agricultural information to the farmers, relevance of on-going research, and technical services available to assess the technical ability of the department. Although not clear in the report these variables could also be used to assess the coordination between the two organizations.

Private Sector. The team appear to consider farmer involvement, organizational coordination, and technical ability as performance indicator. The variable used to assess each of these indicators was availability of inputs. Perhaps in this case it would be more logical to consider availability of inputs as a broad performance indicator relating to the private sector rather than express the team's results in terms of the framework. The variables the team used to assess this indicator are unclear as the inputs considered are not discussed in the report.

Farmer Organization. As has been discussed above the first indicator for farmer organizations was do they exist and if they do how effective were they. In terms of the framework this covers the farmer involvement, technical ability, and organizational coordination. The technical ability and organizational coordination are more or less the same thing. The variables used to assess this broad indicator were present existence of WUOs, historical presence of WUOs (before government intervention), presence of conflicts between head and tail farmers, presence of conflicts between farmers and DIHM, intensity of conflicts, farmer identification with scheme, presence of written rules and regulations, farmer involvement in maintenance, and water allocation and distribution.

The team obviously have some concept of the desired objectives of the water users associations. It is not clear whether they examine the presence of these objectives within the organizations. It is also not clear whether the desired objectives were examined as to their suitability to fit in with the DIHM objectives. The DIHM objectives did not appear to have been explicitly stated by the team.

In all of the organizational assessments, the presence of conflicts between the different role players is used as a performance variable. This could be an indirect measure of the organizations and a performance indicator that the team would be looking for during the reconnaissance.

CONSTRAINTS

The team identified constraints on the government system as:

- high soil percolation rates resulting in high water demand and low fertilizer use,
- farmers live in town and view farming as a sideline,
- uncontrolled water flow from branch to field because of weak DIHM management and lack of control structures throughout the scheme,
- outlets in the scheme are in very poor condition,
- agricultural production is not up to expectation,
- no effective farmer organizations are established in the area, and
- uncontrolled animal grazing and potential extensive hail damage prevents farmers from growing wheat.

The constraint of high percolation rates fits in with the adequacy performance indicator of the water control management objective that was applied at field level by the team.

The absentee farmer constraint does not fit in well with the structure identified above. The team must have used the variables of size of holdings, ownership, residency of farmers, and relevant importance of agriculture in the household. All these variables were addressed in the report, but it is difficult to identify what the performance indicator may have been and what management objective this would come under. This observation is not necessarily a limitation of the diagnosis. It is more likely either a limitation of our interpretation or a limitation of the reference framework we are using.

The uncontrolled water constraint follows logically from the equity, adequacy, and reliability performance indicators applied at the scheme and branch canal levels. The poor condition of the outlets follows from the resource conservation management objective where the team used a performance indicator of degradation which was assessed in part by the deterioration of structures.

The constraint of low agricultural production levels suggests that the team considered performance indicators of cropping intensity, cropped area, irrigated area, area under irrigation and yield variation within the scheme. However, it could be interpreted from this constraint that the yields were low throughout the scheme. Yet the team appear to use the higher yields within the scheme as the desired performance. This suggests that the team considered the agricultural production at some farms as good. It may have been useful for the team to qualify this constraint.

The constraint of effective farmer organization comes from the effective organization and management objectives. In particular the variables of: do farmer organization exist, conflicts, and technical ability would have identified this constraint. However, the team did identify the existence of farmer organizations concerned with agricultural activities other than water supply. The team described these organizations as effective. It may have been more correct to describe the constraint as lack of effective water users' organizations rather than the more general term of farmer organizations. This is a small point that would help the clarity of the report.

The animal grazing and hail damage constraints on winter wheat production are interesting. The low productivity of wheat would have been established from their assessment of agricultural production. However, the next step, that is identifying these two constraints are not easily identified from the key logic. The data concerning other sectors on the farms, such as livestock, and the climatic considerations do not appear readily from the framework. Again, this is not a limitation of the team methodology but a limitation of the key logic or our interpretation. This serves to that we have yet to learn about aspects of diagnosis methodologies.

APPENDIX C

INTERDISCIPLINARY DIAGNOSTIC ANALYSIS OF AND WORKPLAN FOR DAHOD TANK IRRIGATION PROJECT, INDIA WMS REPORT 25

OBJECTIVES

The report noted that the Government of India was attempting to increase food production and that previous attempts had increased the amount of agricultural land under irrigation. This implies that the Government of India had a goal similar to the one considered in this study.

The team stated that the objectives of the diagnosis were to diagnose the constraints in existing irrigation schemes so that previous design, construction, or management problems would not occur in new schemes, and improve the operation of an existing scheme. From this we can conclude that the team were interested in examining the management of an irrigation scheme and should cover the same ground as the key management objectives described in this study. Although these points were not introduced in the teams description of their procedure the key objectives were raised when discussing the constraints of the scheme. Also, throughout the report when the team was assessing the scheme they made many references to performance criterion that implied these key management objectives.

