THE IIMI-MADA

COLLABORATIVE STUDY OF MUDA IRRIGATION PROJECT, MALAYSIA

PERFORMANCE ASSESSMENT AND EVALUATION OF MANAGEMENT INTERVENTIONS

INCEPTION REPORT

International Irrigation Management Institute

Muda Agricultural Development Authority
in cooperation with the
Department of Irrigation and Drainage
September 1994

**Performance Assessment and Evaluation of Management Interventions:
A Case Study of Muda Irrigation Project, Malaysia**

The Muda Irrigation Project is system representing rice double cropping area in Southeast Asia. Muda Agricultural Development Authority (MADA) and Tropical Agriculture Research Center, Japan (TARC) (now reorganized to Japan International Research Center for Agricultural Sciences) have carried out a series of technical cooperation projects in the area since 1968, resulting in noticeable improvements in performance of rice production; e.g. high cropping intensity, reduced production cost, high water productivity and so on.

IIMI recognized that a study of the Muda Project under its Performance Program, will provide an opportunity to extend the excellent ongoing work by MADA and JIRCAS. Hence, IIMI proposed to MADA to initiate an IIMI-MADA Collaborative Study on management interventions and the performance of irrigated agriculture. MADA accepted IIMI's proposal in January 1994 with the support of Dato' Syed Azizan Al Idrus, General Manager, MADA, Dato' Ahmed bin Ibrahim, Secretary General, Ministry of Agriculture and Dato' Shahrizaila bin Abdullah, Director General, Department of Irrigation and Drainage, Malaysia.

On 31 January and 1 February 1994, the first workshop was held at the MADA HQ, to discuss various methodological issues. It was suggested that an Inception Report will be prepared and circulated to members of the Steering Committee. The following persons have contributed to the preparation of this Inception Report.

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It is hoped that this study will contribute to the establishment of a methodology to improve performance of Muda agriculture as well as performance of other irrigation projects in Malaysia and other developing countries.

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PERFORMANCE ASSESSMENT AND EVALUATION OF MANAGEMENT INTERVENTIONS: A CASE STUDY OF MUDA IRRIGATION PROJECT, MALAYSIA

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EXECUTIVE SUMMARY

IIMI-MADA Collaboration

IIMI and MADA have launched a collaborative program from January 1994 to June 1995 under IIMI's Performance Program which aims to develop, validate and disseminate conceptual frameworks, methodologies and quantitative indicators, that can be used for assessing and improving the performance of irrigated agriculture, with special attention to the performance of irrigation systems. The Performance Program encompasses case studies in Malaysia, pakistan and India.

In the Malaysia case study, on the Muda Irrigation Project, quantitative linkages between performance indicators and the following management interventions will be analyzed using three types of indicators, namely: determinant indicator, impact indicator, performance indicator.

- Tertiary development since 1978;
- Introduction of dry sowing into irrigation scheduling since 1991; (for 1990-93);
- Decision support system established in 1988;
- Organization of farmers into Kelompoks and Mini-Estates since 1975.

For instance, construction of tertiary canals (management intervention) enhances canal density (determinant indicator). Enhanced canal density will result in decreased distribution loss (impact indicator) leading to a reduction in irrigation supply or an increase in irrigation area (performance indicator).

Methodology

At project level analysis of existing data (computerized by MADA) are utilized to quantify impacts of aforementioned interventions on water supply agricultural production and profit.

Analysis at block level will be conducted to study the relationship between performance and determinant indicators using data collected in the 1st and 2nd seasons in 1994 in each of the 5 irrigation blocks with and without tertiary development. A Questionnaire will be utilized to survey all farmers in 30 farm lots in each of the 10 blocks on field water conditions, agricultural input, labour input, machine input, expenses, yield and so on.

The data for the block level analysis of agricultural performance will be collected through a combination of secondary sources and a randomly selected sample of tertiary developed irrigation blocks (Muda II) and random samples of farm lots. The non-tertiary developed blocks (Muda I) and farm lots are selected in such a way to compare the performance of Muda I and Muda II blocks in the time period of data collection.

To reduce the effect of variations of different features associated with the selected blocks on the estimates of performance, Muda II irrigation blocks are stratified with respect to topography and existence of organized farmer groups. This gives rise to a stratified two-stage random sampling plan for the farm lot selections in Muda II irrigation blocks. In the first stage, a random sample of blocks will be selected from each stratum. In the second stage, random samples of farm lots will be selected from all selected blocks in the first stage. Therefore a simple random sample of 30 farm lots will be selected without replacement from each of the 5 blocks that are selected in the first stage.

