Working Paper No. 35

IMPACT OF MANAGEMENT INTERVENTIONS ON THE PERFORMANCE OF FIVE IRRIGATION SCHEMES IN SRI LANKA

K.A.U.S. Imbulana
and
Douglas J. Merrey

IIMI

INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE

Imbulana, K.A.U.S.; and Merrey, D.J. Impact of management interventions on the performance of five irrigation schemes in Sri Lanka. Colombo, Sri Lanka: International Irrigation Management Institute (IIMI). xiii, 76p. (IIMI working paper no. 35).

/ irrigation programs / performance evaluation / irrigation management / intervention / irrigation systems / monitoring / performance indexes / history / farmers' associations / farmer participation / farmer-agency interactions / communication / organizations / water potential / rice / crop yield / water supply / land productivity / rain / data collection / Sri Lanka / Dewahuwa / Mapakada / Parakrama Samudra / Rajangane / Ridiyagama /

DDC: 631.7
ISBN: 92-9090-318-X

Information Office
International Irrigation Management Institute
P.O. Box 2075
Colombo
Sri Lanka

Contents

Figures

Tables

Preface

This working paper is the outcome of a data collection process initiated under the advice of Dr. Shigeo Yashima of the International Irrigation Management Institute (IIMI). The objective of this data collection process was to make a preliminary assessment of irrigation performance in Sri Lanka using irrigation systems with different backgrounds to identify areas for further research.

The data were collected from the Irrigation Department, the Irrigation Management Division and the Agriculture Department. Grateful acknowledgment is made of these organizations for their cooperation. We wish to make a special mention of the following personnel from these three organizations.

In the Irrigation Department, we wish to thank Mr. D.W.R. Weerakoon, Senior Deputy Director for Operation and Maintenance and Mr. Linton Wijesooriya, Senior Deputy Director for Rehabilitation, for allowing us to use the data and for their assistance in the selection of schemes. Our thanks are also due to Mr. G.T. Dharmasena, Deputy Director of the Hydrology Division, for releasing rainfall figures of the Ridiyagama Scheme. We also wish to thank the Irrigation Engineers Nihal Palipana, Sriyani Weeratunga, Manel Fernando, Sarath Wijesekara and Shirley Perera, for various forms of assistance including the locating of missing data for us.

In the Irrigation Management Division, the cooperation extended to us by the Additional Directors, Mr. W.H.E. Premaratne and Mr. S. Dhanansooriya, are greatly appreciated. In addition, we wish to express our gratitude to the Project Managers of Dewahuwa, Nagadeepa, Parakrama Samudra, Rajangane and Ridiyagama, for providing data.

We also wish to make use of this opportunity to extend our sincere thanks to Mr. J.K.V. Ranjith, Assistant Director of the Agriculture Department, Hambantota, for his quick response to our requests for data.

Dr. R. Sakthivadivel kindly consented to review this document. This work immensely benefited from his comments and suggestions. The support and advice provided to us by Dr. Ramesh Bhatia as the leader of the Performance Program are also gratefully acknowledged.

Finally, it must be stated that the first author has been responsible for data collection and analysis and writing the first drafts of this paper during the period he worked as a Research Officer at IIMI. The second author's role has been to support and assist the efforts of the former. However, both authors are jointly and fully responsible for the paper.

K.A.U.S. Imbulana
Irrigation Department

Douglas J. Merrey
International Irrigation Management Institute

Executive Summary

Sri Lanka's irrigation systems have evolved through centuries to their present state. A rapid expansion of irrigated agriculture, especially rice cultivation, was experienced after independence in 1948. However, cropping intensity and ratio of harvested area to planted area do not show an appreciable improvement in comparison to the increase in irrigated area and crop yields. This is despite various interventions made to improve irrigation performance, including structural rehabilitation and increased farmer participation in management.

This situation gives rise to three research questions on irrigated agriculture in Sri Lanka. They are as follows:

1. Is the full performance potential of irrigation systems being realized?

2. Why do the irrigation systems achieve or not achieve their potential?

3. Is the present data collection system (of national agencies) adequate to make an effective assessment of irrigation performance?

This study makes a preliminary assessment of the performance of five irrigation systems in Sri Lanka, with a view to answering these research questions. It was intended to achieve this through meeting the following specific objectives:

1. Assessing the impact of management interventions on the performance of irrigation systems.

2. Comparing the water use and performance levels among the five irrigation systems.

3. Suggesting improvements in data collection and performance assessment procedures practiced at present by Sri Lankan irrigation agencies.

The Dewahuwa, Mapakada, Parakrama Samudra, Rajangane and Ridiyagama irrigation schemes were selected for the study. The interventions assessed by this study include crop diversification, structural improvements, and shared management with farmers. In Ridiyagama there were no interventions of significance until 1990.

The results show significant performance gains in water use and productivity in the Rajangane Scheme. The results are mixed in Parakrama Samudra—where performance related to water use has improved while agricultural performance has declined—and in Mapakada—where agricultural performance has increased while water use performance has declined. In Dewahuwa and Ridiyagama, performance has declined with respect to several performance indicators.

The results identify a single factor which has influenced the performance gains related to water use—decreasing the length of the irrigation season. They indicate that interventions which combine both structural and institutional improvements have greater impacts on performance. The following features of management interventions have been found to contribute to good performance:

1. Heavy management bias in rehabilitation projects.
2. Active farmer participation in rehabilitation projects.
3. Farmer participation in management of the system.
4. Structural improvements.
5. Facilities to improve water management.
6. Agronomic practices leading to low water use per unit land.

The following factors impede performance gains:

1. Lack of motivation due to good water availability.
2. Deviation from the usual cropping calendar.
3. Preparation of irrigation schedules without regard of the rainfall pattern.

Further, it appears that overall, Operation and Maintenance (O&M) funds allocated to the Irrigation Department are insufficient to meet the maintenance requirements. This can lead to deterioration of the system even after structural improvements.

A comparison with the best performance recorded during the study period (1984 to 1993), indicates that the irrigation systems are operating below their potential. The results also indicate that full use of rainfall is not made, that the emphasis on water management in some interventions is inadequate, that the length of the irrigation season could be further reduced, and that there is in general stagnation or even decline in the performance of these systems on most parameters. These factors also support the hypothesis that the irrigation systems are operating below their potential.

Because the scope of the available data is limited, a literature survey was made to identify other factors which could lead to achieving the potential performance. Such factors include institutional conditions which provide incentives for good performance, presence of a management cycle through which managers plan, implement, monitor and evaluate their work with the aim of achieving the objectives, and regular assessment of irrigation performance.

The present performance assessment system used by the national agencies seems to be inadequate to make a meaningful contribution to irrigation performance. The data collection system has many shortcomings. Several suggestions are made to improve the performance assessment and data collection systems. They include sharing of the data collected by different national agencies, soliciting farmer cooperation and participation in data collection, and adopting computerized Irrigation Management Information Systems (IMIS).

1. Introduction

1.1 BACKGROUND

1.1.1 Physical Setting

Sri Lanka has a tropical monsoon climate due to its close proximity to the equator. The main contribution to the total annual rainfall is from the monsoonal rains. The northern and eastern parts of the country receive the major part of their rainfall from the northeastern monsoon, from October to March. The southwestern monsoon, which occurs from March to September, provides most of the rain for the southwestern and western parts of the island. The rainfall pattern divides the country into a Dry Zone and a Wet Zone, at the 1.9 meters (m) isoheyt (Framji et al. 1983). A more detailed classification divides the country into a Dry Zone, an Intermediate Zone and a Wet Zone. In the Dry Zone the annual rainfall is less than 1,905 millimeters (mm), and in the Wet Zone the annual rainfall is more than 2,540 mm (Jayawardane and Jayasinghe 1992).

There are two cultivation seasons in Sri Lanka. The rainy season called *maha* is from October to March, and the dry season called *yala* comes between March and September.

1.1.2 Historical Development of Irrigation in Sri Lanka

Numerous studies have been conducted on the hydraulic civilization in Sri Lanka. These studies have been facilitated by the survival of sections of the ancient irrigation systems.

Researchers have adopted different approaches to explain the evolution of irrigation systems in Sri Lanka. According to the irrigation eco-system approach, the evolution took place in several stages. Starting with rain-fed agriculture, the irrigation methods developed through river diversion structures and the associated channel system to the more elaborate storage reservoirs equipped with sluices and access towers (Mendis 1989). According to the records kept from ancient times, the oldest existing reservoir was built in the 4th century B.C. in the North Central Province (Arumugam 1969). Since then, the subsequent monarchs built a large number of irrigation works. But after the 12th century, the irrigation systems began to deteriorate. The British, who occupied the entire island after 1815, renovated a large number of ancient irrigation works, and initiated land policies for the new settlers (Arumugam 1969).

In 1948, Sri Lanka gained independence from the British. Two of the most significant events related to irrigation in post-independent Sri Lanka were the completion of the Gal Oya Scheme in the Eastern Province in the 1950s, and the completion of the Mahaweli Development Program in the late 1980s.

1.1.3 Present Status of Irrigation Performance

The percentage of irrigated land in Sri Lanka is about 60 percent of the total arable lands (FAO 1991). The major portion of the irrigated land is planted with paddy (rough rice). For example, the area cultivated with nonrice crops under irrigation in 1991 was 29,225 hectares (ha) in maha and 42,146 ha in yala (Jayawardane et al. 1993), out of approximately 550,000 ha of irrigated land. This is despite recent attempts to diversify the crops in irrigation schemes. As a result, the changes in irrigated area can be approximated with changes in rice planted area under irrigation.

Sixty-one percent of the irrigated land comes under major irrigation schemes, which are defined as schemes with command areas of 80 ha or more. Lands under major irrigation schemes have increased by 160 percent in the last 30 years, while the increase in the total land irrigated to rice was 60 percent for the same period (see Table 1).

Table 1. Changes in rice land area (area in 1,000 ha).

Period	Irrigated land		Total irrigated land*	Rain-fed land	Total agricultural land
	Major schemes	Minor schemes			
1950-59	114.2	167.7	281.9	161.1	443.0
1960-69	160.9	175.9	337.7	183.8	521.5
1970-79	226.8	184.1	414.1	212.3	626.4
1980-87	294.8	185.2	483.7	220.3	704.0

* Includes area under lift irrigation.

Source: Aluwihare and Kikuchi 1990.

Rice is the staple food of the majority of Sri Lankans. The country can be proud of the developments in rice production after independence in 1948. Rice production, as a percentage of the total requirement, has increased from about 40 percent immediately after independence to about 90 percent in the mid-1980s (Aluwihare and Kikuchi 1990). Table 2 describes the present situation of rice cultivation.

Table 2. Statistics of rice cultivation for the period, 1987-1991.

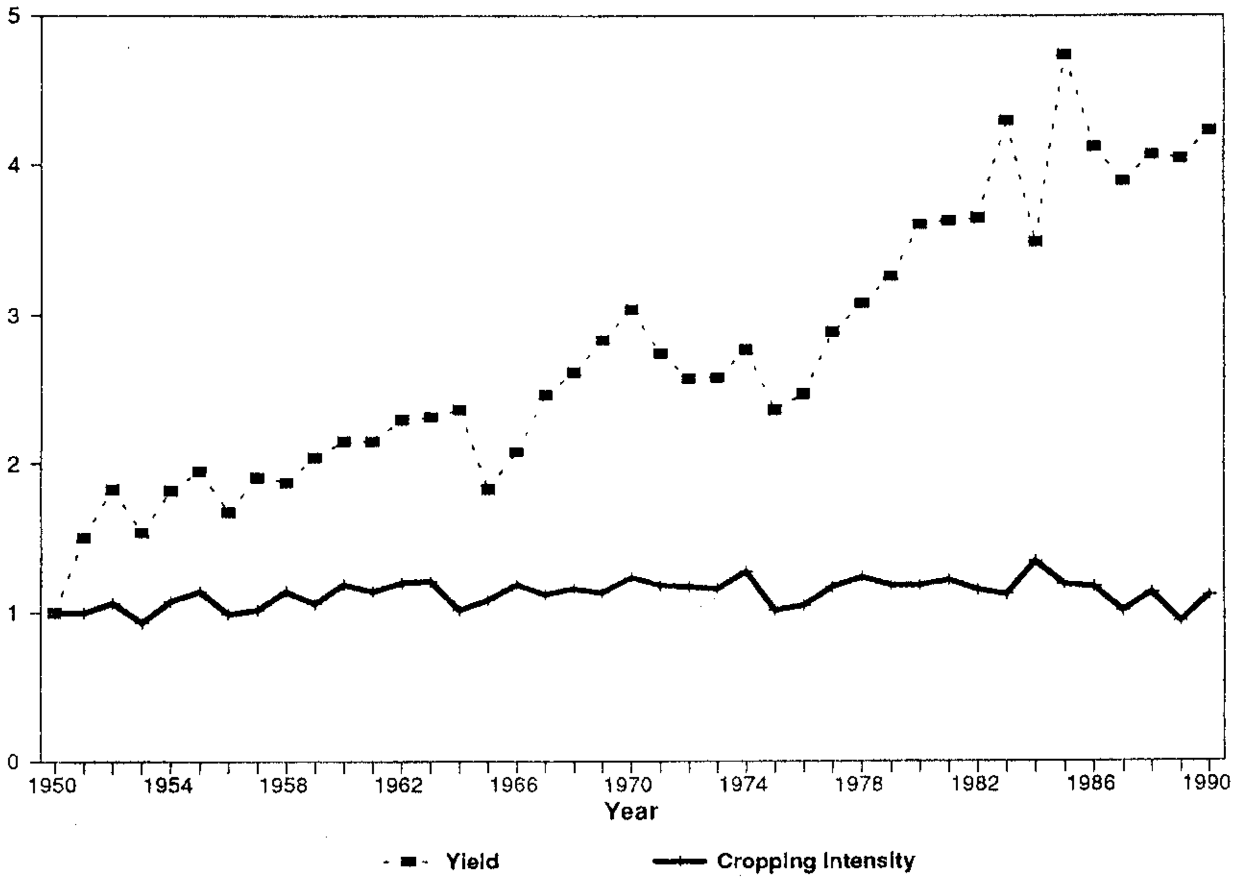
Parameter	Maha	Yala	Total
Cropping Intensity	70.0	41.1	111.1
Yield (kg/ha—rough rice)	3,546.2	3,265.0	3,405.6
Production (1,000 mt)	1,492.0	826.6	2,318.6

Source: Department of Census and Statistics 1992.

Yield increases resulting from the development of improved varieties of rice and increases in the area irrigated, contributed to this success. Irrigated land area was increased through large investments in irrigation infrastructure, in the form of new construction, restoration of ancient schemes, and rehabilitation. The Mahaweli Development Program also contributed to the increase in the irrigated area. The development of most of the river basins for irrigation is now complete.

However, whether the full potential of irrigation is being achieved is a matter of concern. Figure 1, where Rice Yield and Cropping Intensity as a ratio of the base value at 1950 are plotted, compares the increases of those two parameters since 1950. It shows that the increase in Cropping Intensity has not kept pace with the increase in yield or the increase in irrigated land shown in Table 1. The present level of Cropping Intensity, given in Table 2, appears to be low.

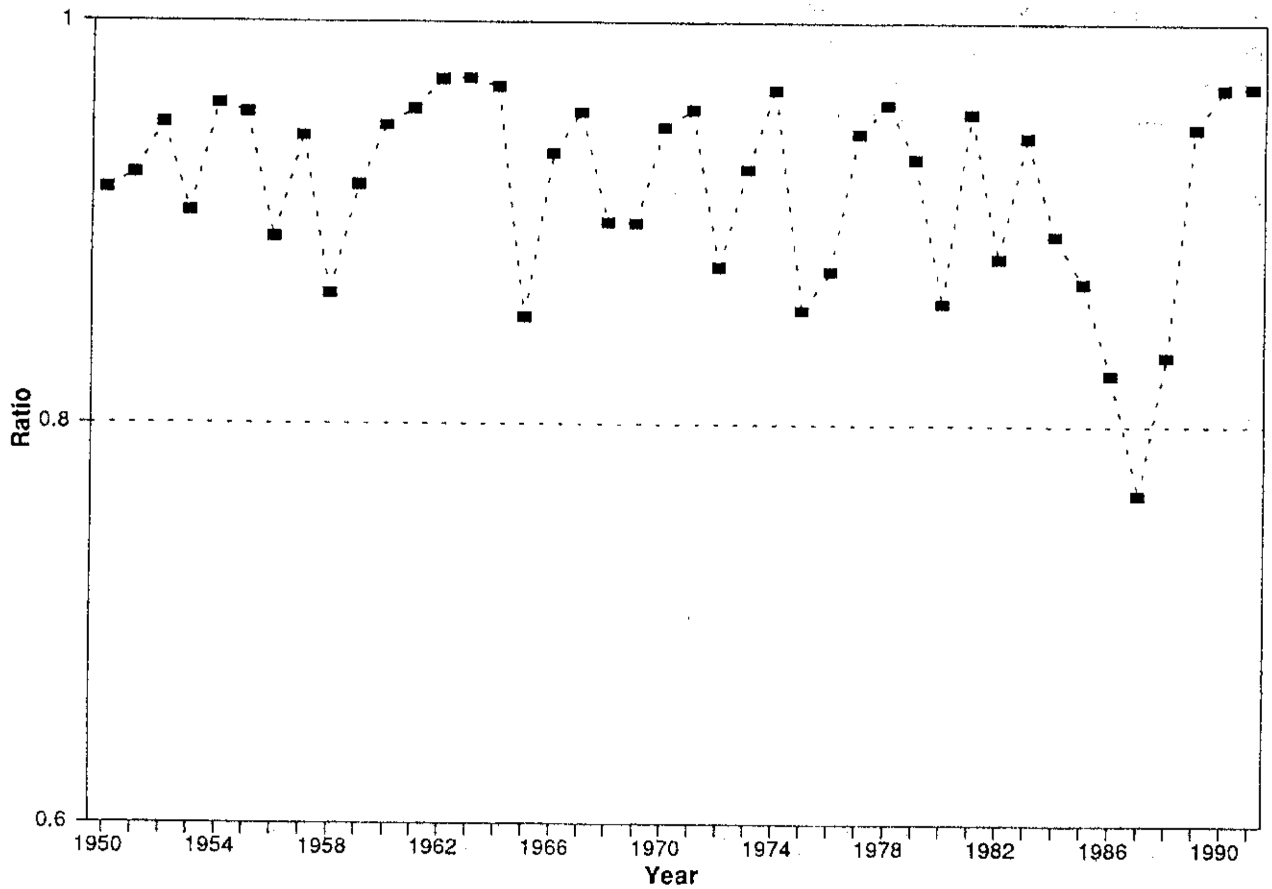
Figure 1. Trends of Rice Yield and Cropping Intensity, 1950-1990.



Sources: Aluwihare and Kikuchi 1990 and Department of Census and Statistics 1992.

Figure 2 shows that the ratio of harvested area to planted area has been fluctuating over the years. There seems to be no appreciable increase in this ratio, indicating that the dependability of agricultural production has not improved.

Figure 2. Ratio of harvested area to planted area.



Sources: Aluwihare and Kikuchi 1990 and Department of Census and Statistics 1992.

This is not a very satisfactory situation, because Table 3 shows that the population depending on agriculture for its livelihood has increased by about 20 percent in the period from 1975 to 1990. In the same period, the economically active population in agriculture has increased by about 27 percent, although agricultural workers as a percentage of the economically active population has slightly decreased from 54.3 to 51.7 percent. These figures show that a substantial proportion of the population of Sri Lanka is engaged in agriculture for a living. Inadequate alternative employment may have forced people to remain engaged in agriculture. But inadequate benefits will have undesirable social effects, as witnessed in two armed rebellions by the rural youth within the past 25 years.

Table 3. Changes in population statistics from 1975.

Year	1975	1980	1985	1990
1. Population	13,603	14,819	16,110	17,217
2. Agricultural population	7,389	7,907	8,463	8,899
3. Economically active population	4,773	5,457	5,915	6,364
4. Economically active population in agriculture	2,593	2,912	3,107	3,289
5. No. 4 as a percentage of No. 3	54.3	53.4	52.5	51.7

Source: FAO Production Yearbook 1990.

1.2 RESEARCH OBJECTIVES AND RESEARCH QUESTIONS

1.2.1 Research Questions

The highest level of performance which can be achieved given the available resources, such as water, land and crop varieties, can be defined as the "full potential performance" of an irrigation system. The level of performance is measured by indicators such as Cropping Intensity.

The irrigation sector statistics discussed above show that although the area with irrigation facilities has increased, the Cropping Intensity has not increased significantly during the past forty years. Several reasons can be suggested for this. One is that the command areas under a large number of irrigation schemes have increased from their original designed area. As shown in the following sections, the specified areas of the irrigation schemes selected for this study have increased by amounts ranging from 4 to 45 percent. As a result, sometimes the water resources may be inadequate to achieve the originally designed Cropping Intensity. Another reason is the poorly planned exploitation of the watershed which results in reducing the inflow to the reservoirs. An example for this is the Mahakanadarawa Scheme in the North Central Province which experiences an acute shortage of water due to the rehabilitation of several smaller tanks in the watershed (Abeysekera 1993).