PERFORMANCE

Water control

The team considered the performance of field application systems using the terms adequacy, efficiency, and uniformity. These correspond to the performance indicators of equity and adequacy at the field level. Data collected by the team included inflow, outflow, advance and recession, infiltration rate, soil moisture and topographical surveys of fields under consideration. These data are variables used to assess the performance indicators above. Most of these variables are concerned with the output from the farmer's attempts to control the water during field application. However, some are inputs that the farmer has little or no control over, such as the inflow to his farm and the infiltration rate. The desired performance would be established by the team members as that which could be achieved given these inputs.

As the team applied the field assessment to fields at the head, middle and tail of the minors, they were also considering the equity and adequacy indicators at other levels within the scheme. The variables used were the flows into the fields, flows into the watercourses and the flows into the minor canals. It is implied that the irrigated area is also used as a variable when assessing equity.

The team noted the lack of drainage facilities both in the system and on-farm. This implies the team considered the adequacy of the on-farm and main drainage removal system. They also examined the spacial distribution of drainage facilities which is a measure of the equity of water removal over the scheme.

The team considered the command area of the irrigation system. They measured the water level in full canals and watercourses to assess where the system could apply water to. The desired performance was the designed command. The performance indicator was the actual command using the variable of elevation of the full water level. This indicator does not appear to fit into the reference framework we have been considering.

The team also consider irrigated area is a performance indicator. The potential area appears to be the actual command area of the system. This indicator could be considered as part of the productivity of agriculture, although there is room for argument against this.

Reliability of water supply was also assessed over the system using the investments in inputs as the variable, particularly the quantity of fertilizer used. The team's logic was that the farmers with more reliable water supply would risk the increased investment in more fertilizer. Cropping patterns was a further variable used to assess the reliability of water supply at the farm level. Those with more intensive patterns, particularly those with irrigated crops, were considered to have more reliable water. Another variable used was the varieties of crops used. Where farmers used dry land varieties on irrigated land, the team suspected unreliable water supply.

Productivity of Agriculture

The team began by examining the performance of irrigated agriculture at the National level over recent years. The indicator used was net return on crops. The variables would have been average inputs and prices for particular crops. There does not appear to have been a desired performance as such except that an improvement was considered good. They also examined the performance of irrigated agriculture at the State level. The indicator used was irrigated area. The desired performance for irrigated area was the area that had been provided with irrigation facilities. The variable was the area actually irrigated.

The team implied the consideration of yield from irrigated agriculture as a performance indicator at the State level. The variables used were area irrigated and the average yields. The absence of a recorded desired performance suggests that the team judges the State production on their experience of what it should be.

At the minor level the team used the performance indicators of cropping intensities, cropping rotations and cropping patterns. Intensity indicator was described in terms of a percentage of the potential cropped area in each season. The variables involved are the areas cropped in each season and the areas that could have been cropped. These correspond to the desired and actual performance.

The crop rotation indicator has already been introduced under the water control objective where it was used as a variable for reliability. However, crop rotation was also considered by the team as a performance indicator concerning the productivity of agriculture. The desired performance was the more intensive crop rotation used in the system, which was wheat-paddy. In this case the indicator could be measured from records and farmer interviews.

The use of yield in this diagnosis is difficult to define in terms of the reference framework we are using in this study. It is used as a performance variable where it is used to assess variability of yield, which in turn is used to indirectly assess equity of water distribution within the system. Yield is also used as a variable for other such indicators. However, it appears that the team did not use the yield records to directly measure the performance indicator of yield. The team conducted plant and tiller counts throughout the system. These variables can be used to estimate the yields expected from the farms and the system. This demonstrates that certain data, such as yield, can be used in different ways to assess the performance of a system. Also, the performance indicator of yield can be assessed in different ways, such as the indirect measurements made by this team.

The team appear to have used crop condition as a performance indicator. They conducted plant tissue analysis in fields at the head, middle and lower reaches of the minors in order to establish the nutrition of the plant. Although not stated, this variable could also have been used when considering the resource conservation indicator of fertility. They also conducted random plant population and tiller counts over the same fields, and visual inspections of each field in the minors for pests or other crop damage. These variables imply the consideration of crop condition and its spacial variability.

Resource Conservation

As was mentioned in the paragraph above, the team may have considered fertility of the soil within the scheme. There appears to be no other mention of it in the report apart from the nutrition analysis of the crops.

The team examined the state of the scheme. Surveys of the existing system, and measurements of the canal and channel cross-sections were the variables used to compare the original design, which was the desired performance for this indicator. This could also be assessing a maintenance performance indicator which could be under the effective organization and coordination in the framework.

Other variables used in assessing the state of the scheme were seepage from the canals and channels, capability of the canals and channels to carry the design flow, visual signs of scouring and siltation, and visual signs of damage to structures and channels. These variables are mainly observational in nature and rely on the experience of the individuals to define the desired performance, that is their interpretation of the designed condition of the system, and the actual performance.