A similar method is used for sampling farm lots from the Muda I blocks for the comparison of the performance with the Muda II blocks. However to ensure that the soil characteristics and agro-climatic conditions are similar in two sets of blocks, Muda I blocks will be selected so that they are adjoining the selected Muda II blocks.

Implementation

The activities under the program will be carried out by IIMI staff at HQ in partnership with irrigation agencies and local research organizations. According to the arrangements for the collaborative study, MADA will contribute the staff time of three professionals on secondment basis. The HQ staff inputs include contributions from an economist, two irrigation engineers and two statisticians/econometricians. In addition, the arrangements also include active involvement of officials from the Department of Irrigation and Drainage (DID).

The Steering Committee will be responsible for the overall supervision, monitoring and evaluation of progress of the collaboration. It includes: The Director (Research) and a Senior Technical Advisor from IIMI; Managing Director, Muda Agricultural Development Agency and Director-General, Department of Irrigation and Drainage, Malaysia.

The Working Group composed of senior staff of IIMI, MADA and DID is responsible for oversight and timely completion of activities.

The study team composed of economists, an irrigation specialist, engineers, an agronomist and statistician of IIMI and MADA will be responsible to conduct the field survey, data analysis and drafting of papers.

A Methodology Workshop was organized in January 1994, which included IIMI staff, some external experts and participants from collaborating irrigation agencies and local research institutions.

Preparations for the field survey have been made for 10 sample blocks and data collection began in April 1994. These data obtained from around 500 farmers will be analyzed to quantify the linkages between irrigation performance and management interventions.

A workshop for the field testing of indicators will be held in January 1995. The project is expected to be completed in June 1995.

Outputs

Following outputs are expected from the Muda study:

a. Sets of indicators to assess impacts of management interventions;

b. Quantifications of linkages between irrigation performance and management interventions;

c. Methodology to assess impacts of management interventions.

d. Effects of management interventions such as tertiary development on performance.

The following reports/working papers/journal articles will be prepared:

1. Productivity and Economic Profitability of Rice Production in the Muda Scheme, Malaysia, December 1994.

2. Water Use Efficiency in the Muda Scheme, December 1994.

3. Water Delivery Efficiency in the Muda Scheme, March 1995.

4. How direct sowing and tertiary development resulted in improved performance in Muda irrigation scheme in Malaysia? : Analysis of time series and block-level data.
   <u>December 1994 and September 1995</u>

A set of indicators relevant to a/or specific interventions will enable irrigation managers in developing countries to plan and design an efficient and effective performance monitoring system.

The quantified linkages of indicators should be a vivid standard to evaluate impacts of a specific intervention in a specific project. Thus, the outputs of this study will be useful tools to make irrigation management performance oriented and to enhance irrigation performance in developing countries.

Impacts

Since action research is carried out in a collaborative mode, a continuous interaction will occur among IIMI staff, MADA and DID. This collaboration itself ensures an increase in the knowledge regarding methods of assessing performance and the determinants of performance. Irrigation managers and policy makers in Malaysia will be able to use a set of field-tested indicators to assess changes in the performance of systems other than those studied in collaboration with IIMI. It is expected that in Malaysia, performance assessment will be carried out in a "routine" manner and this information will be used in changing management practices and in implementing management interventions. Understanding the linkages between performance improvement, management interventions and policy changes will not only be useful for Malaysia, but will also provide systematized knowledge which will be of value to other countries. In particular, the proposed action research study will provide a better understanding of the relationships among short-term operational (water delivery) performance, crop production, social and economic impacts, and long-term sustainability.

Chapter 1

The Performance Program

1.1 Introduction

Irrigated agriculture in developing countries will face important challenges in the coming decades. On the one hand, it has to provide a major share of the required increases in food and fibre production to meet the objectives of poverty alleviation and development. On the other hand, it is threatened by water shortages arising out of increasing competition from domestic, industrial and other sectors. This situation is further worsened by dwindling financial resources available for capital expenditures as the cost of new schemes increase, while international prices for foodgrains decline. Recurrent expenditures are also threatened by fiscal constraints and the unwillingness of governments to raise irrigation charges. In addition, institutional and organizational structures are outmoded and not conducive to management changes.