However, a review of past studies on irrigation management show that there is both a need and an opportunity to improve the water management practices. Many irrigation schemes still do not have measuring devices at secondary canal level. The problems associated with water supply and control include inequity and unreliability (Fowler and Kilkelly 1987a). These observations form the basis for the first research question: **Is the full potential performance in irrigation systems being realized?**

As discussed above, many factors contribute to the inability of irrigation systems to achieve their potential performance. Management interventions are made with the intention of improving the existing performance levels. But researchers sometimes find that those management interventions have not achieved their targets. An irrigation manager who wants to improve the performance of an irrigation system or a policy maker who wants to implement a management intervention is interested in knowing the factors which contribute to good performance. Therefore, the second research question is as follows: **Why do the irrigation systems achieve or not achieve their potential?**

Assessment of performance is a necessary first step to identifying the weak points in the management process which hinder good performance. Similarly, it is important to evaluate whether the management interventions implemented on an irrigation system have achieved their objectives through performance assessment. Therefore, the third research question is as follows: **Is the present data collection system adequate to make an effective assessment of irrigation performance?**

1.2.2 Objectives

The purpose of the present study is to do a preliminary assessment of the performance of five irrigation schemes, using available data, and to provide a base for future studies on performance. It is also expected that this exercise will provide an insight into the data availability, quality of data and data needs for comprehensive performance assessment.

The specific objectives of the study are as follows:

1. To assess the impact of management interventions on the performance of irrigation systems.

2. To compare water use and performance levels among the five irrigation systems.

3. To suggest improvements in data collection and performance assessment procedures practiced at present by Sri Lankan irrigation agencies.

The present study provides an insight into the adequacy of data bases maintained by Sri Lankan irrigation agencies for the assessment of performance of their irrigation systems and management innovations. It will also contribute to the establishment of a database of comparative information on different irrigation systems.

1.3 RESEARCH APPROACH

1.3.1 Type of Irrigation Systems

In 1988, the number of major irrigation schemes in Sri Lanka stood at 395 (Wijesooriya 1990). There is a much larger number of minor irrigation systems. These irrigation schemes have widely differing characteristics. Some attributes of the irrigation schemes which can influence irrigation performance are as follows:

1. Age of the irrigation system.
2. Whether the system was recently rehabilitated or not.
3. Water availability.

4. Location.
5. Size of the system.
6. Management system.
7. Whether the scheme is an old scheme or a new settlement.
8. Design principles and methodology.

To create a representative sample of irrigation systems in Sri Lanka, the ideal sample should be stratified using all the above attributes. However, data and resource limitations have restricted the selection of irrigation systems. Therefore, this study is exploratory, not definitive; its results would require further validation before generalizations can be made about irrigation system performance in Sri Lanka.

1.3.2 Basis of Selection

The selection of irrigation schemes comes under and was based on discussions with the Irrigation Department (ID). The following were also considered in this regard:

1. Schemes should cover as many different attributes as possible.
2. Schemes should cover a variety of interventions intended to improve performance.
3. Data available in the head office should be as continuous as possible.

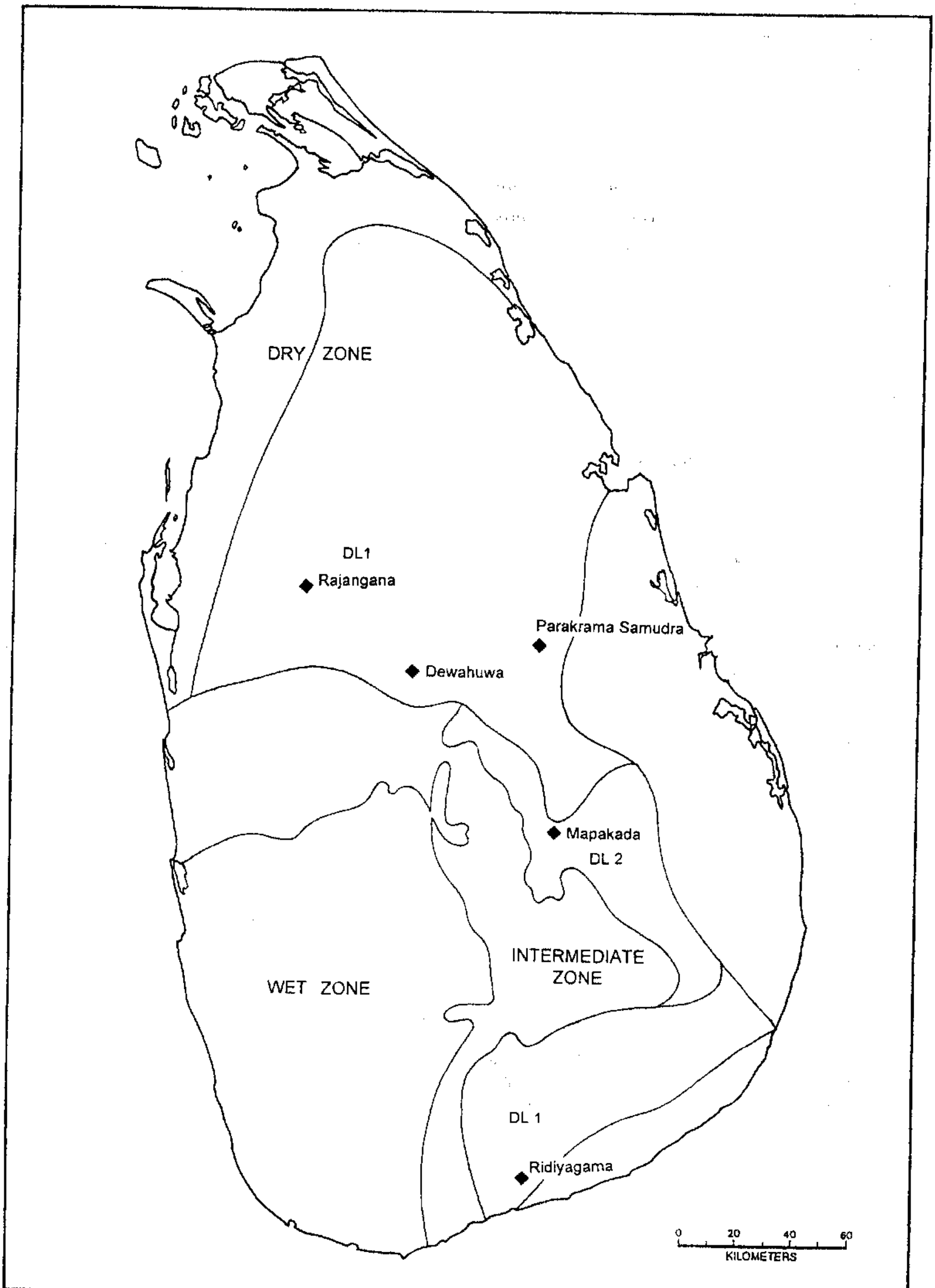
The selected irrigation schemes are listed in Table 4. Their locations in relation to agro-ecological regions and rainfall patterns are shown in Figures 3 and 4, respectively.

Table 4. Irrigation schemes selected for the study.

Scheme	Command area (ha)	Intervention
Dewahuwa	1,214	INMAS, crop diversification
Mapakada	548	IRDP, INMAS
Parakrama Samudra	9,794	ISMP, INMAS
Rajangane	5,600	MIRP, INMAS
Ridiyagama	3,440	INMAS

Notes: INMAS = Integrated Management of Major Irrigation Schemes.
IRDP = Integrated Rural Development Program.
MIRP = Major Irrigation Rehabilitation Project.
ISMP = Irrigation System Management Project.

Figure 3. Location of irrigation systems and agro-ecological regions.



a. Area Irrigated per Unit Water (ha/MCM)

This is calculated per unit of irrigation supply and per unit of total water supply separately. The total water supply is defined as the sum of rainfall and irrigation supply.

Effective rainfall is a complex parameter to calculate, because it is dependent on the depth of water in the field before the rainfall event, intensity and duration of rainfall, field bund heights, crop characteristics, and soil characteristics. As the data are insufficient to calculate effective rainfall accurately, it was decided to use the value of rainfall without adjustment in the analysis.

Considering the fact that the results would be used only for comparison, it is expected that inaccuracies introduced by these approximations would be minimal.

b. Irrigation Intensity

Irrigation intensity is defined as the gross irrigated area divided by the cultivable command area (Muralidaran and Krishna 1993). The cultivable command area used here is the present area and not the design area.

The value of this indicator will indicate the water availability to the system as well as the changes in land utilization as a result of management interventions.

c. Irrigation Duty

Irrigation Duty is used as an indicator here because it is widely used in Sri Lanka and design values are available. It is defined as the amount of water delivered from the sluice to the farm for land preparation and crop water requirement (Ponrajah 1988). It is expressed as the area irrigated per unit discharge and also as a depth.

According to Technical Note 6 of the Irrigation Department, the Irrigation Duty for 135-day rice in maha is 1.33 m (4.36 ft.), and for 105-day rice in yala, 1.7 m (5.56 ft.). These estimates are based on 75 percent probability level long-term rainfall and uniform values for evaporation, seepage and percolation. As a result, these values need to be modified to suit the actual field conditions in irrigation scheduling. However, they can be used as reference values to compare with design stage estimations. To facilitate this comparison, the actual Irrigation Duty is expressed in this study as a depth.

d. Relative Water Supply

Relative Water Supply (RWS) is generally defined as the ratio of supply to demand (Levine 1982) in irrigation planning, design and operation. While the water supply is considered to be the sum of irrigation supply and effective rainfall, water demand comprises of crop evapotranspiration, seepage and percolation losses. The minimum value of RWS for optimum production depends on the management pattern of the system (Sakthivadivel et al. 1992).

A slightly different approach was adopted for the Diagnostic Analysis Study conducted in Minneriya and Kaudulla schemes in 1986-87 (Fowler and Kilkelly 1987b). This study defines water requirement as the difference between crop water requirement and effective rainfall. The water requirement further

1.4 SCOPE AND METHODOLOGY

1.4.1 Scope of the Study

The Irrigation Department of Sri Lanka has been maintaining water delivery records of the irrigation schemes classified as major schemes since 1984 at its head office. In most irrigation schemes the discharge is measured at the head sluice which delivers water to the main canal. Even though water delivery data are recorded below this level in a few irrigation schemes, these data are not transmitted to the head office.

Gauge readings for water delivery are taken by laborers employed for that purpose. At the Irrigation Engineer's office, these data are converted to discharges, usually by a draughtsman.

Irrigation Engineers are instructed to calibrate the gauge posts when changes to the canal profile occur. In addition, the Hydrology Division of the Irrigation Department conducts water balance studies on major reservoirs. If any discrepancy is detected, gauge posts are calibrated. In some schemes, the gauge posts are calibrated once a year regardless of whether the profile has changed or not. Such decisions are taken at the scheme level.

The data are checked at the Irrigation Engineer's office and are sent to the Range Deputy Director's office and the head office. They are checked once again at these offices, and clarifications of any discrepancies are obtained. At the end of a cultivation season, a seasonal summary is prepared at the head office. The summary includes irrigated area, crop types, total issues, rainfall, cultivation period and irrigation water duty. Clarifications are sought from Irrigation Engineers for any significant shortfalls.

The Irrigation Management Division (IMD), which coordinates the activities of several line agencies, collects agricultural data such as cultivated area, crops and crop yield. These data are obtained through line agencies, farmer organizations and surveys. The Project Managers employed by the IMD convey these data to the head office through their progress reports.

Irrigation Department data are used for the irrigated area and irrigable area, while IMD data are used for the cultivated area. While the irrigated area and cultivated area can differ, very large differences indicate the possibility of erroneous data. In such cases, the data were not used for performance estimations.

Irrigation Department data show that the irrigated area has increased over the years in all the schemes. The present value of the irrigable area instead of the designed area was used for the estimation of Irrigation Intensity and Cropping Intensity.

The data collection for this study is restricted to what could be obtained from the Irrigation Department head office and the IMD head office. Because of the late start of the INMAS Project in Ridiyagama, agricultural data for this project were obtained from the Agriculture Department.

1.4.2 Performance Indicators

A comprehensive set of performance indicators is being developed by the Performance Program of IIMI. However, the availability of data restricts the selection of indicators. Hence, the following set of indicators was selected considering the available data.

10 percent deviation (0.9-1.1)	=	good performance
20 percent deviation (0.8-1.2)	=	fair performance
More than 20 percent deviation	=	poor performance

e. *Irrigation Water Productivity*

Irrigation Water Productivity in this report is defined as crop production per unit irrigation water. Because of the unavailability of data on the production of Other Field Crops (OFCs), only rice production will be used for the analysis. It is assumed that when the OFC cultivated area is less than 10 percent of the cultivated area, the irrigation issues will not be significantly affected by OFCs and will be based on rice water requirements. Consequently, when the OFC cultivated area exceeds 10 percent of the cultivated area, Irrigation Water Productivity is not calculated due to the uncertainty of water allocation policies.

f. *Cropping Intensity*

Cropping Intensity, which is defined as the ratio of total cultivated area to cultivable area, is calculated annually. The year is considered to start with the maha season and end with the yala season. The total cultivated area is obtained from records of the Irrigation Management Division, while the cultivable area is obtained from Irrigation Department records.

g. *Land Productivity*

Land Productivity can be defined in two ways. The first is to define it as the ratio of total production for the year to average cultivated area. The value of Land Productivity calculated using this method is related to Cropping Intensity. The second method is to define it as the ratio of total production to total area cultivated (sum of the area cultivated each season), which is in effect the weighted average yield for a single season.

Some of the schemes selected for this study cultivate OFCs in the yala season while others cultivate mainly rice during both seasons. As a result, adoption of the first definition will lead to confusion when the performances are compared, because production from different crops have different values. Hence, using the second method of definition, Land Productivity is defined here as the total production of rough rice divided by the total area cultivated during the year.

1.4.3 Other Indices

The length of an irrigation season is used as an index to assess the immediate impact of interventions. The major crop in the selected irrigation schemes is rice. Since the crop growth period is fairly constant, the variable is the land preparation period. Minimizing the land preparation period will result in shorter irrigation periods. This will ultimately result in saving a significant amount of water. It will also provide sufficient time for the maintenance activities.

Timely, adequate and equitable water supply; better communication between farmers and officers; and adherence to the agreed cropping schedule are expected to shorten the irrigation period. As a includes losses in the canal up to the delivery point. According to this approach, the optimum value of RWS is 1.

The present study combines the two approaches. The definition of RWS is the same as that of Levine (1982). But the irrigation supply at the point of interest is estimated using the available information on conveyance losses. As a result, the optimum value of RWS is 1. This allows the inclusion of different efficiencies of the irrigation conveyance system and rainfall utilization in the RWS calculations.

Since the actual field data on conveyance losses and rainfall losses are not available, the parameters needed to calculate RWS were estimated as follows:

Losses from sluice to farm	=	40 percent
Seepage and percolation rate	=	4 mm per day in the Dry Zone
	=	6 mm per day in the Intermediate Zone
Effective rainfall	=	70 percent in maha
	=	100 percent in yala

These values were arrived at after studying the norms set by the Irrigation Department (Ponrajah 1981); the survey of formulae and methods included in Dastane (1974); and the results of field studies done in the Dry Zone (Somapala 1985), Parakrama Samudra (Fowler and Kilkelly 1987a), Minneriya (Fowler and Kilkelly 1987b) and Kaudulla (Abernathy and Weller 1987). The following factors which are not usually included in the formulae and estimates were also considered:

1. Water lost due to seepage and percolation from one rice field is not wasted completely. Part of it seeps into adjoining rice fields. A portion of what is intercepted by the drainage canals is also diverted to the farms.

2. The portion of rainfall which evaporates in the atmosphere without reaching the ground surface contributes to crop water needs by lowering the temperature and increasing the humidity which results in reduced evapotranspiration.

3. Rain which is intercepted by plants and evaporates without reaching the ground is also useful in reducing transpiration (Dastane 1974).

4. The portion of rainfall which spills over field bunds is found to contribute to raising the ground water level. This indirectly reduces the water requirements (Elkaduwa 1990).

5. Since most of the Sri Lankan main canals are designed along contours, a portion of the surface runoff contributes to the canal flow.

The optimum value of RWS is 1, which refers to the situation where the supply perfectly matches the demand. Irrigation performance measured by RWS is categorized according to the following standards:

2. Irrigation Systems and Their Management

2.1 STATE ORGANIZATIONS INVOLVED IN IRRIGATION MANAGEMENT

2.1.1 Irrigation Department

Outside the Mahaweli areas, the construction of irrigation systems and the Operation and Maintenance (O&M) of all irrigation schemes having a command area over 80 ha are handled by the Irrigation Department. At the scheme level, an Irrigation Engineer with the assistance of Technical Assistants and Work Supervisors handles the O&M of the system.

Established in 1900 as a technical organization, the Irrigation Department has been paying greater attention to water management in recent times.

2.1.2 Irrigation Management Division

In 1984, the Government of Sri Lanka launched a program called the Integrated Management of Irrigation Schemes (INMAS) to improve coordination between the line agencies involved in irrigated agriculture. The Government also decided to recover a portion of the O&M cost from the farmers (M/L&LD 1984).

To facilitate this, the Irrigation Management Division (IMD) was formed under the Ministry of Lands and Land Development (M/L&LD). This division operates with a multi-disciplinary staff. At the irrigation scheme level, the Division functions through a Project Manager. He normally chairs the Project Management Committee meetings, where farmer leaders and line agency officials meet. An Institutional Development Officer and Institutional Organizers help him in institutional development activities on some schemes.

Some of the responsibilities of the division are:

1. Allocation of funds for O&M and improvement works in major irrigation schemes.
2. Establishment of farmer institutions in major irrigation schemes.
3. Monitoring the use of irrigation water and agriculture production activities.
4. Collection of O&M fees from farmers (M/L&LD 1984).[1]

2.1.3 Mahaweli Authority of Sri Lanka

The Mahaweli Authority is the coordinating body for the various agencies connected with the Mahaweli Program. These agencies handle construction, headwork maintenance, distribution of water to different schemes—including some which do not come under the Mahaweli Authority—and O&M of irrigation schemes.

[1]This latter function has not been implemented during the past few years.

result, this study will use the actual duration of the irrigation season as an index to measure the effect of some management interventions.

For land preparation, the officially estimated duration is 15 days. However, in most instances, farmers are unable to complete land preparation within this period, due to several constraints. So it is usual to allow 30 days for land preparation in most major schemes.

While many farmers grow long-term varieties in the maha season, short-term varieties are recommended for the yala season. Since the crop growth period for long-term varieties is 135 days and 105 days for short-term varieties, and assuming that the crops do not require water for the last 15 days of growth (Ponrajah 1981), the following norms can be calculated for this index:

Maha Season

Land preparation	=	15-30 days
Crop growth	=	135 days
- less	=	15 days
Total	=	**135 to 150 days**

Yala Season

Land preparation	=	15-30 days
Crop growth	=	105 days
- less	=	15 days
Total	=	**105 to 120 days**

Subsequently, the *Vel Vidane* System was established. The Vel Vidane was elected by the farmers and appointed by the authorities for a certain period. He was responsible for the supervision of the maintenance of irrigation canals, the distribution of water among the farmers, and the reporting of any breaches of irrigation regulations to the officers concerned (Abeyratne 1986). In the major schemes, his authority extended over the field channel system. For his services, the farmers had to pay him a portion of their production.

Under the INMAS Program and the subsequent Irrigation System Management Project (ISMP), the farmer organizations in the major schemes which came under those programs were institutionalized. The participatory management of irrigation systems was officially adopted as a government policy in 1988. In 1991, steps were initiated to hand over the management of the distributary canals to farmer organizations in the irrigation schemes coming under ISMP.

It is estimated that about 46 percent of the distributary canals are turned over to farmer organizations for O&M. There is a general feeling among the farmers that water distribution within the areas controlled by them have improved, which is attributed to the planning and supervision of water delivery activities by the farmers themselves. However, observations made at Rajangane indicate that funds for maintenance activities are still being provided by the Government. Operations within the areas turned over are also being subsidized. Farmers continue to view the responsibility of repairs to concrete and masonry structures as the responsibility of the Irrigation Department (Gamaathige et al. 1995).

2.3 COMMUNICATION BETWEEN ORGANIZATIONS

The organization of the Mahaweli Economic Agency (MEA) comprises different disciplines such as engineering, agriculture and community welfare. Thus, coordination between different disciplines is included in the structure. Matters related to cultivation are discussed at meetings with farmer groups organized by the MEA staff (Jayawardane and Jayasingha 1990).

Outside the Mahaweli Project area, the Government Agent has, until recently, been the key person to coordinate activities of the line agencies engaged in the irrigation sector of an administrative district. Matters related are discussed at the District Agricultural Committee (DAC) which meets once a month.

Before each cultivation season, a cultivation meeting (*kanne* meeting) is held for an irrigation scheme. It is chaired by the Government Agent and is attended by the respective officers of the line agencies, and all the farmers of the irrigation scheme. The main purpose of this meeting is to fix the dates for the season such as first and last dates of water issue, dates to complete canal clearing, etc. But related matters such as availability of seed paddy and crop insurance are also discussed.