Return on Investment

The economic viability for the farmers was a performance indicator considered by the team. Using information provided by sample farmers from the upper, middles and lower reaches of the four minors, the team determined costs and returns for different crops grown within the scheme. From these variables the team determined the economics of the different crop rotations existing within the scheme. The team appeared to use wheat-paddy as the most economically desirable and, therefore, the desired performance at field level.

Effective Organization and Coordination

Irrigation Department. Farmer involvement in the design, operation, maintenance and planning were indicators used by the team. The variables for these indicators were mainly collected from interviews with sub-engineers (the irrigation department representative on the minors) and with farmers. The variables that appear to have been used were existence of sub-engineer meetings, farmer knowledge of water delivery, farmer communication with the sub-engineer, sub-engineer's response to farmer needs, farmer involvement in the scheme design, responsibility for operation and maintenance of different levels of the scheme, and perceived ownership of different parts of the scheme.

The team also assessed the coordination indicator to the relationship between this department and the Department of Agriculture. The main variable appears to have been whether the plans of the two departments considered each others plans. The team also used the interaction between the sub-engineer and his equivalent in the Agricultural Department as a variable.

The team also assessed the coordination within the department. The main variable was the communication between the staff within the department and between the staff and the farmers. It is unclear how these variables were measured other than qualitative answers from key informants.

Agricultural Department. The relationship between this department and the irrigation department has already been addressed above.

Technical ability of the extension service was one performance indicator the team used. The relevant performance variables were the communication with farmers (from the farmer and service point-of-view), follow up by extension, training of the extension personnel and the personnel's view of their own deficiencies. The team did not appear to have examined the organizational coordination within the department.

Private Sector. The main performance indicator used for the "private sector" appears to have been the availability of inputs to the farmers. These inputs included credit. fertilizers, equipment, etc. To consider credit within the private sector only may be stretching the truth. However, for want of a better way of fitting it into our reference framework, we will proceed. The reader should note that this is a limitation of the framework rather than the methodology used by the team.

The variables used to assess the availability of credit were sources of credit and quantity available, and interest paid. It is implied that the team used the farmers' perceived credit needs as a desired performance. The farmers' perceived needs would also be used for the other private sector inputs necessary for the system.

It is interesting to note that should the recommendations be implemented concerning the removal of constraints the private sector may have to responded to a greater, or different, demand for inputs. The desired performance would then be this new level of farmer needs.

The level of mechanization was a item considered by the team. The report suggests that this was used as a performance indicator, which implies that either high or low levels of mechanization would be considered good performance. This is not necessarily the case as low mechanization can be present where overall performance is good. Level of mechanization could be an indirect performance variable. The spacial distribution of this variable could have been used to measure the equity of credit distribution, risk aversion distribution, etc. The same variable could also be used to measure ability of farmers to accept new technology. However, with the limited information available in the report it is impossible to say what this variable was used for. It may have simply been extra data that were not used in the logic of the diagnosis.

Marketing. Like credits this part of the service industry could be both private and public sector. The indicator used by the team appears to be accessibility of good markets. The variables used were price fluctuations and their effect on the farmers' profitability, information available to farmers on the potential markets, crop use (consumption, labor payment or market), farmer control over selling time, and existence of effective marketing cooperatives.

Farmer Organizations. The variables used by the team relating to farmer organizations were the existence of such organizations, water allocation and distribution procedures, social structure, farmer conflict, information communication, and system maintenance. From this it can be implied that the team considered performance indicators of ability of organizations, farmer involvement, and organizational coordination.

Farming Family. This team closely examined the farming family as an organization within the irrigation scheme organization. Some of the variables mentioned were social structure, record keeping, management practices, perception of production problems, knowledge levels, women's role in activities and decision making, household production and decision making, other uses of water, and impact of irrigation on farming family. The indicators considered appear to have been relative importance of irrigated agriculture, and technical ability within the farm family.

CONSTRAINTS

The major "constraints" identified by the team were:

- lack of equitable and reliable supply of water,
- improper construction and lack of maintenance,
- no prescribed maintenance schedule,
- need for an operational plan for water distribution,
- lack of water courses,
- significant deviations if field elevations leading to non-uniform water application,
- lack of surface drainage network and insufficient cross-drainage,
- small flow rates compared to field size,
- lack of effective, organized farm family involvement in system management,
- absence of agricultural information and training for farm women,
- poor communication breakdown of information between irrigation officials and farmers, and
- lack of farm record-keeping system.

Some of these constraints follow through the logic of the team's methodology. For instance the lack of equity and reliable supply of water, which comes from the teams detail analysis of water control. Also the improper construction and lack of maintenance follow from the teams examination of the adequacy of the present scheme and the present state of the scheme respectively.

The lack of record keeping by farmers is an example of a constraint that does not appear to be well supported by the logic of the methodology. No doubt it was a restriction on the team's diagnosis but it is difficult to see what the performance indicator was that the team assessed to arrive at this as a constraint for the management of the irrigation scheme.