Under the INMAS Program mentioned above, the field staff activities at the project level are coordinated at the Project Management Committee. This provides a better opportunity for communication since only the project level, and irrigated agriculture related matters are discussed at a

The Mahaweli Economic Agency is responsible for the agricultural, social, and economic development in areas coming under the Mahaweli Program. The organization of each project is headed by a Resident Project Manager. His staff comprises a Land Officer, a Water Management Engineer, a Marketing Officer, an Agricultural Officer, a Community Development Officer, an Accountant and an Administrative Officer. The project is subdivided into several blocks and each block is managed by a Block Manager. A block is further divided into units, managed by a Unit Manager assisted by a Field Assistant (Bandaragoda 1986).

The authors expected to include a Mahaweli System in the present study, but had to drop this idea for technical reasons.

2.1.4 Other State Organizations

Other state organizations involved with agriculture include the Agriculture Department, the Agrarian Services Department, the Land Commissioners Department, the Agricultural Development Authority, the Paddy Marketing Board, the Agricultural Insurance Board, state banks, the Department of Co-Operatives, and the Department of Rural Development.

2.2 FARMER ORGANIZATIONS

The history of Sri Lanka's irrigation provides evidence of the existence of farmer participation in irrigation activities from ancient times. Two distinct features of the ancient irrigation system were the small village tank and the large storage reservoir. The macro-irrigation eco-system based on the large storage reservoir contained one or more micro-irrigation eco-systems based on village tanks or river diversions, or both (Mendis 1989). There is evidence that major irrigation systems developed around major cities. Two main functions of this hydraulic system were to provide the city with water and provide the area around the city with a source of reliable irrigation supply. The management of small tanks located in the villages was the responsibility of the villagers. As a result, even during political upheavals which disrupted the functioning of the government and the maintenance of the major works, the village irrigation systems were sustained. Historical documentary sources credit monarchs with constructing and repairing parts of the irrigation system. However, there is no evidence to support the theory that the entire system was centrally controlled or managed (Leach 1959). Hence, it safe to assume that the management of the ancient irrigation system was shared between the beneficiaries and the state.

After the collapse of the hydraulic civilization in the Dry Zone, the first major attempts to restore the collapsed irrigation systems were made by the British. They wanted to increase the food production of the country by improving irrigation in order to reduce the cost of food imports and to stem social unrest to a certain extent. But they also wanted to be least involved in village level irrigation management. Under the policy they adopted, the Government financed a part of the rehabilitation cost while the *Gamsabhava*, or the Village Council became responsible for the management of the village irrigation system. The Irrigation Ordinance of 1856 gave legal recognition to this process. Sometime later, the Village Headman was also incorporated into the system (Abeyratne 1986).

This is an ancient scheme, which was restored in 1951. After restoration, farm families were resettled and allocated 2 ha for farming and 1.2 ha for homestead and highland farming. The deterioration of the physical system resulted in rehabilitation in the early 1970s (IIMI 1992).

This scheme came under the INMAS Program in 1984. Growing nonrice crops was promoted here from the start of the scheme. In 1985, IIMI started a research program with the broad objective of identifying and developing strategies to facilitate more intensive diversified cropping (IIMI 1992). This is reputed to be a scheme affected by water shortages.

2.4.3 Mapakada Scheme

This irrigation scheme is located in the Badulla District in the Uva Province. This is also an ancient scheme, which was restored in 1952-53 (Arumugam 1969). As shown in Table 5, this is the smallest scheme selected for the study having a catchment area of about 7 sq.km (square kilometers) and a capacity of 8.3 MCM (million cubic meters). The designed command area under the scheme is 376 ha. However, this has now expanded 46 percent to 548 ha.

This scheme came under the INMAS Program in 1984. The infrastructure was improved under the Badulla District Integrated Rural Development Program from 1983 to 1989. The improvements included rehabilitation of field channels and the provision of several farm lots with direct access to channels. The expansion of the command area is partly due to the rehabilitation (Palipana, Nihal. Personal communication. 1994).

2.4.4 Parakrama Samudra Scheme

The Parakrama Samudra Scheme (PSS) is located in the North Central Province which falls within the Dry Zone of Sri Lanka. Table 5 shows the catchment area as 73 sq.km and the capacity as 135 MCM. However, the main water source is the diverted inflow from Amban Ganga. At present, the inflow usually exceeds reservoir capacity in maha, and there are no serious water shortages in yala.

This scheme was originally built in the 12th century, by combining three existing smaller reservoirs and augmenting the supply by a diversion weir. Restoration of the irrigation system was completed between 1948 and 1952 by the Irrigation Department (Arumugam 1969). It was resettled with about 4,000 new farm families and each farmer was allocated approximately 2.5 ha of irrigable land and 1.2 ha of highland suitable for perennial crops and homestead. According to Table 5, the originally designed command area of 7,950 ha has increased 23 percent to about 9,800 ha.

The average annual rainfall is 1,470 mm. The major part of the rain falls between October and March, during the northeastern monsoon. The population density of the area is 98 persons per ha (Department of Census and Statistics 1992).

The major crop grown in the scheme is rice. This scheme came under the INMAS Program in 1984 and it was improved under ISMP from 1987.

limited gathering. In schemes where the Project Management Committee System exists, a "pre-kanna meeting" is held where important dates of an irrigation season are negotiated and agreed upon.[2]

For special irrigation projects and programs, national level steering committees or coordinating committees are established to coordinate the activities of the agencies.

2.4 DESCRIPTION OF IRRIGATION SCHEMES

2.4.1 Basic Physical Characteristics of the Five Schemes

Table 5 summarizes the basic physical characteristics of the five irrigation schemes.

Table 5. Basic physical characteristics of the five schemes.

Scheme	Catchment area (sq.km)	Reservoir capacity (MCM)	Designed command area (ha)	Present estimated command area (ha)	Percent change
Dewahuwa	67	10.9	945	1,214	28
Mapakada	7	8.3	376	548	46
Parakrama Samudra	73	135.0	7,950	9,800	23
Rajangane	1,611	101.0	5,370	5,600	4
Ridiyagama	31	27.0	2,513	3,440	37

Sources: Arumugam 1969.
Irrigation Department 1975.
ECL 1992.

O&M of the five schemes are managed by the Irrigation Department. Farmer organizations and inter-agency coordination is handled by the Irrigation Management Division.

2.4.2 Dewahuwa Scheme

The Dewahuwa Scheme is located in the Matale District of the Central Province. Table 5 shows that the command area under the scheme has expanded 28 percent from the designed command area of 945 ha (Arumugam 1969) to 1,214 ha.

---

[2]The system described above is what was in operation for the period covered by the study. Recently, the responsibilities of the Government Agent have been devolved to the Divisional Secretary. More importantly, the Irrigation (Amendment) Act of 1994 has legalized the authority of the Project Management Committee, in essence replacing the cultivation meetings.

3. Sub-Project Management Committee—This is established only in larger schemes. The purpose is to decentralize coordination activities. This is formed of representatives of DCOs and line agencies.

4. Project Management Committee—This is formed of representatives of the farmer organizations and officials of the line agencies.

In the Dewahuwa, Mapakada, Parakrama Samudra, Rajangane and Ridiyagama schemes which were selected for this study, the Project Management Committees are said to be functioning and active (Danansooriya, S. Personal communication. 1994).

2.5.2 Irrigation System Management Project (ISMP)

The ISMP commenced in 1986 with funds received from the United States Agency for International Development (USAID). The Project covers the four major irrigation systems in Polonnaruwa District of the North Central Province, Gal Oya Right Bank System, and an irrigation system in the North Western Province. The project implementation was through the Irrigation Management Division with the Irrigation Department handling the construction component.

The ISMP had wide ranging objectives which included farmer organization development, improvements to the physical system, financial management, training capacity enhancement, research, and promoting a monitoring evaluation and feedback system. Training for the Project and research activities in the form of Diagnostic Analysis Studies commenced in 1984. In the development of farmer organizations, the Institutional Organizer approach was adopted (Blank 1986). The Project further planned to hand over the distributary (secondary) level irrigation system to the farmer organization for management, and this program is underway now.

The Project had a heavy management orientation. As an indirect result, cost-effective construction methods such as rubble packing in place of retaining walls, and vertical mass concrete drop structures in place of reinforced inclined drops were introduced. Attempts were made to calibrate the irrigation structures instead of going for expensive flow measuring structures (Sakthivadivel and Merrey 1992). Apart from one study commissioned by IIMI and conducted by Engineering Consultants Limited (ECL 1992), substantial studies have not yet been done to draw conclusions on the performance of the project.

The handing over of irrigation systems to farmers for management started in 1991. Under the present system, a maintenance plan for the distributary canal is prepared by the farmer organization with the help of the Irrigation Department. Farmers' responsibilities include the maintenance of canals and canal roads inclusive of structures, in accordance with the plan. They are responsible for the security of the system and the resolution of conflicts among water users. Among the rights of farmer organizations are collecting fees, imposing sanctions against members, obtaining details of O&M of the main system and requesting technical assistance from the Irrigation Department on repairs.

2.4.5 Rajangane Scheme

This is a new irrigation scheme constructed in 1957. The command area spreads over the Anuradhapura District of the North Central Province and the Kurunegala District of the North Western Province. It has a catchment area of 1,611 sq.km and a capacity of 101 MCM (Arumugam 1969). The water supply to the reservoir is augmented by drainage water from the lands irrigated by the Kalawewa Reservoir of Mahaweli System H. As shown by Table 5, the designed command area under the scheme has increased slightly from 5,370 ha to about 5,600 ha at present (ECL 1992). Water resources are sufficient to cultivate the full extent in both seasons.

This scheme came under the INMAS Program in 1984. This is one of the schemes remodeled under MIRP from 1985.

2.4.6 Ridiyagama Scheme

The Ridiyagama Scheme is located in the Hambantota District of the Southern Province. Table 5 shows that it has a catchment area of 31 sq.km and a capacity of 27 MCM. The water supply is augmented by diverted waters from the Walawe Ganga. This scheme also rarely experiences water shortages.

The scheme was constructed in 1923-28 (Arumugam 1969) and the designed command area is 2,513 ha. The present area under command is 3,440 ha, a 37 percent increase. This scheme was planned to be brought under the INMAS Program in 1984. However, the actual implementation of INMAS began in 1990.

2.5 DESCRIPTION OF INTERVENTIONS

2.5.1 Integrated Management of Irrigation Systems (INMAS)

Essentially, the objective of this program is to establish closer coordination among the inputs and services needed for agriculture, thereby increasing agricultural productivity. Special focus is on the use of irrigation water (ML&LD 1984).

Under the INMAS Program and the subsequent ISMP, the farmer organizations in the major schemes which came under these programs were institutionalized. The organization structure presently being promoted by the INMAS Program is as follows:

1. Field Channel Group (FCG)—An association of farmers at the field channel level.

2. Distributary Canal Organization (DCO)—A formal organization of farmers served by one or more distributary channels. This is composed of representatives of FCGs.

3. Performance Evaluation

3.1 PERFORMANCE OF DEWAHUWA SCHEME

3.1.1 Performance Level and Changes

The data set available from the Dewahuwa Scheme is discontinuous and had to be supplemented with other sources such as IIMI research records. The estimated level of performance using available data is summarized in Table 6.

Table 6. Performance of Dewahuwa Scheme.

Performance indicator/parameter	Average (1984-1993)		Past performance (1984-1987)		Present performance (1991-1993)		Percent change	
	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
AIUW (ha/MCM) (irrigation only)	58.5	83.8	64.8	94.3	52.3	73.2	-19	-22
AIUW (ha/MCM) (total water)	41.1	74.4	39.9	82.1	42.3	66.0	+6	-20
Irrigation Intensity (%)	80	51	100	35	67	50	-33	+43
Irrigation Duty (m)	1.70	1.22	1.56	1.07	1.91	1.38	+22	-29
Actual Duty/Design Norm (%)	128	72	117	63	144	81		
Relative Water Supply	1.09	-	1.15	-	1.08	-	-6	-
Irrigation Water Productivity (tons/MCM)	289	-	325	-	262	-	-20	-
Total annual production (tons)	4,946	-	6,082	-	4,057	-	-33	-
Cropping Intensity (%) (annual)	116		137		117		-15	
Land Productivity (tons/ha)	4.74		4.85		4.99		+3	

Note: AIUW = Area Irrigated per Unit Water.

2.5.3 Integrated Rural Development Program (IRDP)

The IRDP was initiated with World Bank assistance in 1976. Some of the other organizations involved (for various districts) were International Fund for Agricultural Development (IFAD), NORAD, the Government of the Netherlands and the Government of Japan.

The aims of the project were as follows:

1. Spread development to areas not benefitting from lead projects such as the Mahaweli Development Program, the Greater Colombo Economic Commission (GCEC), and urban development and housing programs.

2. Help achieve balanced regional development.

3. Widen economic opportunities and enhance living conditions of the rural masses.

A basic feature of the Program was to have different programs for different administrative districts, with scope and focus varying to suit the field conditions. In some districts the irrigation sector received the major attention. The Program provided funds to improve medium and minor irrigation schemes. The Program principles stressed the importance of the participation of the intended beneficiaries (Peoples Bank 1989).

2.5.4 Major Irrigation Rehabilitation Project (MIRP)

The MIRP was funded by the World Bank and was implemented through the Irrigation Management Division, while the Irrigation Department attended to the physical improvements. The work started in 1985 and concluded in June 1993. It was originally planned to rehabilitate seven major irrigation schemes in North Central and North Eastern provinces. However, due to unstable civil conditions, work in three of the schemes had to be abandoned.

The Project objective was to increase agricultural production through rehabilitation and improvement of infrastructure and development of institutional organizations. A new approach adopted in this Project was to select a "pilot area" from each scheme to test the proposed improvements (Abeysekara 1993).

During the implementation period, the project was affected by problems like nonavailability of canal system data (Abeysekara 1993). Impacts of the rehabilitation effort were studied by ECL, under contract from IIMI (ECL 1992).

Table 7. Length of irrigation season.

Average		Past		Present		Recommended range	
Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
148	123	165	121	145	135	135-150	105-120

The longer duration of the maha season in the past period is influenced by the 1986/87 maha season which spanned over 176 days. This was cultivated in two staggers. If this season is excluded, the value goes down to 147 days. A decrease in the length of maha seasons can be observed from the results. However, the length of yala seasons has increased by about 12 percent.

3.1.3 Other Performance-Related Parameters

Changes in the performance-related parameters of rainfall, OFC cultivated area and rice yield are shown in Table 8.

Table 8. Performance-related parameters.

Performance-related parameter	Average (1984-93)		Past performance		Present performance		Percent change	
	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
Rainfall (mm)	696	141	946	161	446	120	-53	+25
OFC cultivated area (%)	-	78	-	100	-	100	-	0
Rice yield (tons/ha—rough rice)	4.96	-	4.85	-	4.99	-	+3	-

Note: OFC = Other Field Crops.

The past performance was evaluated using the 1984/85, 1985/86 and 1986/87 maha and 1985, 1986, and 1987 yala seasons. The present performance was measured using data from 1991 to 1993. Because of the high percent of OFC cultivation in the yala season, Irrigation Water Productivity and Relative Water Supply are calculated for the maha season only.

The results show that the performance has decreased with respect to most of the indicators used. One exception is Irrigation Intensity in yala season which has increased by 43 percent. The highest Irrigation Intensity in yala was 100 percent, which was recorded in 1988. Irrigation Intensity in maha shows a decrease of 33 percent, with all three seasons in the past period recording an Irrigation Intensity of 100 percent.

Annual Cropping Intensity has declined from 137 to 117 percent which corresponds with the decline of annual Irrigation Intensity from 135 to 117 percent. The highest Cropping Intensity recorded was 150 in 1985/86 and 1991/92.

The area irrigated per unit volume of irrigation water has decreased by 19 percent in maha and 22 percent in yala. The best performance with regard to this indicator was in 1984/85 maha and 1986 yala, where the values were 74 ha/MCM and 103 ha/MCM, respectively.

The same indicator calculated using rainfall as an input has increased by 6 percent in maha but decreased by 20 percent in yala. The best performance with regard to this indicator was in 1991/92 maha and 1986 yala, when the values were 43.4 ha/MCM and 91 ha/MCM, respectively.

Irrigation Duty has increased by 22 percent during the maha seasons and by 29 percent in the yala seasons. Compared with the Irrigation Duty of 1.33 m (4.36 ft.) for maha seasons specified in Technical Note 6 of the Irrigation Department, the duty in this scheme is 28 percent higher than that specified for the maha seasons. In the yala seasons, the Irrigation Duty is 29 percent lower than the specified norm of 1.7 m (5.56 ft.).

Relative Water Supply (RWS) has decreased by 6 percent during maha seasons. This decrease has resulted in an improvement of performance considering 1 as the optimum value of RWS. According to the categorization adopted, present irrigation performance measured by RWS is of a good standard in the maha seasons. The optimum value recorded for RWS was 1.02 in 1991/92 maha.

The results show that Irrigation Water Productivity has decreased by 20 percent. The highest value of Irrigation Water Productivity was 373 tons/MCM in 1984/85 maha.

Average Land Productivity per season has increased by 3 percent from 4.85 tons per hectare (tons/ha) to 4.99 tons/ha. The highest value for this indicator was 5.27 tons per hectare per season (tons/ha/season) recorded in 1989/90.

Total annual production has decreased by 33 percent from 6,082 tons to 4,057 tons in the maha seasons. The highest production figure was recorded in 1985/86 maha when the value was 6,300 tons.

3.1.2 Length of Irrigation Season

In Dewahuwa Scheme, the maha season usually started between late September and early November. The only exception was maha 1989, which started in January 1989. In the yala seasons, the starting date was within the first half of May, except yala 1984 which started in June.

The behavior of the length of irrigation season is shown in Table 7.

3.2 PERFORMANCE OF MAPAKADA SCHEME

3.2.1 Performance Level and Changes

The estimated level of performance of the Mapakada Scheme using available data is summarized in Table 9.

Table 9. Performance of Mapakada Scheme.

Performance indicator/parameter	Average (1984-93)		Past performance (1985-88)		Present performance (1990-93)		Percent change	
	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
AIUW (ha/MCM) (irrigation only)	65.0	48.6	69.1	49.7	63.9	46.3	-8	-7
AIUW (ha/MCM) (total water)	36.2	44.4	42.3	45.8	32.8	42.2	-23	-8
Irrigation Intensity (%)	100	100	100	100	100	100	0	0
Irrigation Duty (m)	1.6	2.1	1.5	2.0	1.6	2.2	+3	+10
Actual Duty/Design Norm (%)	120	123	113	118	120	129	-	-
Relative Water Supply	1.17	0.94	1.02	0.94	1.27	0.95	+22	+1
Irrigation Water Productivity (tons/MCM)	235	183	239	174	242	185	+1	+6
Total annual production (tons)	1,945	2,052	1,781	1,863	2,073	2,128	+16	+14
Cropping Intensity (%)	200		200		200		0	
Land Productivity (tons/ha)	3.63		3.32		3.83		+16	

Note: AIUW = Area Irrigated per Unit Water.

Rainfall in the maha season has decreased by about 53 percent, while in the yala season it has decreased by 25 percent. OFC cultivated area has remained at approximately 100 percent according to IMD data. The average value is 78 percent because rice was cultivated in the yala seasons of 1988 and 1989. As noted above, rice yields have increased by 3 percent from 4.85 tons/ha to 4.99 tons/ha.

It should be noted that according to IIMI studies done from 1985 to 1987, the rice cultivated area in yala varies between 8 and 20 percent. Hence, IMD data on OFC cultivated area seem to be approximate.

3.1.4 Impacts and Inter-Relationships

This scheme was included in the INMAS Program since 1984. Crop diversification was promoted in this scheme for a substantial period. This may have contributed to low Irrigation Duty in the yala season. Despite the increase in Irrigation Duty, it can be seen that it is still below the design norm in the yala season.

The results show that irrigation performance has deteriorated with respect to most indicators, particularly in the yala season. The reductions in the length of the maha seasons are not reflected in the values for other performance indicators except in RWS.

Table 8 shows that rainfall in maha has decreased by 53 percent. This would partially explain the increase in Irrigation Duty and decrease in Area Irrigated per Unit Water which are inter-related, despite the decrease in the length of the maha seasons. The effect of the decrease of rainfall is further reflected in the decrease in RWS and increase in Area Irrigated per Unit Water with rainfall included, in the maha seasons. The low Irrigation Duty in the yala season is probably associated with the high percentage of OFC cultivation.

Although the Irrigation Intensity in yala has increased, the annual Irrigation Intensity has decreased from 135 to 117 percent. With the available data, it cannot be ascertained whether the increase in cultivated area in yala was at the expense of the maha cultivation. However, it is evident that the overall performance of the scheme has declined.

The results show that the total annual production has decreased over the period. Apparently, the decrease of the cultivated area in the maha seasons has prevailed over the slight increase in rice yield.

The decrease in Irrigation Water Productivity is due to the decrease of production and increased irrigation water use resulting from decreased rainfall in maha.

A major cause for the drop in performance in maha seems to be the decreased rainfall. This has probably contributed to higher irrigation releases. Although the length of the maha season has decreased, this was not sufficient to offset the ill-effects of reduced rainfall on performance.

Table 10. Length of irrigation season.

Average		Past		Present		Recommended range	
Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
153	140	151	124	152	136	135-150	105-120

The meda (intermediate) season of 1991 described above was not included in the calculations. The results do not show an appreciable change in the length of maha seasons. However, an increase in the length of yala seasons is evident.

3.2.3 Other Performance-Related Parameters

Changes in the performance-related parameters of rainfall, OFC cultivated area and rice yield are shown in Table 11.

Table 11. Performance-related parameters.

Performance-related parameter	Average (1984-93)		Past performance (1985-88)		Present performance (1990-93)		Percent change	
	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
Rainfall (mm)	1,308	186	1,136	172	1,448	201	+27	+17
OFC cultivated area (%)	-	5	-	1.76	-	8.26	-	+400
Rice yield (tons/ha—rough rice)	3.55	3.74	3.25	3.40	3.78	3.88	+16	+14

The past performance was evaluated using the 1985/86, 1987/88 and the 1988/89 maha seasons and 1985, 1987, and 1988 yala seasons. The present performance was measured using data from the 1990/91 to 1992/93 maha seasons and the 1990, 1992 and 1993 yala seasons.

The area irrigated per unit volume of irrigation water has decreased by 8 percent in maha and 7 percent in yala. The best performance with regard to this indicator was in 1987/88 maha and 1989 yala, where the values were 83 ha/MCM and 52 ha/MCM, respectively.

The same indicator calculated using rainfall as an input has decreased by 23 percent in maha and increased by 8 percent in yala. The best performance with regard to this indicator was in 1987/88 maha and 1989 yala, where the values were 61 ha/MCM and 47 ha/MCM, respectively.

Irrigation Intensity in both seasons has remained at 100 percent. Cropping Intensity has also remained constant at 200 percent.

Irrigation Duty has increased by 3 percent during maha seasons and by 10 percent in yala seasons. Compared with the average Irrigation Duty of 1.33 m (4.36 ft.) for maha seasons specified in Technical Note 6 of the Irrigation Department, the duty in this scheme is 20 percent higher than that specified for maha seasons. In yala seasons, the Irrigation Duty is 29 percent higher than the specified value of 1.7 m (5.56 ft.).

Relative Water Supply (RWS) has increased by 22 percent during maha seasons, and by 1 percent in yala seasons. The increase in maha has resulted in a decrease in performance considering 1 as the optimum value of RWS. According to the categorization adopted, present irrigation performance measured by RWS is of a poor standard in maha seasons, but of a good standard in yala seasons. The optimum values for RWS were 0.99 in 1984/85 maha and 0.96 in 1987 yala.

Irrigation Water Productivity has increased by 1 percent in maha, and by 6 percent in yala. The best values for Irrigation Water Productivity were 291 tons/MCM in 1992/93 maha and 203 tons/MCM in 1989 yala.

Land Productivity has increased by 16 percent over the period. The best achievement with regard to this indicator was 4.03 tons/ha, which was recorded in 1992/93.

The total annual production has increased by 16 percent in maha seasons and by 14 percent in yala seasons. The best values for production were 2,192 tons in 1992/93 maha seasons, and 2,219 tons in 1993 yala.

3.2.2 Length of Irrigation Season

The start of the maha season in Mapakada Scheme has varied between early October to mid-November. The recent maha seasons have started in early October to mid-October. The yala seasons have started between late March and late April.

A *meda* (intermediate) season was cultivated in 1991. OFCs were planned to be grown in 81 ha. Although the planned duration was 122 days, the season lasted for 202 days, from 10 March to 28 September 1991.

The behavior of the length of irrigation season is shown in Table 10.

Table 12. Performance of Parakrama Samudra Scheme.

Performance indicator/ parameter	Average (1984-93)		Past performance (1984-87)		Present performance (1990-93)		Percent change	
	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
AIUW (ha/MCM) (irrigation only)	73.4	65.7	76.3	61.7	70.4	67.3	-8	+9
AIUW (ha/MCM) (total water)	47.2	56.6	46.5	57.6	45.4	59.3	-2	+3
Irrigation Intensity (%)	100	100	100	100	100	100	0	0
Irrigation Duty (m)	1.37	1.53	1.32	1.62	1.43	1.5	+8	-7
Actual Duty/Design Norm (%)	103	90	99	95	108	88	-	-
Relative Water Supply	0.85	1.05	0.79	1.06	0.85	1.07	+8	+1
Irrigation Water Productivity (tons/MCM)	350	256	376	249	308	273	-18	+9
Total annual production (tons)	46,600	38,100	48,300	39,300	42,700	36,400	-11	-7
Cropping Intensity (annual) (%)	201		201		203		+2	
Land Productivity (tons/ha)	4.47		4.55		4.26		-6	

Note: AIUW = Area Irrigated per Unit Water.

3.2.4 Impacts and Inter-Relationships

As mentioned earlier, this scheme was included in the INMAS Program from 1984, and the infrastructure was improved under IRDP. Although beneficiary participation at the implementation stage was envisaged under IRDP, studies show that this has not been very successful (Dayaratne 1991).

The rehabilitation under IRDP included improving and extending the field channels, and providing several farms with direct access to field channels. This must have improved the equity and reliability of the water supply. According to Irrigation Department estimates, the area with irrigation facilities increased by 46 percent from 376 ha to 548 ha immediately after rehabilitation. The actual irrigated area remained constant at 548 ha. It can be assumed that better water distribution has helped increase the productivity, though water use has also increased. The changes in length of the season correspond with the performance changes related to water supply, especially in the yala season.

The rainfall in the later period is higher than that in the earlier period. But, this has not resulted in a decrease in Irrigation Duty as expected. This indicates that rainfall utilization can be improved in the Mapakada Scheme. However, due to high water availability in the maha season and constraints due to tank capacity, motivation for high rainfall utilization is minimal. Because of the low and sporadic nature of rainfall in yala, it is preferable to compare the performance in yala without the effect of rainfall.

The results show substantial improvements in performance with respect to agricultural production related indicators. The rice yield has increased by 16 percent in maha and by 14 percent in yala. These increases can be linked to the increase in Land Productivity and the total production. The increase in Irrigation Water Productivity is dampened by the increase of water use, despite higher rainfall in the later period.

In summary, the results show that the performance can be improved by higher management effort. Reducing the length of the irrigation season and better utilizing rainfall can substantially increase the water supply performance.

3.3 PERFORMANCE OF PARAKRAMA SAMUDRA SCHEME

3.3.1 Performance Level and Changes

The estimated level of performance using available data is summarized in Table 12.

The past performance was evaluated using the 1984/85 to 1986/87 maha seasons and the 1984 to 1986 yala seasons. The present performance was measured using the data from 1990/91 to 1992/93 maha seasons and 1991 to 1993 yala seasons.

The area irrigated per unit volume of irrigation water has decreased by 8 percent in maha, but has increased by 9 percent in yala. The best performance with regard to this indicator was in 1985/86 maha and 1989 yala, when the values were 82 ha/MCM and 75 ha/MCM, respectively.

The same indicator calculated using rainfall as an input has decreased by 2 percent in maha, but has increased by 3 percent in yala. The best performance with regard to this indicator was in 1987/88 maha and 1992 yala, when the values were 63 ha/MCM and 66 ha/MCM, respectively.

Table 13. Length of irrigation season.

Average		Past		Present		Recommended range	
Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
142	135	148	143	145	134	135-150	105-120

3.3.3 Other Performance-Related Parameters

Changes in the performance-related parameters of rainfall, OFC cultivated area and rice yield are shown in Table 14.

Table 14. Performance-related parameters.

Performance-related parameter	Average (1984-93)		Past performance (1984-87)		Present performance (1990-93)		Percent change	
	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
Rainfall	800	242	864	115	804	201	-7	+7
OFC cultivated area (%)	2.3	3.6	1.9	2.4	4.7	5.4	+2.8	+3.0
Rice yield (tons/ha-rough rice)	4.68	4.21	4.78	4.29	4.36	4.15	-9	-3

The rainfall decreased by 7 percent in maha, but increased by 7 percent in yala. OFC cultivated area seems to be insignificant in both seasons but shows an upward trend. Rice yield has decreased in both seasons.

3.3.4 Impacts and Inter-Relationships

Water availability in this scheme is good. Usually, the tank spills during the maha season and reaches the full supply level at the beginning of yala, so there is little motivation to improve water use in maha.

Irrigation Department data suggest that the area irrigated has remained constant at 9,794 ha throughout the period from 1984 to 1993. As a result, Irrigation Intensity remains constant at 100 percent during both maha and yala seasons.

Irrigation Duty has increased by 8 percent during maha seasons, but has decreased by 7 percent in yala seasons. Compared with the average Irrigation Duty of 1.33 m (4.36 ft.) for maha seasons specified in Technical Note 6 of the Irrigation Department, the duty in this scheme is 3 percent higher than that specified for maha seasons. In the yala seasons, the Irrigation Duty is 10 percent lower than the specified norm of 1.7 m (5.56 ft.).

Relative Water Supply has increased by 8 percent during maha seasons and by 1 percent in yala seasons. The increase in yala has resulted in an increase in performance considering 1.0 as the optimum value of RWS. According to the categorization adopted, present irrigation performance measured by RWS is of a good standard in maha seasons. It is of a fair standard in yala seasons. The best values for RWS were 0.99 in 1984/85 maha, and 0.96 in 1987 yala.

Irrigation Water Productivity has decreased by 18 percent in maha, but has increased by 9 percent in yala. The best values for Irrigation Water Productivity were 408 tons/MCM in 1987/88 maha, and 283 tons/MCM in yala 1992.

Cropping Intensity has increased by 2 percent over the study period. The highest Cropping Intensity of 207 was recorded in 1992/93.

Land Productivity has decreased by 6 percent over the period. The best achievement with regard to this indicator was 4.77 tons/ha, which was recorded in 1989/90.

Total annual production has decreased by 11 percent from 48,300 tons to 42,700 tons in maha seasons. The drop in yala season is 8 percent from 39,400 tons to 36,400 tons. As a result, the annual production has decreased by 10 percent from 87,700 to 79,100 tons. The highest production figures were recorded in 1987/88 maha and 1990 yala when the values were 52,500 tons and 43,900 tons, respectively.

3.3.2 Length of Irrigation Season

The starting dates of the maha seasons vary from mid-October to early November. After maha 1987/88, a clear shift of the maha starting date to early November can be observed. This was probably made to accommodate a longer construction period for ISMP.

There is very little variation in the start of yala. It has started between 10 and 22 April for the entire study period.

The behavior of the length of irrigation season is shown in Table 13.

The duration of the yala seasons has decreased by about 6 percent. The lowest durations were recorded in yala 1988 (126 days) and yala 1989 (125 days). However, changes in maha seasons are comparatively small.

The same indicator calculated using rainfall as an input increased by 8 percent in maha and 1 percent in yala. The best performance with regard to this indicator was also in 1989/90 maha and 1989 yala, when the values were 53 ha/MCM and 84 ha/MCM, respectively.

Table 15. Performance of Rajangane Scheme.

Performance indicator/parameter	Average (1984-93)		Past performance (1985-88)		Present performance (1990-93)		Percent change	
	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
AIUW (ha/MCM) (irrigation only)	50.0	55.5	42.2	47.2	50.4	49.9	+19	+6
AIUW (ha/MCM) (total water)	41.9	48.2	37.9	43.2	41.1	43.8	+8	+1
Irrigation Intensity (%)	105	99	105	92	105	108	0	+17
Irrigation Duty (m)	2.08	2.03	2.4	2.4	2.0	2.1	-17	-10
Actual Duty/Design Norm (%)	156	119	180	141	150	124	-	-
Relative Water Supply	1.21	1.17	1.26	1.15	1.16	1.20	-8	+4
Irrigation Water Productivity (tons/MCM)	231	130	180	111	268	155	+48	+39
Total annual production (tons)	27,000	13,600	24,900	12,300	30,200	19,000	+22	+54
Cropping Intensity (%)	182		177		206		+16	
Land Productivity (tons/ha)	4.16		4.01		4.37		+9	

Note: AIUW = Area Irrigated per Unit Water.

Apart from that, Irrigation Intensity in maha was 100 percent throughout. As a result, the scope for performance improvement at main system level during maha is small.

Viewed in this background, there are appreciable performance gains in the yala season with respect to water use. These gains correspond well with the changes in the length of the irrigation season.

However, it should be noted that the rainfall received in recent maha seasons is lower than that in earlier maha seasons. This may have increased the irrigation issues resulting in a low value for Area Irrigated per Unit Water and increased the Duty. Insignificant changes in RWS also indicate that increases in irrigation issues were in relation with irrigation demands. Similarly, rainfall in yala shows an increase in the later period. The performance gains can be partly attributed to this, although as previously mentioned, it is difficult to respond to rains during yala.

The data show that rice yields have dropped by 9 percent and 3 percent in maha and yala, respectively. The drop in rice yields and increased water use in maha have contributed to the decline in Irrigation Water Productivity in the maha season. In yala however, despite the drop in rice yields, the Irrigation Water Productivity has increased due to less water use. Similarly, the decline in Land Productivity and the total production can be attributed to the drop in rice yields.

The OFC cultivated area is small both in maha and yala seasons and unlikely to make a significant contribution to water use. However, an upward trend in OFC cultivation can be noticed.

This scheme was included in the INMAS Program and further improved under ISMP. Studies done prior to the improvements suggest that the water supply was inequitable and unreliable (Fowler and Kilkelly 1987a). Under ISMP, flow measurement structures were constructed at distributary canals. The development of farmer organizations and joint management activities were done in a comparatively systematic manner. Hence, greater impacts can be expected at lower levels of the system.

The Parakrama Samudra supplies the Polonnaruwa town with water for domestic purposes. Polonnaruwa is a major town in the North Central Province with the possibility of expanding, which means that water demand for domestic purposes is likely to increase in the future. The implications of this for the sustainability of performance of the scheme need to be studied.

3.4 PERFORMANCE OF RAJANGANE SCHEME

3.4.1 Performance Level and Changes

The estimated level of performance using available data is summarized in Table 15.

The past performance was evaluated using the 1985/86, 1986/87 and 1987/88 maha seasons, and 1985, 1986, and 1987 yala seasons. The present performance was measured using the data from 1990/91 to 1992/93 maha seasons, and 1990 to 1992 yala seasons. The results show that the performance has improved with respect to all the indicators used.

The area irrigated per unit volume of irrigation water has increased by 19 percent in maha and 6 percent in yala. The best performance with regard to this indicator was witnessed in 1989/90 maha and 1989 yala, when the values were 67 ha/MCM and 104 ha/MCM, respectively.

Table 16. Length of irrigation season.

Average		Past		Present		Recommended range	
Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
148	140	158	147	140	131	135-150	105-120

3.4.3 Other Performance-Related Parameters

Changes in the performance-related parameters of rainfall, OFC cultivated area and rice yield are shown in Table 17.

Table 17. Performance-related parameters.

Performance-related parameter	Average (1984-93)		Past performance (1985-88)		Present performance (1990-93)		Percent change	
	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
Rainfall (mm)	425	248	499	166	453	311	-9	+87
OFC cultivated area (%)	1.17	5.42	1.7	11.6	1.24	2.43	-27	-79
Rice yield (tons/ha—rough rice)	4.86	3.16	4.89	2.94	5.21	3.50	+7	+19

3.4.4 Impacts and Inter-Relationships

This scheme, like Parakrama Samudra, enjoys a reliable supply of water to the tank. Early records show that water use, especially in the maha seasons, was excessive. For example, tank duty in maha 1972/73 was 3.4m (Ponrajah n.d.). More recent studies (ECL 1992) have also stressed this fact as follows:

Irrigation Intensity in maha seasons has remained constant at 105 percent. The highest Irrigation Intensity in maha seasons was 107 percent, which was recorded throughout all the seasons from 1986/87 to 1989/90. Irrigation Intensity in yala seasons show an increase of 17 percent, with highest Irrigation Intensity of 108 percent being recorded in 1992 yala. On the average, annual Irrigation Intensity is 205 percent.

Irrigation Duty has decreased by 17 percent during maha seasons and by 10 percent in yala seasons. Compared with the average Irrigation Duty of 1.33 m (4.36 ft.) for maha seasons specified in Technical Note 6 of the Irrigation Department, the duty in this scheme is 56 percent higher than that specified for maha seasons. In the yala seasons, the Irrigation Duty is 19 percent higher than the specified value of 1.7 m (5.56 ft.).

Relative Water Supply has decreased by 8 percent during maha seasons but increased by 4 percent in yala seasons. The decrease in maha has resulted in an increase of performance considering 1.0 as the optimum value of RWS. According to the categorization adopted, the present irrigation performance measured by RWS is of a fair standard in maha seasons, but of a poor standard in yala seasons. The optimum values for RWS were 1.01 in 1992/93 maha, and 1.06 in 1990 yala.

Irrigation Water Productivity has increased by 48 percent in maha and 39 percent in yala. The best values for Irrigation Water Productivity were 296 tons/MCM in 1989/90 maha, and 191 tons/MCM in 1992 yala.

Cropping Intensity has increased by 16 percent over the study period. The highest Cropping Intensity of 212 was recorded in 1989/90.

Land Productivity has increased by 9 percent over the period. The best achievement with regard to this indicator was 5.24 tons/ha, which was recorded in 1991/92.

The total annual production has increased by 22 percent from 24,900 tons to 30,200 tons in the maha season. In the yala season, the increase was 54 percent from 12,300 tons to 19,000 tons. As a result, the annual production has increased by 32 percent from 37,100 to 49,200 tons. The highest production figures were recorded in 1991/92 maha and 1992 yala, when the values were 33,500 and 21,900 tons, respectively.

3.4.2 Length of Irrigation Season

The maha season in Rajangane Scheme started between mid-September and early November. The yala season started between mid-March and mid-April. The behavior of the length of irrigation season is shown in Table 16.

In the past, it was difficult to identify the length of the season. The data show that there had been several extensions after the official cut-off date of water issues. As a result, the actual closure of the season was decided using personal judgement in some cases. However, in the later seasons, the length of the seasons can be identified more easily.

Results shown in Table 16 indicate that the duration has decreased by 11 percent in maha and yala.

Table 18. Performance of Ridiyagama Scheme.

Performance indicator/ parameter	Average (1986-93)		Past performance (1986-88)		Present performance (1990-93)		Percent change	
	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
AIUW (ha/MCM) (irrigation only)	49.4	43.8	49.1	44.1	51.3	42.2	+5	-4
AIUW (ha/MCM) (total water)	40.4	39.4	43.4	40.2	37.8	37.4	-13	-7
Irrigation Intensity (%)	89.3	88.7	95.5	92.1	85.5	85.3	-10	-7
Irrigation Duty (m)	2.1	2.3	2.1	2.28	2.0	2.31	-2	+1
Actual Duty/Design Norm (%)	158	135	158	134	151	136	-	-
Relative Water Supply	1.21	1.22	1.11	1.19	1.29	1.28	+16	+8
Irrigation Water Productivity (tons/MCM)	242	215	251	230	235	201	-6	-12
Total Annual Production (tons)	13,500	13,000	12,900	14,200	12,100	11,600	-6	-18
Cropping Intensity (%)	177		185		171		-8	
Land Productivity (tons/ha)	4.82		4.99		4.52		-10	

Note: ALUW = Area Irrigated per Unit Water.

The past performance was evaluated using the 1986/87 to 1988/89 maha seasons, and 1986 to 1988 yala seasons, because rice yield data were available from 1986 only. The present performance was measured using data from 1990 to 1993. The 1992 yala data were not used because the data set was incomplete.

The area irrigated per unit volume of irrigation water has increased by 5 percent in maha, and decreased by 4 percent in yala. The best performance with regard to this indicator was witnessed in 1990/91 maha and 1987 yala, when the values were 64 ha/MCM and 48 ha/MCM, respectively.

Rainfall records were not provided in the Ridiyagama Scheme data set. As a result, rainfall data from Hambantota and Ambalantota rain gauges maintained by the Hydrology Division of the Irrigation

This system has a plentiful supply of water. As a result, farmers cannot be persuaded to cut down wastage although control and measuring devices have been installed.

One may question why farmers should reduce "wastage" in the face of a surplus water supply, nevertheless, the present analysis shows improvements in water use both in maha and yala. Perhaps there may be greater impacts at the distributary and field channel levels.

A comparison of past and present lengths of irrigation seasons shows a decrease in both maha and yala. Apart from this, the irrigation seasons are more clearly defined and water issues in-between the seasons are minimized in the later period. These observations agree with the improvements in water use.

It can be seen that rainfall in maha seasons have decreased in the later period, while the rainfall in yala has increased. This makes the performance increases in maha more significant than increases in yala.

Irrigation performance in yala with respect to RWS had to be categorized as poor, due to the increase in the value of RWS in yala. However, it should be noted that the total seasonal water requirement has decreased by 9 percent during the period. This is mainly due to the reduction in length of the irrigation season. Increased rainfall and reduced water requirement in yala have contributed to the increase of RWS.

The area under the OFC cultivation has decreased over the period. The present level of OFC cultivation is unlikely to have any effect on water use.

A variety of reasons has contributed to the improved Irrigation Water Productivity. In maha, rice production has increased mainly due to improved yields. Irrigation water use has decreased in spite of lower rainfall. The net result is a very significant improvement in Irrigation Water Productivity in maha.

Increase of Irrigation Water Productivity in yala can be attributed to higher rainfall and yields. Rice yields in yala have increased from a fairly low value of 2.9 tons/ha to 3.5 tons/ha—an increase of 19 percent. Rainfall in yala has increased by 87 percent.

The total rice production shows a very significant increase of 54 percent in yala seasons. This is due to the increase in rice yield and Cropping Intensity in yala seasons. Since cropped area increased mainly in yala, the production increase in maha is lower than that of yala.