RECOMMENDATIONS

The major recommendations given were:

- line main canal and review alignment and capacity of minors and reconstruct if necessary,
- establish a regular maintenance schedule,
- institute a rotational water distribution schedule,
- build watercourses and drains and promote land leveling,
- permit and encourage farmers and farm women to participate in system rehabilitation, maintenance and management,
- encourage farmers to build effective farmer organizations,
- provide agricultural information and training for extension personnel, farmers, and farm women,
- introduce a farm record keeping system, and evaluate potential economic impacts of improvement, and
- improve availability of fertilizers, seeds and credit.

The recommendations like the constraints appear to follow well from the apparent methodology applied by the team. The recommendation to institute a rotational water distribution system does not appear to be as well supported as is implied. It does follow on from the constraints above which came from the performance assessment of earlier. However, it appears that the decision to go with a rotational schedule was pulled out of the air.

The recommendation to line the main canal does not appear to be justified from the performance assessment conducted. The land leveling recommendation also suffers from a lack of supporting evidence.

The recommendation concerning availability of fertilizer, seeds and credit are interesting. From the review of the report it appears that the availability of credit was the only indicator assessed in any detail.

APPENDIX D

IRRIGATION SYSTEMS MANAGEMENT PROJECT DESIGN REPORT, SRI LANKA
WMS REPORT 33

OBJECTIVES

The objectives of the Government of Sri Lanka (GSL) concerning the Integrated Management of Major Irrigation Schemes (IMMIS) were identified by the team as:

- no new irrigation schemes,
- rehabilitation,
- improved water management, and
- recovery of operation and maintenance costs.

The team objective was to establish the terms of reference of the ISM project. The goals of which were identified as:

- help the GSL expand food production,
- increase employment opportunities, and
- raise the standard of living for farmers with small holdings.

Comparing the ISM goals with the "overall goal for irrigated agriculture" discussed in the introduction of this paper we see that the ISM project addresses the increased food production and farmer welfare. We can, therefore, conclude that the team began with a goal consistent with improving irrigated agriculture.

The team does not directly give the key irrigation management objectives, which is to be expected. However, the key management objectives of effective organization and coordination and return on investment are addressed in the report. By implication, the team also considered productivity of agriculture. It is even addressed in the ISM project goal of expanded food production. The objective of resource conservation is implied as the team emphasis the development-deterioration-rehabilitation-deterioration cycle and their desire to break this cycle. This is a performance indicator concerning the resource of the physical system. The team, therefore, considered this key management objective. The team's consideration of water control is implied throughout the report as will become apparent as we address the performance indicators below.

PERFORMANCE

Much of this report is devoted to the description of the design of the Irrigation System Management (ISM) project rather than describing the diagnosis the team went through in order to arrive at the design. Therefore, much of the performance assessment is implied from the recommendations given in the design.

Water Control

The team used equity as a performance indicator at field channel, distributary, and main system levels. Using data from schemes next to those in the ISM project the team considered the performance variable of yield. The team stated that the inputs were the same throughout the scheme and that the differences in yield were due to differences in water delivered. The higher yields within the scheme were used as the desired performance in the whole scheme for both growing seasons. Improved irrigation management would mean yields in the dry season equivalent to those in the wet. This assumption could be incorrect, but this design study was followed by a long term DA in which better data would be collected.

Equity was also addressed in the list of "performance indicators" given by the team as part of the design. They suggested that, on a weekly bases, the ISM measure selected farmers access to water in order to assess equity. By implication the team must have addressed this performance indicator in their diagnosis.

Reliability was only addressed in the description of the design and not in the limited description of the diagnosis conducted by the team. The team suggested "performance indicators" of how well the main system met target discharges, observing and quantifying irrigation deliveries throughout the scheme, observing water application, crop water stress on sample farms, and drainage flow. These are essentially performance variables which imply consideration by the team of the reliability performance indicator in the main system, the distributaries, the farm delivery, farm application, farm use and removal. The team also recommended monitoring the waste or reuse of drainage water. The reuse of drainage water is another subsystem of water control that should be added to our framework.

The performance variable of crop water stress is not only a measure for in-field equity, it is a measure of adequacy of water supply to the field. Adequacy is further implied by the team in their general description of the ISM project design where management is designed ..."to meet crop water requirements anywhere in the system (scheme)"... Also, equity is considered when the team give one of the ISM objectives as developing more knowledge so management can employ improved practices to equitably distribute water and to improve equity in farm income.

From the above we can see that the team has addressed the performance indicators of equity, reliability, and adequacy at all levels of the system. However, the actual performance variables measured or desired performances were not recorded in the report.