3.5 PERFORMANCE OF RIDIYAGAMA SCHEME

3.5.1. Performance Level and Changes

The estimated level of performance using available data is summarized in Table 18.

There were substantial differences in the estimated area provided by the Irrigation Department, Agriculture Department and IMD. IMD data are available from 1991 only. A continuous data set for irrigated area was also not available from the Irrigation Department. After inspecting the data and comparing with water issues and rainfall, it was found that the area estimated by the Agriculture Department is reasonably accurate. As a result, it was decided to use the area estimated by the Agriculture Department for this analysis.

Table 19. Length of irrigation season.

Average		Past		Present		Recommended range	
Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
138	143	140	141	141	151	135-150	105-120

Low average values for maha seasons given in Table 16 are influenced by maha 1986/87 and maha 1987/88, for which the durations were 128 and 135 days, respectively. Similarly, the duration of yala 1987—128 days—was the lowest for the study period.

The results do not indicate an appreciable change in the length of maha seasons. The length of yala has increased by 7 percent.

3.5.3 Other Performance-Related Parameters

Changes in the performance-related parameters of rainfall, OFC cultivated area and rice yield are shown in Table 20.

Table 20. Performance-related parameters.

Performance-related parameter	Average (1984-93)		Past performance (1986-88)		Present performance (1990-93)		Percent change	
	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
Rainfall (mm)	438	237	266	216	659	202	+148	-7
OFC cultivated area (%)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Rice yield (tons/ha—rough rice)	4.89	4.74	5.09	4.9	4.6	4.63	-10	-6

Note: n.a. = Data not available.

The maha season rainfall in the later period has increased by 148 percent. But rice yield has dropped by 10 percent in the maha season, and by 6 percent in the yala season.

Department were used for the analysis. Area Irrigated per Unit Water including rainfall has decreased by 13 percent in maha and by 7 percent in yala. The best performance with regard to this indicator was witnessed in 1988/89 maha and 1987 yala, when the values were 47 ha/MCM and 44 ha/MCM, respectively.

Irrigation Intensity has decreased by 10 percent in maha and by 7 percent in yala. The best performance was witnessed in 1987/88 maha and 1986 yala, when the values were 97 and 96, respectively.

Irrigation Duty has decreased by 2 percent in maha seasons and increased by 1 percent in yala seasons. Compared with the average Irrigation Duty of 1.33 m (4.36 ft.) for maha seasons specified by the Irrigation Department, the duty in this scheme is 58 percent higher than that specified for the maha seasons. In the yala seasons, the Irrigation Duty is 35 percent higher than the specified value of 1.7 m (5.56 ft.).

Relative Water Supply has increased by 16 percent during maha seasons, and by 8 percent in yala seasons. The increases in maha and yala have resulted in a decrease in performance. According to the categorization adopted, present irrigation performance measured by RWS is of a poor standard in both maha and yala seasons. The optimum values for RWS were 1.02 in 1988/89 maha, and 1.11 in 1987 yala.

Irrigation Water Productivity has decreased by 6 percent in maha and by 12 percent in yala. The best values for Irrigation Water Productivity were 285 tons/MCM in 1987/88 maha, and 251 tons/MCM in 1987 yala.

Cropping Intensity has decreased by 8 percent over the study period. The highest Cropping Intensity of 189 was recorded in 1987/88.

Land Productivity has also decreased by 10 percent over the period. The best achievement with regard to this indicator was 5.35 tons/ha/season, which was recorded in 1988/89.

Total annual production has decreased by 6 percent from 12,900 tons to 12,100 tons in the maha season. In the yala season, the decrease was 18 percent from 14,200 tons to 11,600 tons. Thus, annual production has dropped by 12 percent from 27,100 to 23,700 tons. The highest production figures were recorded in 1988/89 maha and 1986 yala when the values were 15,800 tons and 14,200 tons, respectively.

3.5.2 Length of Irrigation Season

The starting date of the maha season has varied from September to November. The start of the yala season was from March to April. The behavior of the length of irrigation season is shown in Table 19.

4. A Comparison of Five Irrigation Schemes

4.1 PRESENT PERFORMANCE LEVEL

Table 21 describes the present performance level and related parameters of the five irrigation schemes. Values of the most recent three seasons were used in this analysis.

Table 22 shows that the rainfall in the maha season is highest in the Mapakada Scheme. It is approximately 92 percent of the irrigation supply. Rainfall in maha is lowest in Rajangane and Dewahuwa. Accordingly, the dependency on irrigation in maha seasons would be low in Mapakada but high at Rajangane and Dewahuwa.

In the yala season, the rainfall was 10 to 15 percent of the irrigation supply in all the schemes. As discussed earlier, rainfall in yala may not make a significant contribution to the water supply.

The performance indicators and related indices are compared in the following sections.

4.2 AREA IRRIGATED PER UNIT WATER

Area Irrigated per Unit Water (irrigation supply) for the five schemes is plotted in Figure 5. Area Irrigated per Unit Water is highest in Parakrama Samudra in the maha seasons. Performance in the Mapakada Scheme is only slightly lower. In the yala seasons, the best performance is observed in the Dewahuwa Scheme, followed by Parakrama Samudra and Rajangane.

In Figure 6, Area Irrigated per Unit Water with respect to the total water supply is plotted. When rainfall is considered as an input, the best performance is recorded in the Parakrama Samudra Scheme in the maha season, followed by Dewahuwa and Rajangane. In the yala season the best performance is observed in Dewahuwa. This is followed by Parakrama Samudra and Rajangane.

4.3 IRRIGATION INTENSITY

Figure 7 compares Irrigation Intensity in the five schemes. Except in Dewahuwa, Irrigation Intensity is good in the other five schemes. According to the data, there is no room for further improvement in the Parakrama Samudra, Rajangane and Mapakada schemes, with respect to this indicator. However, the Irrigation Department's estimate of irrigated area is based on the agreement reached with the farmers at the cultivation meeting and the estimated maximum cultivable area. The actual area cultivated can differ. In the case of water-short situations, this variation can be substantial. For the Ridiyagama Scheme, the cultivated area estimated by the Agriculture Department was used for the analysis. The comparison of the performances shows that better water management including maximum utilization of rainfall is very important in the Dewahuwa and Ridiyagama schemes.

3.5.4 Impacts and Inter-Relationships

This scheme was included under the INMAS Program in 1991. No major rehabilitation has been done in recent times. The level of farmer participation in the management of the irrigation system is less than in the schemes coming under ISMP or MIRP. The system is not water short, and as a result there is little motivation among farmers to participate in irrigation management (S. Danansooriya. Personal communication. 1994). Similar attitudes among officials can be expected. Another factor affecting the performance may be that the farmer organizations are not as developed as other schemes studied, because of the late adoption of the INMAS System.

The available data show a decrease in irrigation performance in both seasons. The improvement in Area Irrigated per Unit Water (irrigation supply) in maha can be attributed to increased rainfall in the later period. The decrease in the length of the yala season also agrees with the changes in water related performance indicators.

The substantial increase in rainfall in maha has not resulted in a corresponding reduction of irrigation water releases. The slight drop in irrigation water use in maha was insufficient to offset the bigger decrease in rice yields. As a result, Irrigation Water Productivity has decreased in maha. In yala, the drop in Irrigation Water Productivity is higher due to higher water use and the drop in rice yields.

The drop in rice yields is reflected in the decrease in Land Productivity. The decrease in total production is a result of both the drop in rice yields and Cropping Intensity.

Table 22. Irrigation performance-related parameters of the five schemes.

Indicator/ Parameter	Dewahuwa		Mapakada		Parakrama Samudra		Rajangane		Ridiyagama	
	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
Command area (ha)	1,214	1,214	548	548	9,800	9,800	5,600	5,600	3,440	3,440
Rainfall (mm)	446	166	1,448	201	804	201	453	311	659	202
RF/IS[1]	23	14	92	10	54	14	22	15	-	-
Length of season (days)	145	135	152	136	145	134	140	131	141	151
OFC cultivated area (%)	0	100	0	8.26	4.7	5.4	1.24	2.43	n.a.	n.a.
Rice yield (tons/ha—rough rice)	4.99	-	3.78	3.88	4.36	4.15	5.21	3.5	-	-

[1] Ratio of Rainfall/Irrigation Supply.

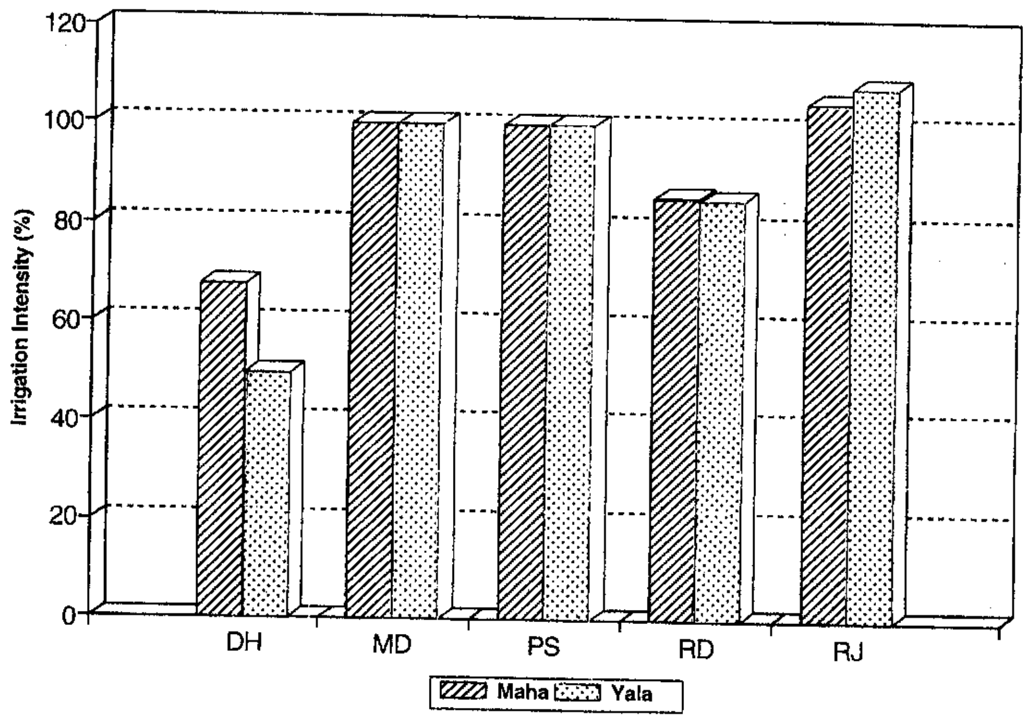
Notes: n.a. = Data not available.
OFC = Other Field Crops.

Table 21. Irrigation performance of the five schemes.

Indicator/ Parameter	Dewahuwa		Mapakada		Parakrama Samudra		Rajangane		Ridiyagama	
	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
AIUW(I)[1]	52.3	73.2	63.8	46.3	70.4	67.3	50.4	49.9	51.3	43.2
AIUW(T)[2]	42.3	66.7	32.7	42.2	45.4	59.3	41.1	43.8	37.8	37.4
Irrigation Intensity	67	50	100	100	100	100	105	108	85.5	85.3
Irrigation Duty (m)	1.91	1.5	1.6	2.2	1.43	1.5	2.0	2.1	2.0	2.3
RWS[3]	1.08		1.27	0.95	1.07	0.85	1.16	1.20	1.29	1.28
IWP[4]	262		242	185	308	273	268	155	235	201
Production (tons)	4.1		2.1	2.1	42.7	36.4	30.2	19.0	12.1	11.6
Cropping Intensity	117		200		203		206		171	
LP[5]	4.99		3.83		4.26		4.37		4.52	

1 Area Irrigated per Unit Water (irrigation only) (ha/MCM).
2 Area Irrigated per Unit Water (total water supply) (ha/MCM).
3 Relative Water Supply.
4 Irrigation Water Productivity (tons/MCM).
5 Land Productivity (tons/ha/season).

Figure 7. Irrigation Intensity.



Notes: DH = Dewahuwa. MD = Mapakada. PS = Parakrama Samudra. RJ = Rajangane. RD = Ridiyagama.

4.4 IRRIGATION DUTY

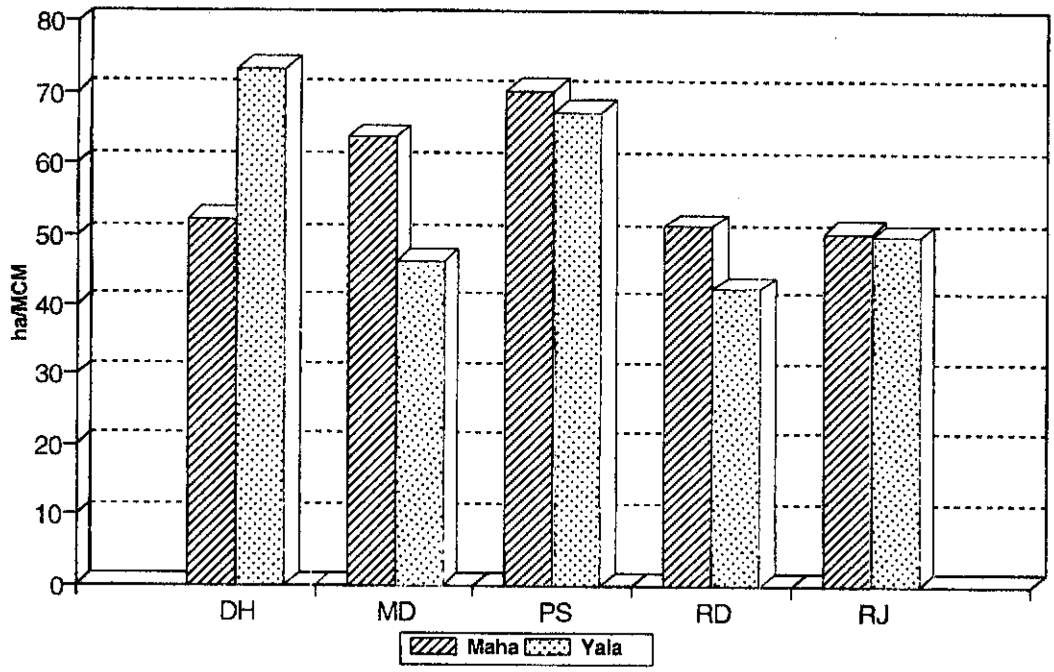
Figures 8 and 9 compare the Irrigation Duty in the five schemes in maha and yala, respectively, with the Irrigation Department's design assumption. Comparatively high duties are observed in Ridiyagama, Rajangane, Dewahuwa (in maha) and Mapakada. Although exceeding the Irrigation Department's value does not necessarily mean excessive water use, the comparison shows that two irrigation schemes recorded lower water duties than the specified norm in yala seasons. Reasons for exceeding the specified value in the maha season need to be further investigated.

4.5 RELATIVE WATER SUPPLY

Figures 10 and 11 compare the Relative Water Supply of the irrigation schemes in maha and yala, respectively. Because of the high OFC cultivation in yala in the Dewahuwa Scheme, the RWS was not calculated there in yala.

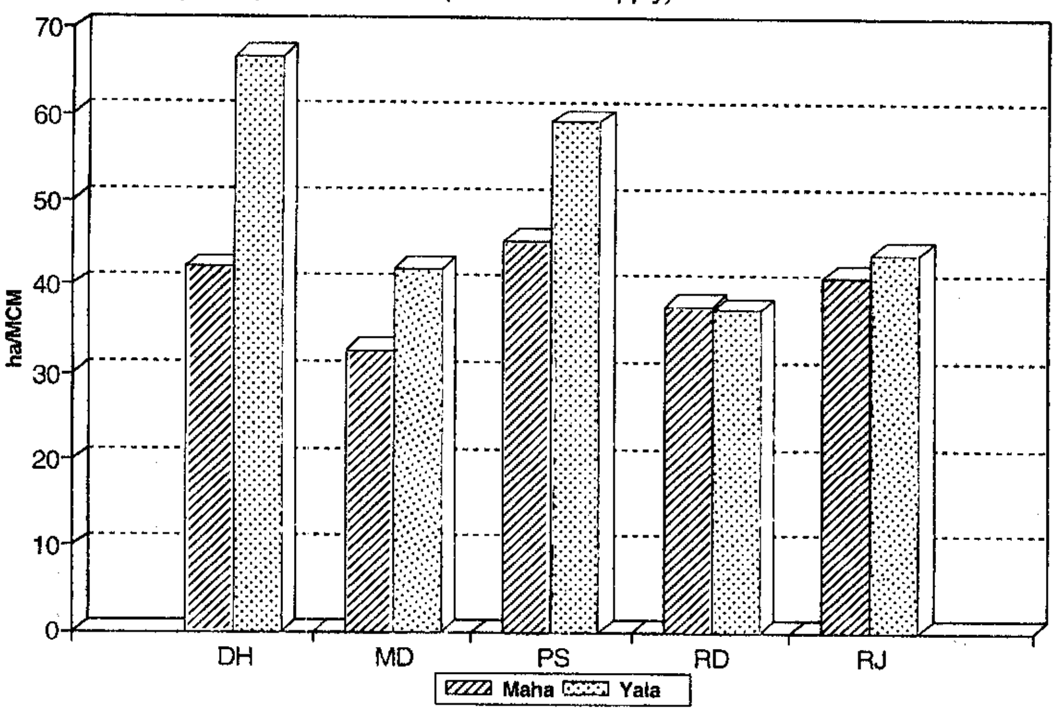
Figure 10 shows that RWS in all the schemes was above 1 in the maha season. The optimum value was recorded in the Parakrama Samudra Scheme. The Mapakada and Ridiyagama schemes recorded high RWS values.

Figure 5. Area Irrigated per Unit Water (irrigation supply).



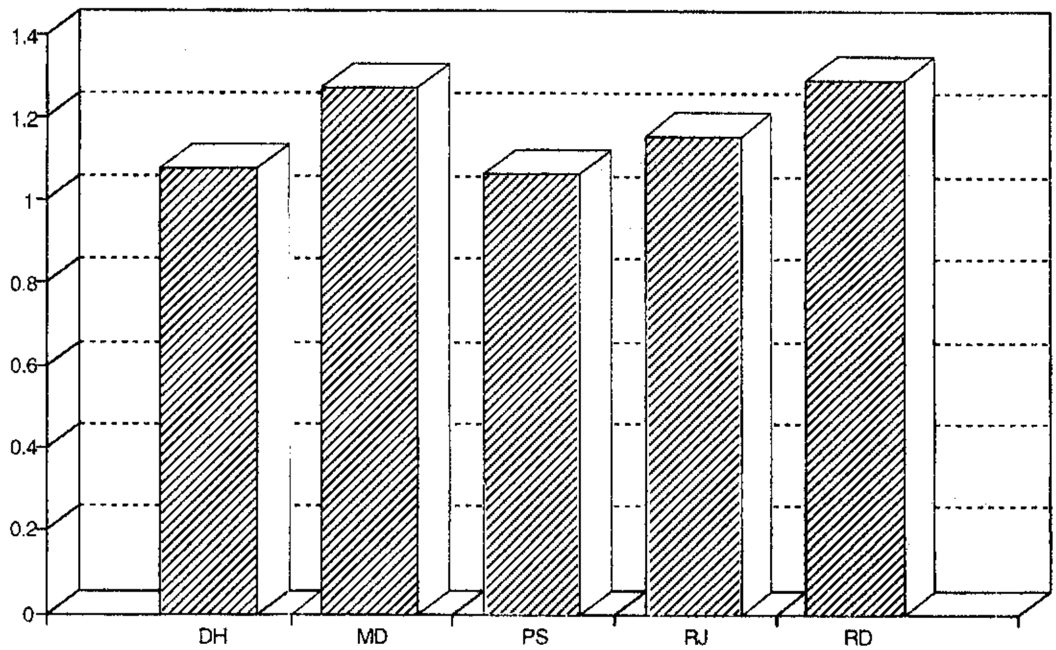
Notes: DH = Dewahuwa. MD = Mapakada. PS = Parakrama Samudra. RJ = Rajangane. RD = Ridiyagama.

Figure 6. Area Irrigated per Unit Water (total water supply).



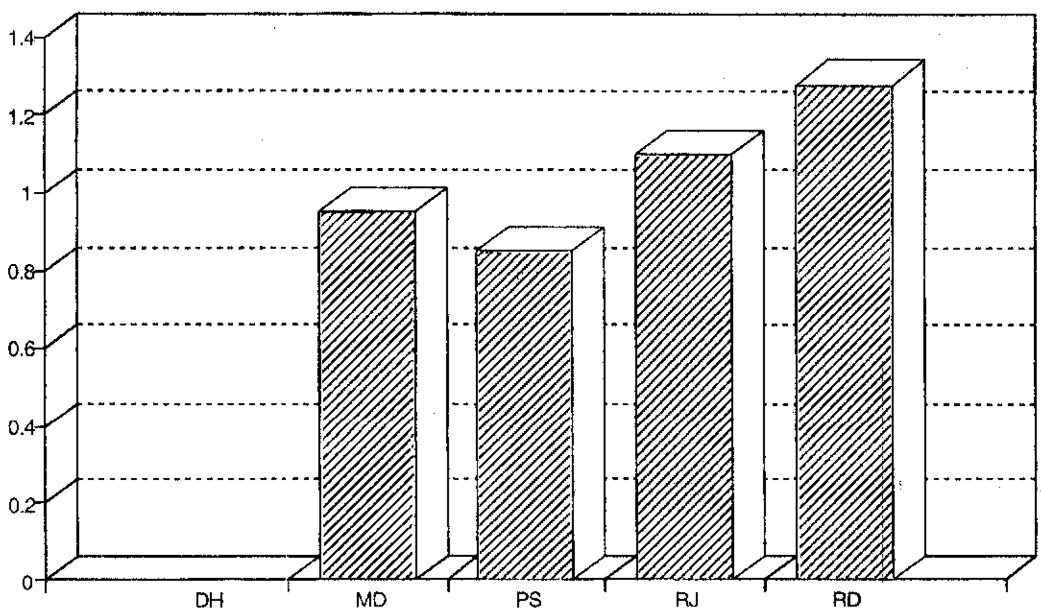
Notes: DH = Dewahuwa. MD = Mapakada. PS = Parakrama Samudra. RJ = Rajangane. RD = Ridiyagama.