Productivity of Agriculture

The major performance indicator relating to productivity of agriculture that is implied by the report is variability of yield. This indicator was applied to the four irrigation schemes considered by the team. The report also implies the consideration of cropping intensity both at farm and scheme level, and cropped area at scheme level. Yield is also widely used in the report, but in the majority of cases, yield is a performance variable used to assess the variability of yield. Yield is used as a performance indicator at the National level where the team examines the impact of the project on the National production levels. Crop diversity appears to be used by the team as a performance indicator. This ties in with the National goal of more diversified crop production.

The variability of yield is determined from yield data available from schemes neighboring those in the ISM project. The yields are those reported by farmers in previous years. These data are also used to determine the crops grown in each season and the area of crops grown, which are used to determine the performance indicators above.

The desired performance used in the report was the higher yields reported in the neighboring schemes extrapolated over the schemes under the ISM project and over both growing seasons.

The team appears to have considered the performance indicators listed in the framework plus crop diversification. Also, it is interesting to note the use of yield as both a indicator and a variable when fitted to our framework.

Resource Conservation

One of the main goals of the ISM project identified by the team was to break the development-deterioration-rehabilitation-deterioration cycle that occurs in irrigation schemes in Sri-Lanka (and elsewhere). This is an attempt to conserve the resources involved in the physical irrigation system. By reducing the expenditure on system rehabilitation through improved management. This appears to be the only reference in the report to resource conservation. The performance indicators in this case would be some measure of the state of repair of the physical system. This could have been the ability of the physical system to deliver water as originally designed. The performance variables to assess this indicator could have been silting-up of the system, structures intact from the original design, damage to structures, or leakage from the canals. However, it appears from the report that the team were already aware of this particular problem and did not measure the performance to confirm it.

Return on Investment

Unlike the other key objectives considered above, the report gives significant information on the team's diagnosis of this area before they recommended a design. Economic and financial analyses were conducted of the sector (the ISM project area) and each of the schemes involved. These indicators were described in terms of the rate of return on the investment. The variables used to arrive at these indicators were described as "conservative estimates" from "official data" as there was limited empirical data available to the team. Cropping intensity, cropped area and yield were the three performance variables used to determine the desired production due to the investment and, therefore, the rate of return. The collection of fees is a performance variable used by the team in determining the performance indicator of financial viability of the schemes.

It appears that the report does not include a rate of return for the project without the investment. In terms of the terminology used in this paper the team did not report a present level of performance. The economic and financial performance indicators were also applied to the farmers. The performance variables used were size of holdings, farm incomes, and distribution of incomes. However, the report does not address the financial viability of the individual farms should the project be implemented. This shortcoming can be described as not addressing the potential performance of the farmers. This may be due to the lack of empirical data, but it should have been considered.

Effective Organization and Coordination

Irrigation Department. The team examined this department in detail and specifically examined the indicators of technical ability, organizational coordination within the Irrigation Department, and farmer involvement.

For the indicator of technical ability the team used the performance variables of qualifications of personnel, and experience of personnel. For organizational coordination the team described the many different meetings within the organized structure of the department. Farmer involvement in the irrigation department was apparently only considered by the variables of the existence of meetings between the farmers and the ID, and the impressions of the two parties to the benefits of these meetings.

The team appears to have applied the above indicators to the design, construction and O&M functions within the department.

A notable exclusion from the coordination of this department is the diagnosis of its coordination with other agencies.

Agricultural Department. This is not considered in the report. Neither is its coordination with the Irrigation Department.

Planning and Development. This is considered at the National level where the team state that the emphasis is no longer towards the creation of new schemes, rather the rehabilitation of existing ones. The team uses disciplines within the irrigation department as a performance variable to determine the ability of the department to implement this.

Private Sector. Other than a brief reference to the availability of credit to the farmers from the private sector there was no diagnosis of the private sector in this project. This reference to farmer involvement in the private sector must have been assessed from interviews with farmers and farmer's groups.

Other Organizations. The team assessed the performance of existing training facilities within the country in order to improve the technical capability of the farmer's organizations and the irrigation department. The performance indicator used was their training capability and the variable used to assess this were previous experience in irrigation, qualifications of personnel, and experience of personnel. The desired performance used was that required to meet the needs of the ISM project.

RECOMMENDATIONS AND CONSTRAINTS

As this report gives a description of the design and limited information on the performance of the existing system the recommendations are relatively easy to define whereas the constraints identified by the team have to be implied. The recommendations given by the team in the "objectives for the ISM project" are:

- develop and strengthen the WUOs,
- enhance the capability of the Irrigation Department staff for operation and maintenance, support the IMMIS project,
- institutionalize the training capabilities for WUOs, O&M and project management, and
- document lessons learned with special reference to policy implications to consider in order to ease the transfer of technology.

From these recommendations we can imply that the constraints identified by the team were:

- non existence of WUOs in some cases, and low internal coordination and ability of some of those that do exist,
- low technical ability of Irrigation Department to organize O&M,
- low capabilities within the country to undertake training for WUOs, O&M and project management, and
- National policy constrains the transfer of technology.