Figure 10. Relative Water Supply (maha).



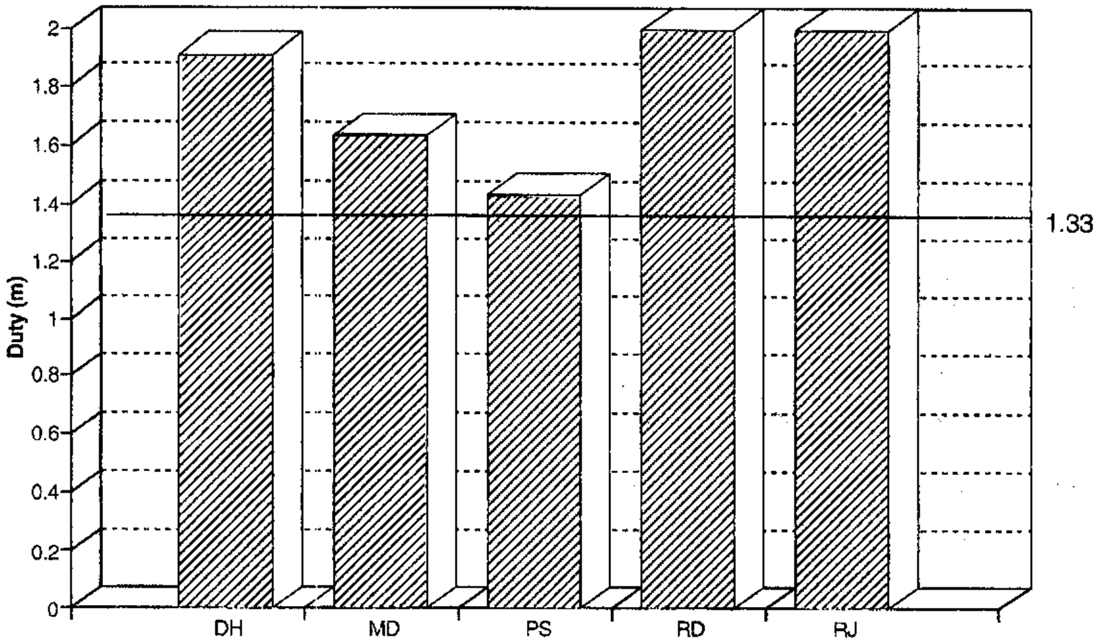
Notes: DH = Dewahuwa. MD = Mapakada. PS = Parakrama Samudra. RJ = Rajangane. RD = Ridiyagama.

Figure 11. Relative Water Supply (yala).



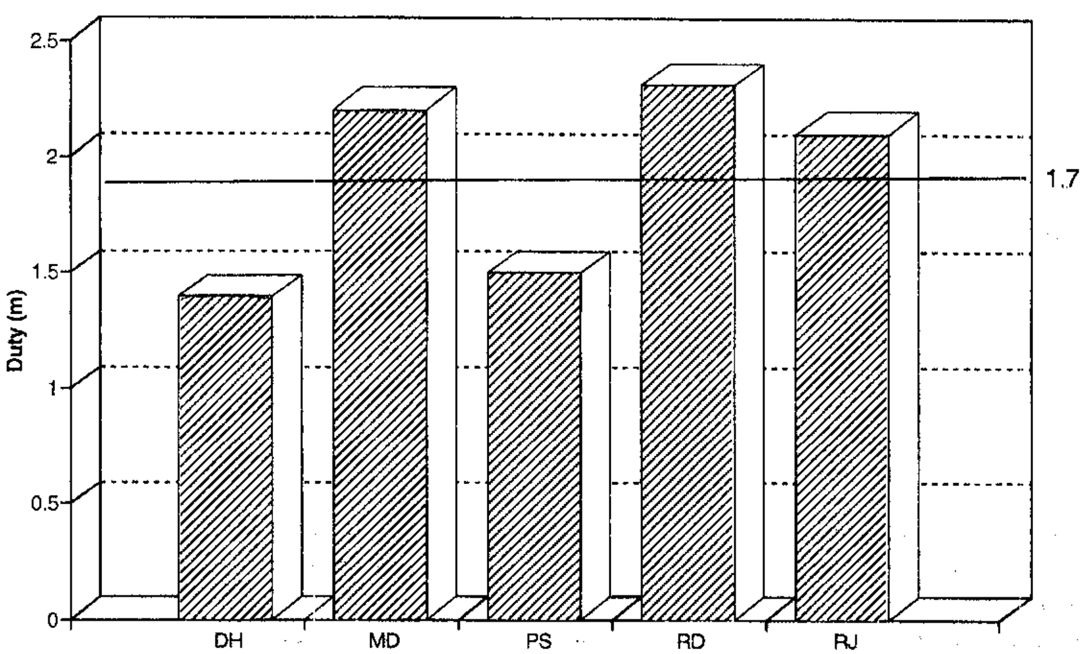
Notes: DH = Dewahuwa. MD = Mapakada. PS = Parakrama Samudra. RJ = Rajangane. RD = Ridiyagama.

Figure 8. Irrigation Duty (maha).



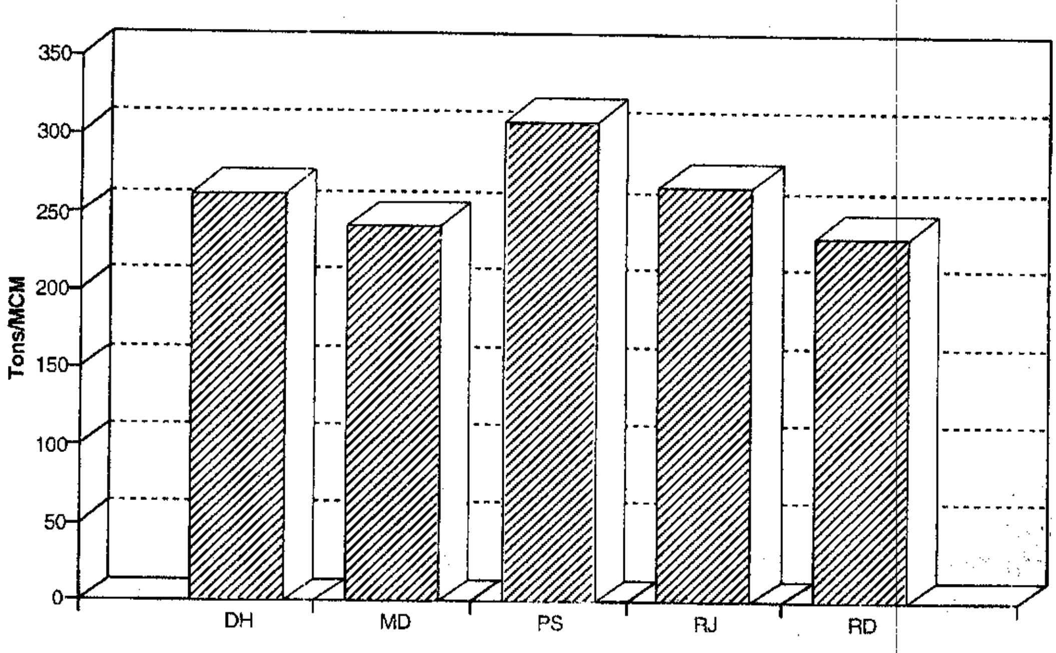
Notes: DH = Dewahuwa. MD = Mapakada. PS = Parakrama Samudra. RJ = Rajangane. RD = Ridiyagama.

Figure 9. Irrigation Duty (yala).



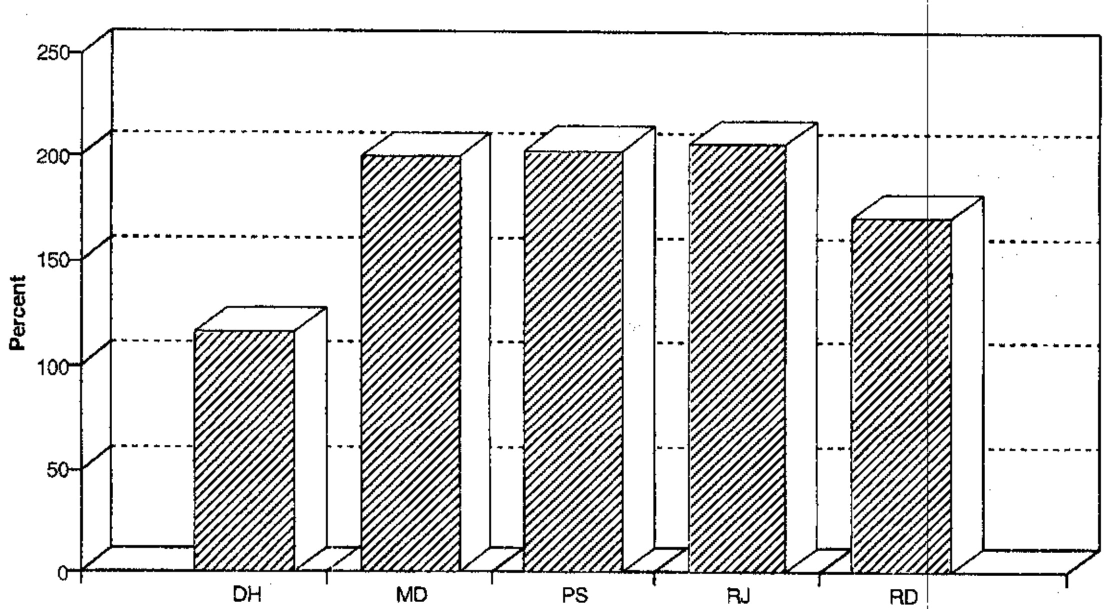
Notes: DH = Dewahuwa. MD = Mapakada. PS = Parakrama Samudra. RJ = Rajangane. RD = Ridiyagama.

Figure 12. Irrigation Water Productivity (maha).



Notes: DH = Dewahuwa. MD = Mapakada. PS = Parakrama Samudra. RJ = Rajangane. RD = Ridiyagama.

Figure 13. Cropping Intensity.



Notes: DH = Dewahuwa. MD = Mapakada. PS = Parakrama Samudra. RJ = Rajangane. RD = Ridiyagama.

According to Figure 11, the optimum RWS in yala was recorded in the Mapakada Scheme. While RWS of the Parakrama Samudra Scheme is the lowest, the values of Rajangane and Ridiyagama are high.

According to the categorization indicated in Section 1.4.2-d of this paper, the performance of the schemes in relation to RWS can be summarized as in Table 23.

Table 23. A comparison of performance in relation to RWS.

Season	Good	Fair	Poor
Maha	Dewahuwa, Parakrama Samudra	Rajangane	Mapakada, Ridiyagama
Yala	Mapakada	Parakrama Samudra, Rajangane	Ridiyagama

Note: RWS = Relative Water Supply.

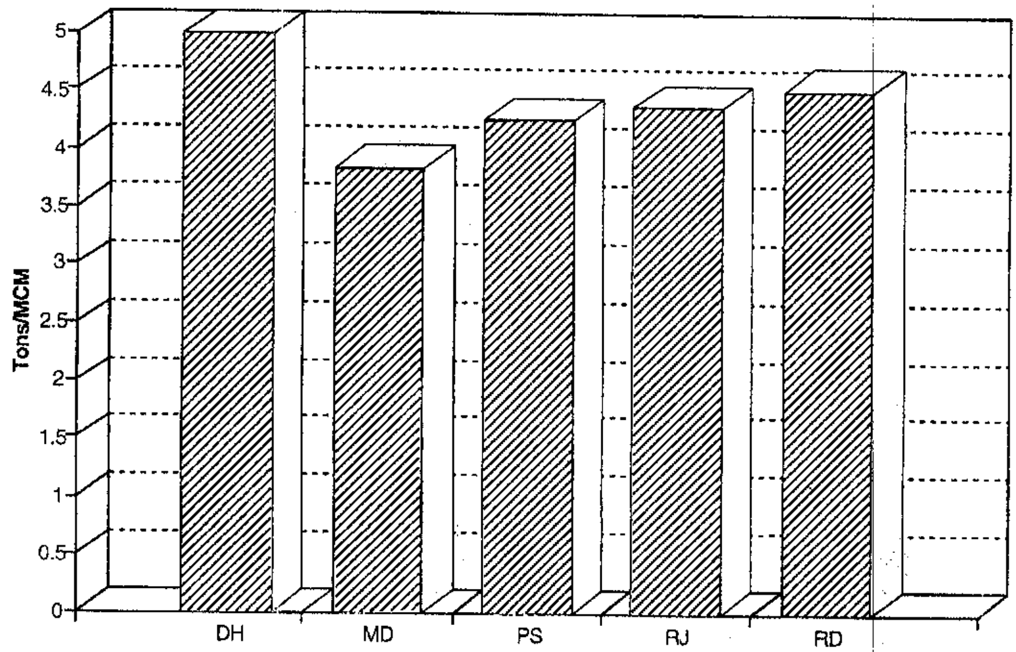
4.6 IRRIGATION WATER PRODUCTIVITY

Due to the varying nature of OFC cultivation in yala seasons in the five schemes, Irrigation Water Productivity is compared for maha seasons only. Figure 12 shows that highest Irrigation Water Productivity is observed in the Parakrama Samudra Scheme. It should be noted that among the Dry Zone schemes, Parakrama Samudra receives the highest amount of rainfall in the maha season (see Table 22). This probably enhances the Irrigation Water Productivity. The Mapakada Scheme, which is located in the Intermediate Zone has not recorded a good Irrigation Water Productivity despite the high rainfall. Table 22 shows that rice yield in Mapakada Scheme is also comparatively low.

4.7 CROPPING INTENSITY

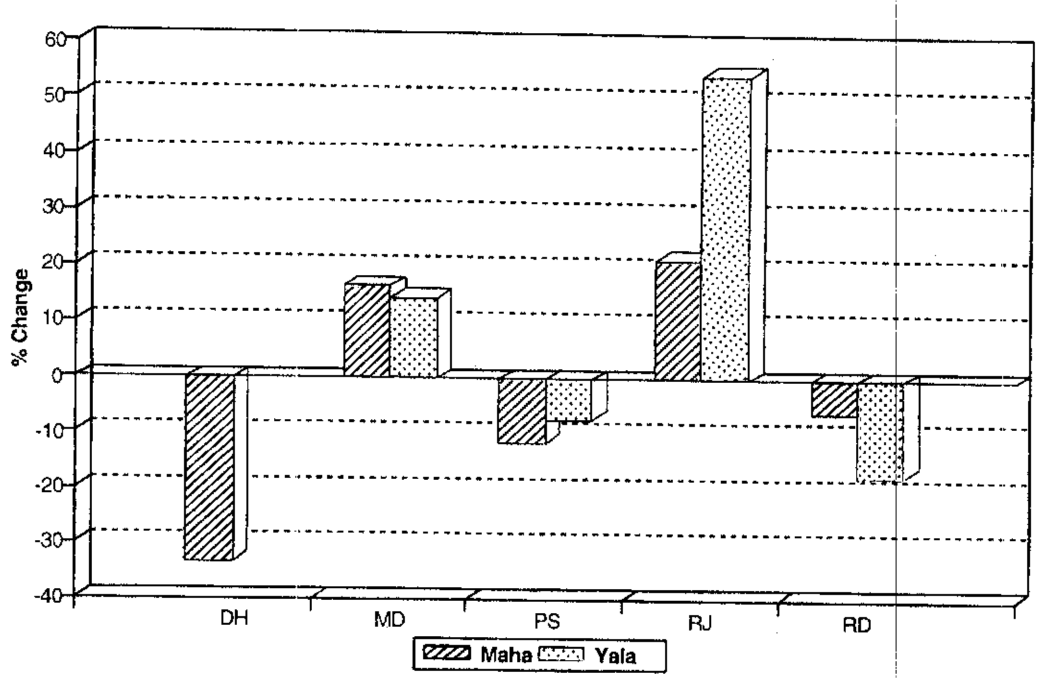
Figure 13, which compares the Cropping Intensity of the five schemes, shows that the highest values were recorded in Parakrama Samudra and Rajangane. Despite high OFC cultivation, Cropping Intensity in the Dewahuwa Scheme is low. Cropping Intensity is largely a function of the available water supply, though it can be enhanced through better management.

Figure 14. Land Productivity.



Notes: DH = Dewahuwa. MD = Mapakada. PS = Parakrama Samudra. RJ = Rajangane. RD = Ridiyagama.

Figure 15. Changes in rice production.



Notes: DH = Dewahuwa. MD = Mapakada. PS = Parakrama Samudra. RJ = Rajangane. RD = Ridiyagama.

4.8 LAND PRODUCTIVITY

Figure 14 shows that Land Productivity is highest in the Dewahuwa Scheme. However, as the records indicate that the rice cultivation in this scheme in yala was negligible, Land Productivity here is based on the maha season data only. Table 22 shows that the maha season rice yield was highest in the Rajangane Scheme. Land Productivity in Rajangane is affected by low yields in the yala season. High rice yields in yala are recorded in the Parakrama Samudra Scheme, though the yields in maha are lower than in both Rajangane and Dewahuwa.

4.9 TOTAL PRODUCTION

The total production essentially depends on the command area of the scheme. Most of the management interventions aim at increasing the total production. Considering these, it is more appropriate to compare the increases of rice production than the actual values of production.

Figure 15 shows that the highest increases in rice production were recorded in the Rajangane Scheme. Production has decreased in the Dewahuwa, Parakrama Samudra and Ridiyagama schemes. The largest decrease is observed in Dewahuwa.

4.10 LENGTH OF IRRIGATION SEASON

The length of the irrigation season in maha for the five schemes is shown in Figure 16. A similar comparison for the yala season is made in Figure 17.

As explained earlier, variations in length of the irrigation season is mainly the result of variation in the land preparation period. In principle, because of the smaller number of farmers and smaller farm area, a shorter land preparation period could be expected from smaller schemes. However, this hypothesis is not supported by the results.

Figure 16 shows that four of the five irrigation schemes managed their maha season within the expected range of duration. This shows that allowing 15-30 days for land preparation is reasonable. However, all the schemes exceeded this range in the yala season, as shown by Figure 17. Some reasons for this may be the following:

1. Cultivation of long-term varieties of rice in the yala season, contrary to instructions from the management.

2. Dependence on irrigation because of low rainfall. Since most of the farmers start land preparation at the same time, there is a heavy demand for water at the beginning of a season. The irrigation requirement for land preparation in yala is more than that in maha, because the rainfall is low in yala. Irrigation canals, constrained by carrying capacities, may not be able to supply the farmers with land preparation irrigation requirements in yala as fast as in maha.

The shortest duration of maha season was recorded in Ridiyagama and Rajangane. Yala season was the shortest in Rajangane followed by Parakrama Samudra.

4.11 RAINFALL UTILIZATION AND DATA COLLECTION

The rainfall in maha seasons is higher in Mapakada (92% of irrigation supply) than in Parakrama Samudra (54% of irrigation supply). But the latter scheme has irrigated more land per unit of water in the maha season. Similar observations can be made in yala seasons. This shows that rainfall utilization can be improved in Mapakada. In both of the schemes, maha rainfall is quite significant.