In this design study, much of the information in the report makes indirect reference to the methodology the teams used. This is why the actual measurements made by the team are unclear. This is not a failing of the report as they were not trying to record the details of the methodology they used.

The above constraints appear to fit the logic of the diagnosis methodology with only a couple of exceptions. The low capabilities for training for O&M does not appear to be supported by the report. The report suggest (p. 92) that the required training facilities are largely intact. The facilities for training project management were discussed but it is unclear to what extent they were assessed for performance. This could be an exclusion in the report or in the diagnosis.

DISCUSSION

With the lack of reported performance indicators and constraints it is difficult to decide whether they were measured and how they were measured.

It appears that the team did consider all five of the key management objectives. The desired performance concerning the farmers' economic and financial situation do not appear to have been established. This is particularly interesting considering one of the goals of the ISM project is to increase the standard of living for small farmers.

APPENDIX E

SYSTEM H OF THE MAHAWELI DEVELOPMENT PROJECT, SRI LANKA
WMS REPORT 20

OBJECTIVES

The objectives of this system were identified by the team as equity of supply and control over available water supply. The major team objective was recorded as training of host country professionals in interdisciplinary team methods, which was diagnostic analysis in this case. The team conducted the reconnaissance in disciplines and the remainder of the activity in interdisciplinary groups. However, the report was divided in terms of the disciplines. The disciplines represented were agronomy, engineering, economics, sociology and women's role in irrigated agriculture. The team consisted of two agronomists, two engineers, one engineer-/economist, two economists, two sociologists, and two sociologists/women in development. Five of the eleven member team were local professionals.

PERFORMANCE

The team collected data from the five groups mentioned above. Each group places different emphasis on the performance considered. The agronomy report is primarily concerned with testing the hypotheses developed in the reconnaissance that agricultural production was low due to inequitable distribution of water, over irrigation of upland crops, low input levels, poor land preparation and weed control, and the development of salinity problems in the lower reaches of the turnouts. From this we can conclude that at least part of the team considered the management objective of productivity of agriculture. Examining the "causes" of the suspected low productivity it can be implied that they considered performance indicators of equity of water distribution, resource conservation, technical ability of farmers, and input levels. From this, we can conclude that the key objectives of water control, resource conservation, productivity of agriculture, and effective organization and coordination (relating to the level of inputs and farmer technical ability) were considered by at least this part of the team.

For the detailed study the group began with another walk through. This time they were concentrating on their assigned turnouts. The data collected was observational in nature and included crops growing, differences in growth stages, general condition of crops, and areas of poor growth. These data, which would be described as performance variables in the terms used in our study, were used to assess cropping patterns, cropping patterns, and "management related problems". These are essentially the performance indicators considered at this stage and were used to decide the allotments to use for detailed study. Up to this point, the group concentrated on secondary and observational data.

The agronomy group went on to collect data from their selected allotments on the soil types and their condition, and on the level of the water table. This data was directly measured. The group also collected further data on the crops grown. This included asking the farmers about the varieties grown and observing the field practices, such as plant spacing, and directly measuring the observations they had made previously such as the weed infestation and the projected yield from tiller counts. Plant nutrient information was also collected. All these variables are primarily concerned with the objective of productivity of agriculture but the information could also be used as secondary data for other objectives. For instance, differences in cropping patterns can be used to assess the inequity of water delivery.

The engineering section, like that of the agronomy, used the information from the reconnaissance to develop a hypotheses from which they developed a methodology for testing it. The system was divided into water conveyance and distribution system, water application system, and drainage system. The indicators they selected from the reconnaissance relating to the delivery, farm and drainage systems were maintenance of channels, state of channel structures, erosion and sedimentation in channels, state of turnouts and level of control and measurement available, water logging, reliability and adequacy of supply to farmers, and tampering by farmers. The team made assumptions from these observations and proceeded to test them. Comparing these observations with the reference framework of this study we can see that the team considered the management objectives of water control. They mention the two indicators of adequacy and reliability and, although they do not refer to the indicator of equity, this has already been covered in the section on agronomic aspects. The team also considers the objective of resource conservation. Here the team has examined indicators of water logging, deterioration of structures, sedimentation, erosion, salinity, and fertility. A number of these observations relate to indicators concerned with the objective of organization and coordination. The tampering of farmers and level of maintenance are two specific examples.

After observing indicators of low performance, hypothesizing the constraints associated with these indicators and identifying the indicators concerned with them, the team goes on to consider the information they need to test their hypotheses. This section identifies those as original and actual maintenance plans, original and actual maintenance procedures, original design specifications, discharge measurements from delivery channels and field turnouts, staff and farmer inputs concerning the communication channels, inflow and outflow measurements from sections of field channels, present condition of structures, and elevation of drainage channels with respect to farms served. It should be noted that the maintenance variables were applied at the three subsystems mentioned above. The variable concerning the communication channels was applied at both the conveyance and distribution subsystem, and the application subsystem interfaces. It can be seen that there is great emphasis on the organization and communication both between and among the different organization involved, and the resource conservation relating to the original system. Most of the data listed in this paragraph are either performance variables of desired performance relating to these two objectives. However, the implication of this information is that it has already been established that the objectives of water control and productivity of agriculture are not being met.

The data for this section of the report came from direct measurement and interviews with the farmers and the staff. There appears to have been a lot of direct measurement concerning the present state of the system.

The economics section of the report concentrated on collecting input/output data from the major cropping enterprises of the previous year. The main objective being considered here is the return on investment at the farmer level. The data were collected by means of interviews with a sample of farmers. Soil types and head-tail considerations were used when selecting the sample. This implies that the team were also considering distribution of return on investment within the system which in-turn implies that the team suspect that there is an inequity in water distribution within the system. Therefore, the return on investment data were also used as secondary data for water control.

The economic section of the report also refers to data collected concerning the cropping patterns and intensity, agricultural production inputs and activities, and production level, marketing and credit. Here they have collected data that concerns the objectives of agricultural productivity and the organization and coordination of the marketing and inputs.

The sociology section of the report lists certain aspects of attitudes and behavior that influence irrigation activity. These were availability and utility of institutional services, perceived problems of farmers, farmers' irrigation knowledge, effectiveness of <u>bethma</u> (existing water delivery policy) system and pattern of land tenure, farmer involvement in the maintenance of the system, and farmer perception of community life after the resettlement. In selecting the sample areas the team considered the head-tail issue and the different organizations within the irrigation system. The team interviewed both field assistants concerned with irrigation and agriculture. However, the team only refers to the irrigation organization at other administrative levels. No discussion concerned with the agricultural department input with the system except for the field assistants.

It can be seen that the sociology section is primarily concerned with the organization and coordination objective, especially from the farmers point of view. Their selection of sample area suggests that equity of water delivery is also considered.

The women in development section used a list of aspects very similar to that used in the sociology section except this is directed at the woman's role in irrigated agriculture. Similarly the emphasis was on the organization and coordination objective from the woman's point of view. More emphasis was placed on the farm family as a organization.

CONSTRAINTS

The major constraints identified by the team were poor maintenance at the farm and channel level contributing to physical deterioration, drainage, farmer practices, leveling in fields, labor, farmer participation, credit, understaffing of the irrigation department, at the level that communicated with the farmer users organizations.

RECOMMENDATIONS

The team give a detailed list of recommendations for this system. Basically these are repair and replace the physical system and construct additional structures and measuring devices at critical points, implement a regular maintenance schedule, establish a rotational system of farm irrigation, develop an incentive and penalty system, more involvement of women, establish farmer organization to communicate problems and work with the irrigation department, improved extension, develop a mobile demonstration unit to bring Community Development Center Programs to those with time and travel constraints, more detailed soil surveys, farmer managed research trails, detailed evaluation of domestic water supplies, develop methods to ease seasonal labor constraints, develop a farm record system, efforts to stimulate crop diversity, and detailed investigation of the real value of capital and credit in the production process.

The recommendations are extensive. The constraints identified do not appear to justify all of these recommendations. For instance, the recommendation on crop diversity does not come from the constraints identified. It appears that this may be an objective at regional or national levels. The recommendations concerning further research are questionable. It is not apparent that more detailed soil information is of critical importance to the management of this system.

The recommendations were divided into physical, organizational, and further research. The physical and organizational appear to follow on well from the methodology discussed by the various components of the team. The team appear to have covered the five main objectives very well in this diagnosis.

APPENDIX F

SMALL SCALE IRRIGATION DEVELOPMENT, INDONESIA
WMS REPORT 30

The system being considered in this diagnosis was small scale irrigation within specific regions of Indonesia. The team consisted of three irrigation engineers, two rural sociologists, one agricultural economist, and one lift irrigation specialist. All the members were expatriates, but two had extensive experience of small-scale irrigation schemes in Indonesia and the team was complemented with local professionals throughout the diagnosis. Two weeks prior to the team arriving two graduate students were sent ahead to collect data and establish contacts. Team members were appreciative of this, but warned that careful selection of these students was critical. The wrong person could cause more problems than they overcome.

OBJECTIVES

The team did not specifically mention the Government of Indonesia's objectives in the report. However, the report does refer to Repelita IV, which is the present GOI five year plan, with reference to small scale irrigation development.

The team objective was to produce a project design study that could be implemented to ..."improve the Government of Indonesia's institutional capability to increase food production by improving the performance of small-scale irrigation systems ... and implement improvements, including alternative water delivery options". The report also listed secondary objectives as part of the proposed design, which were:

* improve reliability and duration of the irrigation water supply to 30,000 hectares,
* improve the capability of village level organizations to operate and maintain Small-Scale Irrigation Systems,
* introduce and test several new technologies and institutional arrangements,
* monitor and evaluate the evolution of Small-Scale Irrigation development strategy, and
* identify the indicators and optimal mix of public and private responsibilities.