Since the results of the analysis suggest that performance could be improved with better utilization of rainfall, it is necessary to examine the existing facilities for rainfall measurement. Rainfall is recorded in all the schemes except Ridiyagama. Assuming readings of all the rain gauges are included in the data sets, the area covered by a rain gauge in each scheme is as follows:

Dewahuwa	:	1,214	ha	
Mapakada	:	548	ha	
Parakrama Samudra	:	9,794	ha	(4,897 ha from 1990)
Rajangane	:	5,600	ha	

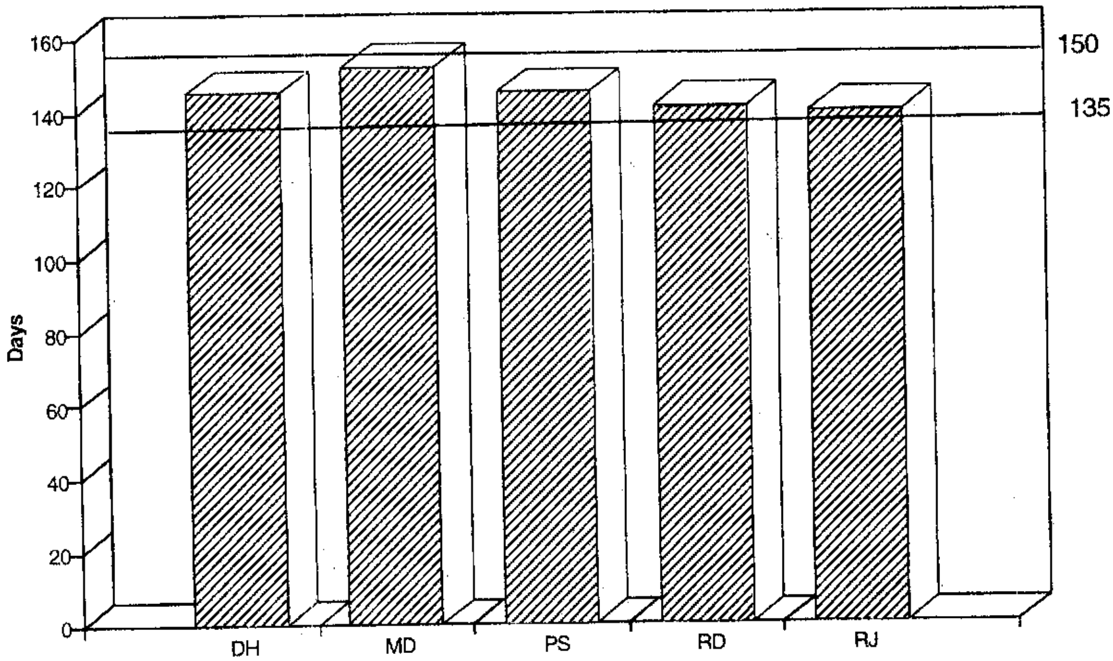
In the Parakrama Samudra Scheme, an additional rain gauge was installed in 1990, using the funds provided by ISMP. This has resulted in a change in the area covered by a rain gauge.

It can be seen that there is a lack of uniformity in the area covered by a rain gauge. The number of rain gauges in larger schemes does not seem to be adequate to enable effective use of rainfall. In the Muda Scheme in Malaysia, there are 57 rainfall stations for 97,000 ha, giving an average of 1,700 ha per rainfall station. Thus, the Muda Scheme is able to make good use of rainfall (Teoh and Chua 1988).

In spite of the apparent inadequacy of rain gauges, the Parakrama Samudra and Rajangane schemes perform relatively well. In Parakrama Samudra, even though the area covered by a rain gauge was halved, the Area Irrigated per Unit Water (including rainfall) registered only a marginal change. This shows that increasing the number of rain gauges alone will not boost the performance. The facilities provided for transmitting data should also be taken into consideration when comparisons are made.

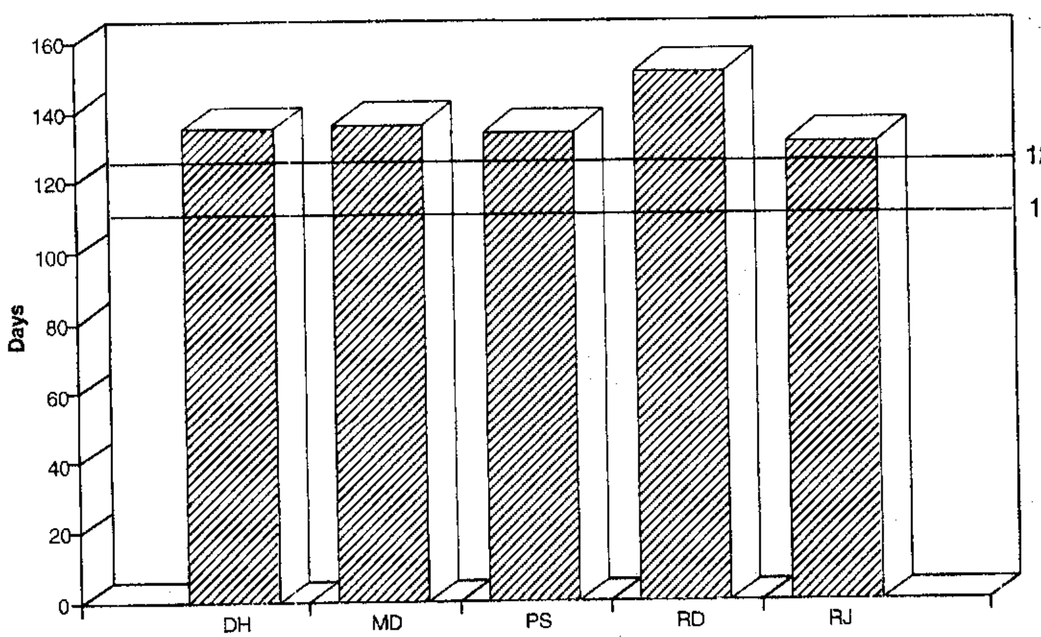
In the Muda Project, telemetric rainfall recorders convey the data directly to a main-frame computer located in the MADA Headquarters. Data from other rainfall stations are sent through four field computer terminals. Such facilities do not exist in Sri Lankan projects. It is also doubtful that they are affordable for the country. However, the transmission of data is an important link in the decision making process, which needs to be improved.

Figure 16. Length of maha season.



Notes: DH = Dewahuwa. MD = Mapakada. PS = Parakrama Samudra. RJ = Rajangane. RD = Ridiyagama.

Figure 17. Length of yala season.



Notes: DH = Dewahuwa. MD = Mapakada. PS = Parakrama Samudra. RJ = Rajangane. RD = Ridiyagama.

deviate much from the planned duration. However, the irrigation supply was about 22 MCM which was very high for the Dewahuwa Scheme. The irrigation supply went above 20 MCM only twice in the study period. Records show that in the following yala, only 202 ha was irrigated giving an Irrigation Intensity of 20 percent.

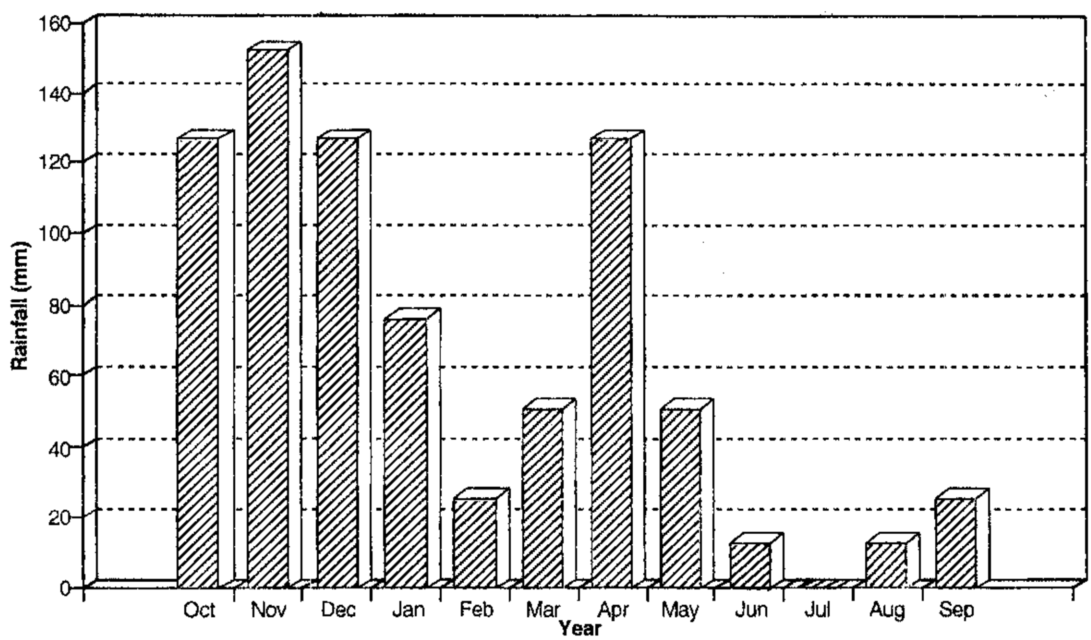
Second, in the Mapakada Scheme, a meda (intermediate) season was planned in 1991. The planned area for irrigation was 81 ha and the planned duration was 122 days, starting from 5 March 1991. However, according to IMD records, 510 ha were cultivated. The duration was extended to 202 days. The irrigation supply was 13.4 MCM, which was the highest in the study period.

4.12 CROPPING CALENDAR AND WEATHER PATTERN

Based on the water issues, the start of the maha season has been between late September and early November. The start of yala has varied between early March and late May.

The implications of rainfall for the starting date of the seasons can be studied with the aid of Figure 18. As the majority of the schemes fall within the Agro-Ecological Zone DL1, the rainfall pattern of the DL1 Zone is plotted in Figure 18. Starting the maha cultivation in October provides the opportunity for maximum utilization of high rainfall in October and November. Further, it allows the harvesting to be done in relatively dry February and March.

Figure 18. Rainfall in DL1 Agro-Ecological Region.



Source: Ponrajah 1982.

In a similar manner, starting yala in late March or early April seems to be the best arrangement with regard to the rainfall pattern. This will allow the high rainfall in April to be utilized for land preparation and harvesting to take place in July or August. However, a cultural problem affects the implementation of this schedule. The Sinhala and Hindu New Year falls around 13-14 April. As Sinhala-Buddhist and Tamil-Hindu farmers are a majority, only a few participate in agricultural activities for about a week in mid-April. Similarly, most officers are also on leave and good supervision is not possible. As a result, some managers prefer to start yala in late April. If the reservoir water level is low after the maha season, April rains can be used to fill up the reservoir.

Deviations from the generally accepted dates for maha and yala seasons were observed on two occasions. On both occasions, heavy water use was observed. First, in the Dewahuwa Scheme, the 1986/87 maha was cultivated in two staggers. The duration of the season was 176 days, which did not

5. Conclusions

5.1 OUTCOME OF THE STUDY

5.1.1 Performance Changes and Inter-Scheme Comparisons

The results show that some schemes were performing at optimum levels even at the beginning of the study period, with respect to indicators like Irrigation Intensity. Another factor to be considered is that the reservoir capacity limits the saving of water in the maha season in schemes such as Parakrama Samudra and Mapakada. As a result, sometimes the scope for performance improvement in schemes with good water availability is small in the maha seasons.

Parakrama Samudra, Rajangane, Mapakada, and Ridiyagama can be considered as irrigation schemes with good water availability in the maha season. Out of the four schemes, Parakrama Samudra and Rajangane show an improvement in performance related to water use. In Rajangane, the improvements are more significant and can be observed in both seasons. The following features of the interventions implemented in the four schemes need to be considered in this context:

1. All four schemes came under INMAS, and farmer organizations were established. In the case of Parakrama Samudra, Mapakada and Rajangane, the INMAS System was established in 1984. Although Ridiyagama was also included in the original plan of INMAS (ML&LD 1984), the system was formally established only in 1991.

2. Improvements to physical infrastructure have been implemented in Parakrama Samudra, Mapakada and Rajangane, but not in Ridiyagama.

3. The level of farmer participation in rehabilitation activities was high in Parakrama Samudra and Rajangane because of the institutional development activities implemented through ISMP and MIRP.

4. Facilities for water management were improved in Parakrama Samudra and Rajangane under the respective rehabilitation projects. The improved facilities included provision of gates and measuring devices for the distributary canals, provision of computer software for canal operation and establishment of weather stations.

In the case of the Rajangane Scheme, the length of the irrigation season has decreased and water issues between seasons have also decreased. These indicate a more disciplined water use by the farmers and a more systematic water distribution by the managers.

Observations on performance changes in the Parakrama Samudra Scheme can be summarized as follows:

1. The length of the irrigation season has decreased in yala. Corresponding performance gains related to water use can be observed in the yala seasons.

There was a substantial difference in the area cultivated reported by the IMD and the area irrigated reported by the Irrigation Department in Mapakada and Ridiyagama schemes. It should be noted that if the lower values of area are adopted, the relative position of performance of these two schemes would be lower.

5.1.2 Comparison of Performance Levels with Potential

The main difficulty in assessing whether an irrigation system has achieved its potential is in estimating the potential itself. For example, the Irrigation Intensity is dependent on available water resources, which can vary with each scheme. Considering the effects of soil properties, water resources, expansion of cultivated area, land use preferences, etc., it is not possible to define a potential for the selected schemes with the available data.

However, the existence of scope for improvement of performance is an indirect indication that the full potential is not achieved. If this argument is accepted, the following observations can be made:

1. The results show that maximum rainfall utilization is not achieved in some schemes, for example in the Mapakada Scheme.

2. The interventions with more emphasis on water management have contributed to increasing performance. However, the level of emphasis on water management varies with the interventions. For example, ISMP and MIRP have heavier emphasis on this aspect. If similar efforts are made in the other schemes, further performance improvements can be achieved.

3. The length of the irrigation season is a parameter which is not affected by site-specific physical conditions. The results show that the value of this parameter varies among the schemes. In yala, the length of the irrigation season is higher than the expected value in all schemes. The season is often extended due to management problems such as inability of the management to provide a reliable water supply, non-adoption of water saving agronomic practices like dry sowing, lack of officer-farmer coordination, and cultivation of long-term varieties in the yala season. If these defects are rectified, there is further scope for improvement of the performance.

4. Lower yields even in systems with adequate water supplies suggest that variables not related to irrigation management have an important impact on performance.

Another method for assessing whether the full potential is achieved is comparing the present performance with the best achievement recorded. The best achievement recorded need not be the potential. However, if the present performance is lower than the best achievement recorded, it means that the performance is lower than the potential as well.

Table 24 presents the current performance levels as a ratio of the best achievements. Irrigation Duty and length of the irrigation season are not included in this analysis because they were already compared with reference values. The following reservation should be noted when referring to this table: The best performance in Area Irrigated per Unit Water in Rajangane were recorded in 1989/90 maha and 1990

2. A decline in agricultural performance can be observed in maha. Because of good water availability and physical improvements, it is unlikely that this is related to the water supply. Available data do not provide an explanation for the decline in agricultural performance.

3. Even at the beginning of the study period, the performance of the scheme was fairly good. The changes in performance should be evaluated on this basis.

In Parakrama Samudra and Rajangane, part of the performance improvements can be attributed to the shortening of the length of the season. One objective of shortening the irrigation season was to accommodate a longer construction period between the end of yala and the start of maha. It should be noted that farmer organizations also participated in construction activities in these two schemes. This also may have helped in making the farmers understand the importance of shortening the length of the season. Hence, in the case of Parakrama Samudra and Rajangane, the performance gains can be attributed to a combination of physical improvements, active farmer participation in management and improved water management.

Observations on the performance changes in the Mapakada Scheme can be summarized as follows:

1. Performance with regard to agricultural productivity has increased over time, although it still remains lower than in some of the other schemes studied.

2. Performance with respect to water use has generally decreased.

3. Lengths of irrigation seasons have not improved.

Because of structural improvements, while water use per unit area has increased, it is likely that the equity and reliability of the water supply have also improved. Available information suggest that further improvement can be made through effective water management.

The major management interventions implemented in this scheme are the structural improvements effected through IRDP and the institutional developments made through INMAS. Hence, the performance gains can be partly attributed to the structural improvements, while substantial contributions would also have been made by the farmer organizations. A more detailed field study would be needed to understand the relative contributions of these interventions. Information on agricultural extension services and input supply are not available at this stage. Hence, the reasons for improved agricultural productivity cannot be identified without further research.

In the Dewahuwa Scheme, the interventions include:

1. Encouraging OFC cultivation.
2. Adoption of the INMAS system.

OFC cultivation is high in yala seasons. The impact of this is reflected in the high values of Area Irrigated per Unit Water and the low values of Irrigation Duty. However, a decrease in the level of performance in Dewahuwa can be observed from the data. Except for a drop in rainfall, available data do not provide reasons for this decrease. Further research is suggested in this case.

Table 24. Current irrigation performance as a ratio of the best achievement in the study period.

Performance indicator	Dewahuwa		Mapakada		Parakrama Samudra		Rajangane		Ridiyagama	
	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
AIUW(I)[1]	71	71	90	89	86	90	75	65	80	88
AIUW(T)[2]	97	73	73	88	72	90	78	66	80	85
Irrigation Intensity	100	50	100	89	100	100	97	100	88	93
RWS[3]	94	-	73	99	86	97	85	85	72	81
IWP[4]	70	-	83	90	75	96	91	81	88	93
Production (tons)	64	-	95	96	81	83	90	87	77	82
Cropping Intensity	78		98		98		97		90	
LP[5]	95		95		89		83		84	

1 Area Irrigated per Unit Water (irrigation only) (ha/MCM).
2 Area Irrigated per Unit Water (total water supply) (ha/MCM).
3 Relative Water Supply.
4 Irrigation Water Productivity (tons/MCM).
5 Land Productivity (tons/ha/season).

Often, these features interact positively, and as a result, it is a combination of these which contribute to good performance. It is difficult to isolate the effect of a single feature.

Similarly, the following factors dampen the effectiveness of management interventions and obstruct the improvement of performance:

1. Lack of motivation due to good water availability.
2. Deviation from usual cropping calendar.
3. Preparation of irrigation schedules without due regard to rainfall pattern.

5.2.2 Maintenance of Irrigation System

An important factor which was not analyzed in this study for want of data was the level of maintenance of the irrigation systems. An indirect indicator of the level of maintenance is money spent on maintenance. Although data specific to individual schemes are not available, the overall fund allocation of the Irrigation Department can be used as a proxy in this context. Available data show that expenditure on O&M was Rs 330 per ha (Rs 134 per ac) in 1982. In 1989, the corresponding figure was Rs 410 per ha (Rs 166 per ac) (Wijesooriya 1990 and Irrigation Department 1990). In 1982 prices, the expenditure in 1989 was Rs 172 per ha, which means a reduction of 48 percent from 1982.

A survey done by the Irrigation Department in 1982 estimated that the average expenditure required for O&M is about Rs 494 per ha (Rs 200 per ac). Compared with this, the money actually spent is about 65 percent less than the requirement. This indicates that the infrastructure of irrigation systems is likely to deteriorate even after a system has benefitted from a rehabilitation program.

5.2.3 Conditions Required for Good Performance

Although a considerable amount of academic literature on performance assessment exists, systematic studies on the relationship between irrigation management processes and irrigation performance are comparatively few. As a response to this situation, a comparative study of three irrigation systems was conducted by IIMI (Merrey et al. 1994). The study is based on data from three irrigation systems in Nepal, the Philippines and Sri Lanka.

The hypotheses verified in this study are as follows:

1. Institutional conditions which both enable managers to do their jobs effectively and provide effective incentives to encourage good performance, are necessary conditions to achieve and sustain good irrigation performance.

2. Presence of a management cycle which plans to achieve the objectives, implements the plan, monitors the implementation and evaluates the achievement of objectives, is a necessary condition for achieving good performance.

3. Regular assessment of key parameters of performance is necessary for sustaining and improving canal irrigation system performance.

The following discussion attempts to ascertain whether the existing irrigation management processes in Sri Lanka are conducive to achieving good performance. As information specific to the five irrigation systems are not available, this would be based on general information.

5.2.4 Effects of Institutional Conditions

The study by Merrey et al. (1994) shows that irrigators' associations and agency staff are both rewarded for achieving targets in the Philippines. However, such a systematic approach to rewarding good performance, especially in system operation, does not exist in Sri Lanka. On the contrary, sometimes the rewards are negative. For example, the officers who attempted to establish a seasonal planning system in the Kirindi Oya Project had to endure harassment and abuse (IIMI 1994). Other studies cite the following reasons for the poor standard of operation of irrigation facilities:

1. Lower level officers, with whom the responsibility of operation usually rests, lack the authority to take decisions.

2. Training in water management provided to officers is inadequate (IIMI 1990).

Since participatory management of irrigation systems has been adopted as the government policy in Sri Lanka, a system to reward good performance should include both public servants and farmer organizations. Although differences exist on the effectiveness of farmer organizations, a systematic organizational setup is present within farmer organizations for farmers to participate in management activities. This provides the necessary ground conditions for an institutional setup in which both the agency staff and farmer organizations benefit from good performance.

5.2.5 Effectiveness of the Management Cycle

Merrey et al. (1994) categorizes the tasks involved in an effective management cycle into four major categories:

The first task in an effective management cycle is identified as **planning the process by which objectives are set or modified, operational targets identified and implementation plan established.**

In general, the present irrigation planning system comprises a water issue schedule with target dates of main cropping activities. In the past, inadequacy of discharge measurement structures prevented the managers from volume-based irrigation planning. However, in most of the modified irrigation systems flow measurement structures are in place now. Hence, the potential exists to plan irrigation based on volumes and discharges.

The lessons learnt from the studies conducted by IIMI are important in this context. Some of them are described below:

The Kirindi Oya Project in southern Sri Lanka has experienced severe water shortages since its inception in 1985. As a result, IIMI was invited by the Government of Sri Lanka and the Asian Development Bank to assist in improving its system performance by conducting a diagnostic survey.

One of the major conclusions of the researchers was that irrigation water use efficiency is low in Kirindi Oya, although a great potential exists to save water through proper management policies. The proposed innovations to improve performance included the improvement of main system management through seasonal planning (IIMI 1991).

Similar research was carried out in the Uda Walawe Scheme by IIMI. The proposed improvements include seasonal planning here too (IIMI 1991).