A comparison of the above objectives with the key management objectives on page 7 of this study, we can see that tho team's consideration of "...institutional capability to increase food production by improving the performance of small-scale irrigation systems..." addresses the goal of increased agricultural production through increased farmer welfare. In the secondary objectives listed above we can see specific reference to the objectives of increased water control and effective organization and coordination, with particular emphasis on farmer involvement. The design recommendations of this report include the implementation of an environmental impact statement. This implies the consideration of the resource conservation objective by the team. However, the explicit evidence of such considerations is limited in the report. The key management objective of increased agricultural production is already addressed in the major objective of this study.

PERFORMANCE

The organization and coordination of the public works and the farmer organizations were of major importance in this study. The team used the performance indicators of level of organization of public works, and the existence of farmer institutions at the schemes visited. The team also considered the interaction between public works and the local irrigation works in different types of irrigation schemes. This information could have been used as desired performance of the coordination between the National public works and the local organizations for small-scale irrigation.

The report also refers to social soundness as a measure of the particular scheme's ability to support improved small scale irrigation development. This "social soundness" could be interpreted as the level of local organization. In addition, the team assessed the "technical level of run-of-the-river schemes. This information came from the individual scheme visits but was used as a general assessment of the technical levels within the public works organization. The data collected included description and configuration, diversion structures, conveyance structures, planning, design, operation and maintenance, design standards, problems with present design practices, technical challenges and innovative solutions. From this list, we can conclude that the team were considering the existence of major physical components of small-scale irrigation schemes, and the planning, design and operation. This implies the consideration of both the farmer organization and the public works technical abilities.

The team were concerned with the performance of individual schemes and the performance of small-scale irrigation at a regional level. The visits to the schemes were relatively short and the variables collected were restricted to interviews with key informants, observations by the team, and a few physical measurements. Because of this emphasis on secondary and observed data the team relied heavily on the local professionals to identify key informants and provide them with background information. This local professionals were crucial as little data existed concerning small-scale irrigation schemes in Indonesia.

As well as assessing the present state of small-scale irrigation in Indonesia, the team had to select schemes to be included in the project design. The schemes were selected on the expected yield increases from the projected improvement of irrigation and increase of irrigated area.

CONSTRAINTS

The team identified the general constraints in small-scale irrigation schemes as uncertainty and seasonal variation of water supply; limited technical capability of Public Works personnel especially if present plans are implemented; unreasonable amount of increased staff would be required to establish government controlled systems in place of the existing systems; and limited technical, institutional and financial capabilities at the village level.

A comparison of these findings with the objectives and performance discussed above suggests a relatively complete logic on the part of this team. They were primarily concerned with the sector and the constraints identified were, therefore, related to the sector. The data collected from specific schemes were used to identify these general constraints. The emphasis in the performance indicators assessed was on the public works and local organizations, the constraints identified are primarily concerned with these organizations and their technical abilities to support the intended project.

RECOMMENDATIONS

The team made six specific recommendations. These were shifting the development policy of Public Works away from government managed to farmer managed small-scale systems, improve village-level irrigation systems other than through Public Works programs, identify the dynamics of the small-scale system, identify the secondary impacts of small-scale irrigation development and their importance in evaluating project feasibility, study the effect of different cropping patterns, and support the irrigation schemes through improved agronomic practices.

Comparing these recommendations with the constraints identified above we can see that the team were addressing the limited ability of the national level public works to under take the intended project. The other recommendations are aimed at further study of specific irrigation schemes. This is due to the secondary nature of the information already established.

In a more general context, the team recommended that the project should follow a policy of augmentation, decoupling, and capacitation. Augmentation is the improvement of water supply, decoupling is the creation of a distinct division between the responsibilities of the Public Works and the farmer organizations, and capacitation is increasing the capability of existing systems and organization to implement the other two. These recommendations are addressing the constraints of uncertainty and variation in water supply, and limiting government involvement in water control in order to reduce the necessary staffing levels.

The Indonesian project initially recommended project sites on Java, Sumbawa and Timor. These areas had been selected before the team arrived. Upon completion of the report USAID and GOI decided that no further development was required on Java. The team was recalled to conduct the same study on Sulawesi, which has now been chosen as the third area. This confusion concerning the regions to be considered appears to have arisen from not identifying the specific objectives of the GOI in the initial stages.

DISCUSSION

In this diagnosis, the team was supported by three local engineers from the USAID Mission and public works professionals at the regions visited. This inclusion of Mission personnel appears to have facilitated the inclusion of USAID objectives in the diagnosis. The confusion over the GOI objectives may have been avoided had there been more central public works involvement in the team.

The absence of a good data base concerning small-scale irrigation at the National and Regional level required that the team relied on the field visits. The advance party of graduate students appears to have offset the lack of available data, to some extent. Much of the emphasis was placed on the organizations involved in small-scale irrigation development including the public works and the farmer institutions.