In Kirindi Oya and Uda Walawe, seasonal water distribution plans based on target volumes of water delivery are being prepared now. Similarly, in the Parakrama Samudra and the Rajangane schemes studied in this report, the rehabilitation packages included computer software for planning water deliveries.

The second task in the management cycle is identified as **implementation of the agreed plan.** The existing infrastructure facilities and staff strength need to be studied further to see whether they are adequate to implement the plans.

Apart from the infrastructure and staff strength, a set of well defined operational rules is necessary to implement the plans smoothly. For example, during a rainfall event, the staff should know the adjustments to be made to the irrigation supply depending on the amount of rainfall. In the Uda Walawe Project, a set of guidelines to respond to rainfall was developed by the consultants to the Walawe Irrigation Improvement Project. They were based on the following parameters:

1. The week in the irrigation season during which rainfall occurred.
2. Location of rainfall event (lower tracts or upper tracts).
3. Intensity of rainfall (IIMI 1990).

Monitoring the implementation of the plan to check whether operations are carried out efficiently and targets are met, is identified as the third task. In other words, this poses the question:

Are the managers doing things right?

In the majority of irrigation systems, water measurement is confined to the main canal. At the field level there is very little monitoring of water distribution (IIMI 1992).

The measures adopted at the Kirindi Oya Project for monitoring are as follows:

1. Introduction of a data collection program and a communication network.
2. Introduction of a computerized Irrigation Management Information System (IMIS).

One of the advantages of using the IMIS for monitoring operations in the Kirindi Oya Project is that it provides the manager with a global view of water use in different areas under the project (IIMI 1994).

The fourth task in a management cycle is **evaluation of performance** to see whether the broader objectives are met. In other words, this poses the question:

Are the managers doing the right thing?

In most irrigation schemes in Sri Lanka comprehensive performance assessment is limited to amendments done under specific research studies. However, this system is not of much use as a management tool. One of the reasons for the present situation is the lack of resources to assess performance in time to make an impact. Studies done in the Kirindi Oya Project (IIMI 1994) and in the Mahi Kadana Project in India (Murray-Rust et al. 1994) show that the introduction of MIS has improved the capacity of management to effectively evaluate performance. The observed benefits of using an MIS as a technique to evaluate performance are as follows:

1. It provides information to evaluate system performance when required.

2. It provides seasonal summary reports which are useful for higher level planners and policy makers.

5.2.6 Performance Assessment System

The importance of performance assessment as a management tool is supported by the following factors which arise from the present review:

1. The foregoing analysis shows that there is potential for improvement of performance in some of the schemes studied.

2. Management interventions such as rehabilitation projects are implemented at a substantial cost with objectives such as increasing the productivity. It is important to see whether these objectives are achieved.

To be effective as a management tool, the set of performance indicators used by the managers should cover a broader spectrum of objectives than what is covered in this study. The range of indicators required to make a comprehensive assessment of irrigation performance can be described as follows:

* Water supply performance.
* Agricultural performance.
* Economic, social and environmental performance (Bos et al. 1994).

In view of the above, the present performance assessment system seems to be inadequate to make a meaningful contribution to irrigation performance. For example, Irrigation Duty, which is widely used as a performance indicator, does not reflect the effect of rainfall. Moreover, specific targets for different schemes have to be set. The present situation does not permit the combination of water, agriculture and other kinds of performance assessment, so any assessment by senior managers is limited.

Even the indicators used in this report do not provide information such as adequacy, reliability and timeliness. Another factor to be considered is the ways and means by which to utilize the performance indicators to improve performance. For this, targets have to established for each indicator.

The Performance Program of IIMI plans to develop a comprehensive system for the assessment of performance and make it available to irrigation managers. As a primary step, a set of performance indicators is being developed now. However, to implement this system, it is essential to have a reliable set of data. Although certain deficiencies exist in this field, it should be noted that several agencies collect data related to irrigated agriculture. They include the Irrigation Department, Irrigation Management Division, Agriculture Department, Department of Agrarian Services and Mahaweli Authority. Sometimes the collected data are duplicated. However, what is lacking is a proper system by which to share these data, especially at the provincial and scheme levels.

5.3 RECOMMENDATIONS

Since this is a subjective assessment of performance, far reaching recommendations are not made at this stage. The following recommendations are based on data analysis and review of management interventions:

1. Performance assessment needs to be adopted by irrigation managers as a tool to improve the performance of the irrigation systems they manage.

2. A methodology should be established to share the data useful for performance assessment, at respective levels. For example, the project level data collected by different agencies should be shared by the project level officers of different agencies and the Project Management Committee. The information can be sent to respective headquarters to form a national level data base and assess national level irrigation performance.

3. Each irrigation system should be equipped with a data collection and feedback system for day-to-day operations and seasonal planning.

4. Volume-based operations should extend at least to the distributary level. Target volumes and discharges should be used for this purpose.

5. Computerized IMIS should be used to process the data speedily, and schedule the operations. The same system can be used to assess performance.

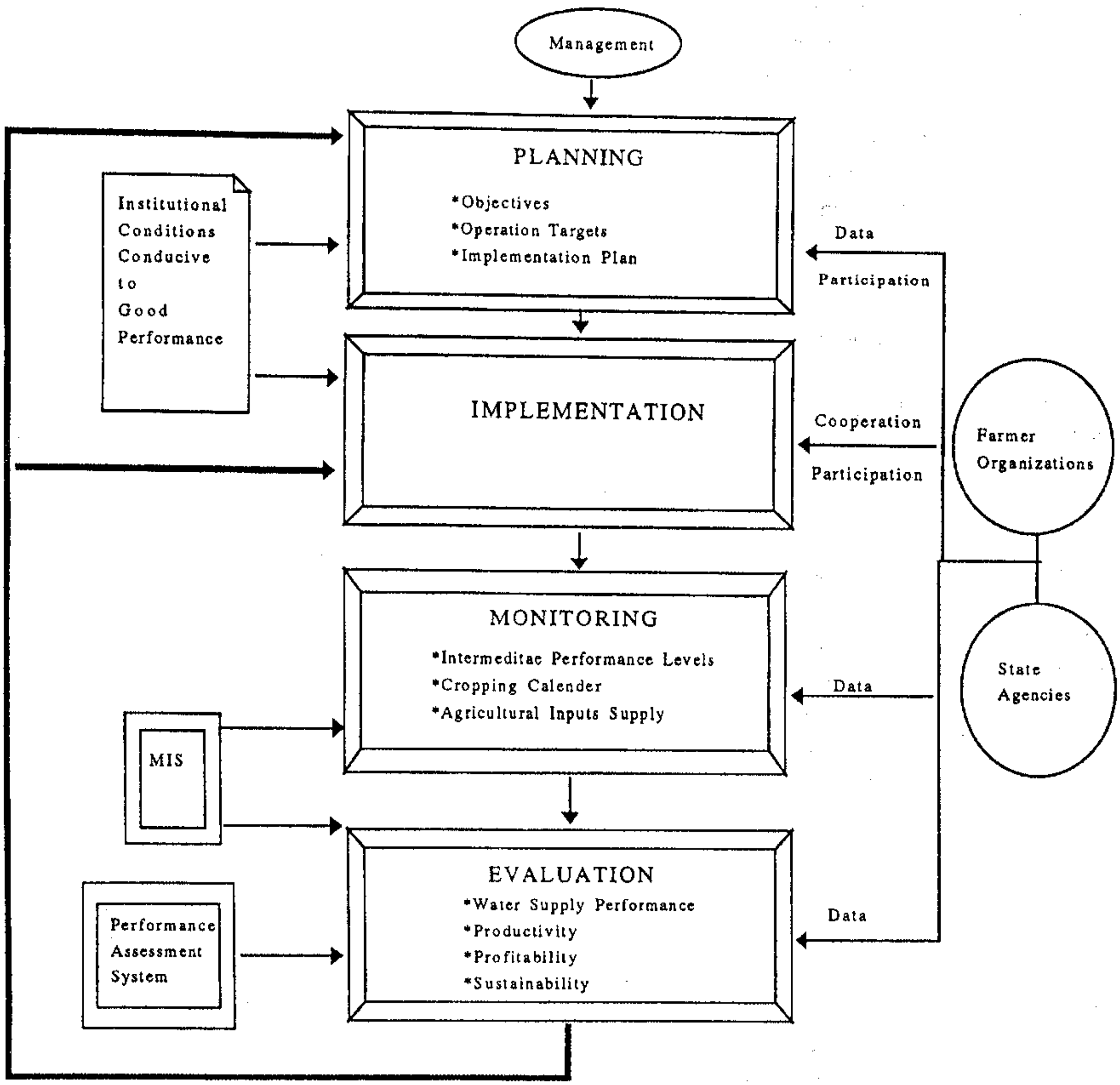
6. The data available at the Irrigation Department headquarters should be computerized, incorporated into an MIS and used for performance assessment.

Based on the review of past studies on irrigation management in Sri Lanka made in Section 5.2 of this paper, it is further suggested that active participation and information feedback from farmer organizations and other state agencies are important to improve the performance through an efficient management cycle.

The importance of sharing information among agencies was observed when the data from the Mapakada and Ridiyagama schemes were analyzed. If there is a continuous dialogue among different agencies, the substantial differences in values of area cultivated could have been avoided.

These recommendations and suggestions are illustrated in Figure 19. The illustration is based on the four major categories of tasks in the management cycle (Bos et al. 1994) discussed above.

Figure 19. Suggestions to improve the effectiveness of the management cycle.



The effectiveness of the task of **planning** is enhanced by the participation and the provision of data by farmer organizations and other state organizations. Appropriate institutional conditions conducive to good performance also contribute positively to the planning process.

Similarly, the task of **implementation** is facilitated by the cooperation and participation of farmer organizations, proper institutional conditions and cooperation of other state agencies.

The **monitoring** process can be strengthened by the data supplied by farmer organizations and other state agencies. Management Information Systems would also make an important contribution to this process, especially in areas such as the calculation of intermediate performance levels.

The effectiveness of **evaluation** will be enhanced by a systematic performance assessment system as well as by the data supplied by farmer organizations and other state agencies. Performance related to productivity and profitability cannot be accurately evaluated without information from farmers and agencies like the Agriculture Department. Management Information Systems also contribute to this task by efficient and timely evaluation of performance using a large data base.

Once performance is evaluated, the information should be used to identify the weak points in planning and implementation. This leads to a cyclic process which eventually enhances the effectiveness of the management cycle.

5.4 FUTURE RESEARCH NEEDS

This study is not definitive. Further data collection at project level is required to quantitatively assess the trends of performance change. Furthermore, the assessment of hydraulic performance is not sufficient to see whether the objectives of management interventions are met. Most of the rehabilitation programs had more far reaching objectives than improving the hydraulic performance of the irrigation system.

Therefore, it is suggested that this study be used as a base for a more comprehensive study including a larger number of irrigation schemes and a larger set of performance indicators. This type of study will provide a representative sample of Sri Lanka's irrigation systems and would provide a better view of the country's irrigation performance. Further, it will validate the suggestions and recommendations made in Section 5.3.

This paper discusses the performance changes which have taken place in several irrigation schemes over a period of time. It also discusses the features of management interventions which may have contributed to these changes. However, to identify the exact causes of these changes, more intensive data collection at the scheme level is necessary. For example, the reduction in productivity can be due to a variety of reasons such as low fertilizer use, climatic factors and water logging and salinity buildup. Similarly, changes in length of the irrigation season can be due to cultivation of short-duration varieties, rehabilitation of the system, transfer of the management to farmers, and improved water management. Identifying these factors and quantifying their effects on irrigation performance would be useful for the managers to improve performance.

Another factor to be investigated is whether the capacity to improve performance exists in the present setup. Although an assessment would show that the potential for improving performance exists, the recommendations for improvement may meet with failure if the capacity for such improvement does not exist. IIMI has proposed a procedure to overcome this problem which is called the *Performance Improvement Capacity Audit* (Merrey et al. 1995). The methodology adopted essentially comprises of a set of questions which will examine the capacity of the management to improve performance level. This capacity audit is a necessary second step after evaluating the potential for performance improvement.

References

Abernathy, C.L. and J.A. Weller. 1987. Water distribution within small farmer groups at Kaudulla, Sri Lanka. Report OD 67. Wallingford, Oxfordshire: Hydraulic Research Limited.

Abeysekera, W.A.T. 1993. Rehabilitation of irrigation systems in Sri Lanka: A literature review. Colombo, Sri Lanka: IIMI. IIMI Country Paper—Sri Lanka—No. 11.

Abeyratne, Shyamala. 1986. The development of institutional arrangements for irrigation water management in village irrigation systems in Sri Lanka. Paper presented at the Seminar on Irrigation Management and Agricultural Development in Sri Lanka, Agrarian Research and Training Institute, Colombo, Sri Lanka. 19-21 February 1986.

Aluwihare, P.B. and M. Kikuchi. 1990. Irrigation investment trends in Sri Lanka: New construction and beyond. Colombo, Sri Lanka: IIMI.

Arumugam, S. 1969. Water resources of Ceylon: Its utilization and development. Colombo, Sri Lanka: Water Resources Board.

Bandaragoda, D.J. 1986. Irrigation initiated development in Sri Lanka with special reference to the Mahaweli Development Programme. Paper presented at the Seminar on Irrigation Management and Agricultural Development in Sri Lanka. Agrarian Research and Training Institute, Colombo, Sri Lanka. 19-21 February 1986.

Blank, H.G. 1986. Lessons from Gal Oya and implication for ISM. Paper presented at a Seminar on Irrigation Management and Agricultural Development in Sri Lanka. Colombo: ARTI. 19-21 February 1986.

Bos, M.G.; D.H. Murray Rust; D.J. Merrey; H.G. Johnson and W.B Snellen. 1994. Methodologies for assessing performance of irrigation and drainage management. Irrigation and Drainage Systems, 7 (4) : 231-261.

Danansooriya, S. Irrigation Management Division. Personal communication. 1994.

Dastane, N.G. 1974. Effective rainfall in irrigated agriculture. Rome: Food and Agriculture Organization of the United Nations (FAO).

Dayaratne, M.H.S. 1991. A review of alternative strategies for improving farmer-managed irrigation systems in Sri Lanka. Colombo, Sri Lanka: IIMI. IIMI Country Paper—Sri Lanka—No. 7.

Department of Census and Statistics. 1992. Statistical Pocketbook of the Democratic Socialist Republic of Sri Lanka, Colombo, Sri Lanka: Department of Census and Statistics.

ECL. 1992. Final report of the study on cost effective irrigation modernization strategies for the 1990s. Report submitted to IIMI by Engineering Consultants Ltd. and Associated Development Research Consultants Ltd. Colombo.

Elkaduwa, W.K.B. 1990. Water management practices in lowland rice of Mahaweli System C Project. *In* Gunawardana, E.R.N. (ed.). Irrigation and water resources. Department of Agricultural Engineering, Faculty of Agriculture. Sri Lanka: University of Peradeniya.

Fowler, D. and M.K. Kilkelly. (eds.). 1987a. Diagnostic analysis of Parakrama Samudra Scheme. Water Management Synthesis (WMS) Project. WMS Report 57. Fort Collins, Colorado, USA: Colorado State University.

Fowler, D. and M.K. Kilkelly. (eds.). 1987b. Diagnostic analysis of Minneriya Scheme. Water Management Synthesis Project. WMS Report 59. Fort Collins, Colorado, USA: Colorado State University.

Food and Agriculture Organization of the United Nations (FAO). 1991. Production Yearbook 1990. Rome: FAO.

Framji, K.K.; B.C. Garg and S.D.L. Luthra. 1983. Irrigation and drainage in the world: A global review, Volume III. New Delhi, India: International Commission on Irrigation and Drainage (ICID).

Gamaathige, A.; J.D. Brewer and K. Jinapala. 1995. Sri Lanka's INMAS Program: An experiment in Participatory Irrigation System Management. IIMI—Sri Lanka Field Operations (SLFO). Mimeo.

International Irrigation Management Institute (IIMI). 1990. Final Report on the Technical Assistance Study. Irrigation management and crop diversification (Sri Lanka), Volume 1. Colombo, Sri Lanka: IIMI.

IIMI. 1991. Irrigation management and crop diversification (Sri Lanka): Inception Report on the Phase II Technical Assistance Study TA 1480 SRI. Colombo, Sri Lanka: IIMI.

IIMI. 1992. Irrigation management for crop diversification in the North Central Province of Sri Lanka. Irrigation Management Group for Crop Diversification. Colombo, Sri Lanka: IIMI.

IIMI. 1994. Draft Final Report on the Technical Assistance Study. Irrigation management and crop diversification (Sri Lanka), Volume II. Kirindi Oya Project. Colombo, Sri Lanka: IIMI.

Irrigation Department. 1975. Register of irrigation projects in Sri Lanka. Sri Lanka: Irrigation Department.

Irrigation Department. 1990. Administrative Report 1989. Sri Lanka: Irrigation Department.

Jayawardane, J. and A. Jayasinghe. 1990. Management arrangements for diversifying rice irrigation systems in Sri Lanka. *In* Miranda, Senen M. and Amadao R. Maglinao (eds.). Management arrangements for accommodating nonrice crops in rice-based irrigation systems. Colombo, Sri Lanka: IIMI.

Jayawardane, J.; A. Jayasinghe and P.W.C. Dayaratne. 1993. Promoting implementation of crop diversification in rice-based systems in Sri Lanka. *In* Miranda, Senen M. and Amadao R. Maglinao (eds.). Promoting crop diversification in rice-based irrigation systems. Colombo, Sri Lanka: IIMI.

Leach, E. 1959. Hydraulic society in Ceylon. Past and Present, Volume 15 : 2-26.

Levine, G. 1982. Relative water supply: An explanatory variable for irrigation systems. Technical Report No. 6. The determinants of developing country irrigation project problems. Ithaca, NY: Cornell University.

Mendis, D.L.O. 1989. Hydraulic civilizations: Irrigation ecosystems and the modern state. E.O.E. Pereira Commemoration Lecture 1989. Institution of Engineers. Sri Lanka. 13 September 1989.

Merrey, D.J.; Alfredo Valera and Lalith Dassenaike. 1994. Does assessing performance make a difference? Results from a comparative study of three irrigation systems. Quarterly Journal of International Agriculture, 33 (3) : 276-293.

Merrey, D.J.; D. Hammond Murray-Rust; Carlos Garces-Restrepo; R. Sakthivadivel and Wasantha Kumara. 1995. Performance assessment capacity audit: A simple methodology for identifying potential interventions to improve irrigation performance. Water Resources Development, 11 (3) : 11-24.

Ministry of Lands and Land Development (M/L&LD). 1984. Programme for Integrated Management of Major Irrigation Schemes. Colombo, Sri Lanka: Division of Irrigation Management of the Ministry of Lands and Land Development.

Molden, D.J. and T.K. Gates. 1990. Performance measures for evaluation of irrigation-water delivery systems. Journal of Irrigation and Drainage Engineering, 116 (6) : 804-823.

Muralidaran, V. and K.V.S.M. Krishna. 1993. The dynamics of irrigation system performance. Colombo, Sri Lanka: IIMI. IIMI Working Paper No. 25.

Murray-Rust, D.H.; O.T. Gulati; R. Sakthivadivel; V.B. Prajapati and P.L. Shukla. 1994. Improving irrigation performance through the use of Management Information Systems: The case of Mahi Kadana, Gujarat, India. Colombo, Sri Lanka: IIMI. IIMI Country Paper—India—No. 1.

Palipana, Nihal. Irrigation Department. Personal communication. 1994.

Peoples Bank. 1989. Integrated Rural Development Program. Special Report. Economic Review, Jan/Feb 1989. pp 3-5.

Ponrajah, A.J.P. 1981. Technical Note No. 6. Sri Lanka: Irrigation Department.

Ponrajah, A.J.P. 1982. Design of irrigation headworks for small catchments. Sri Lanka: Irrigation Department.

Ponrajah, A.J.P. 1988. Technical guidelines for irrigation works. Colombo: Irrigation Department of Sri Lanka.

Ponrajah, A.J.P. n.d. Water management synthesis training: Rajangane Project Operation. Mimeo.

Sakthivadivel, R. and D.J. Merrey. 1992. Flow measurements at drop structures for irrigation system management in Sri Lanka. Colombo, Sri Lanka: IIMI. IIMI Country Paper—Sri Lanka—No. 10.

Sakthivadivel, R.; D.J. Merrey and Nihal Fernando. 1993. Cumulative relative water supply: A methodology for assessing irrigation system performance. Irrigation and Drainage Systems, 7 : 43-67.

Samarasinghe, S.A.P. 1985. Rotational water distribution at the farm level: Potential problems and remedial actions. Lecture notes provided for the Water Management Improvement Course 1995. Galgamuwa: Irrigation Training Institute.

Somapala, B.W. 1985. Agronomics of rice. Water management for rice cultivation. Lecture notes provided for the Water Management Improvement Course 1995. Galgamuwa: Irrigation Training Institute.

Survey Department. 1988. The national atlas of Sri Lanka. Sri Lanka: Survey Department.

Teoh, W.C. and T.S. Chua. 1989. Irrigation management practices in MADA. Malaysia: Muda Agricultural Development Authority (MADA).

Wijesooriya, L.T. 1990. Sri Lanka's experience in resource mobilization for system O&M: As viewed by the Irrigation Department. *In* Resource mobilization for sustainable management. Colombo, Sri Lanka: IIMI.