In the context of the threats of water shortages and declining financial resources, the productivity of existing irrigation systems will be the primary determinant of sectoral performance in the short run, and the sustainability of physical resource base will determine the long run contribution of irrigation. In light of these challenges, the International Irrigation Management Institute (IIMI) has defined its mission **as seeking to foster the development, dissemination and adoption of lasting improvements in the performance of irrigated agriculture in developing countries.**

1.2 Program Goals

The introduction of performance assessment methodologies is an effective and necessary first step in bringing about changes in irrigation management practices. Consistent use of performance indicators generates information which provides the basis for defining, monitoring and evaluating improved operational procedures for existing systems and for determining what further investment in irrigation, if any, are justified.

In view of the above, IIMI has developed/structured the Performance Program to address those important issues. It is anticipated that, over the next five years, the Program Workplan will :

Assist irrigation agencies and policy makers to incorporate a Performance Assessment System as an integral part of the management process;

Develop and disseminate methodologies to enable policy makers and irrigation managers to select appropriate indicator sets for evaluating productivity and sustainability of irrigated agriculture;

Establish a database which can be used for comparing information on the performance of irrigated agriculture in varying agro-climatic and management situations;

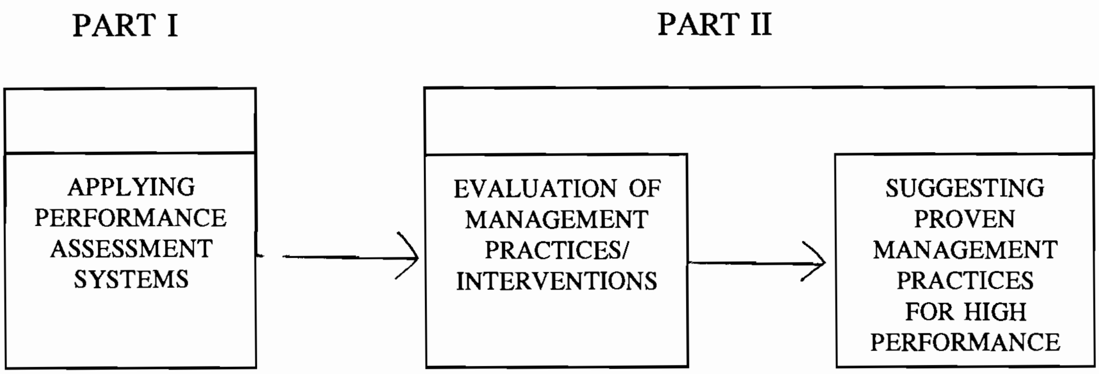
Identify proven management practices which are associated with high performance and assist in their adaption.

1.3 Activities

The proposed activities under this program will integrate and carry forward research presently underway on both performance assessment and decision support packages. Based on the framework developed earlier (Bos et al 1994) and other work (Small and Svendsen 1992, Abernethy 1991, Rao 1993 and Murray-Rust and Snellen 1993), a set of specific indicators will be identified that can be used by policy makers, irrigation managers and researchers. Performance indicators will be grouped into four types: (i) water supply performance; (ii) agricultural performance; ~~and~~ (iii) economic and social impacts, and (iv) environmental performance. These performance indicators will be applied and field-tested in selected irrigation schemes as discussed below.

As outlined in Figure 1, the major activities of the Program are divided into two interrelated parts. Part I will focus on developing, applying and refining a comprehensive Performance Assessment System which will provide data regarding an irrigation scheme in terms of water supply, productivity, equity, financial viability, environmental sustainability and the degree to which the existing "scheme" meets current and further agricultural requirements. The outputs of these activities would be a package of practical and cost-effective performance indicators which will be used to assist policy makers and irrigation managers to assess and improve the performance of irrigated agriculture.

Figure 1
Major activities of the performance program



Part II of the program will concentrate on using the performance assessment system to evaluate the performance impacts of a set of management practices and interventions. The empirical studies will evaluate the impact of an existing management practice (e.g. fixed rotational water supply) in selected irrigation schemes or assess the performance improvements achieved as a consequence of a management intervention (e.g. use of a decision support system). The outputs of this part of the Program will be to generate and disseminate knowledge about proven management practices associated with high performance. These evaluations will generate empirical information about the "determinants" of performance-enhancing management practices and institutional changes.

1.4 Part I: Developing and Applying a Comprehensive Performance Assessment System

1.4.1 Major Components of the Performance Assessment System

As outlined in Figure 2 , the major components of the performance assessment system are:

Identification of objectives and performance indicators;

Development of practical and cost-effective methodologies for measurement of performance over large irrigation systems;

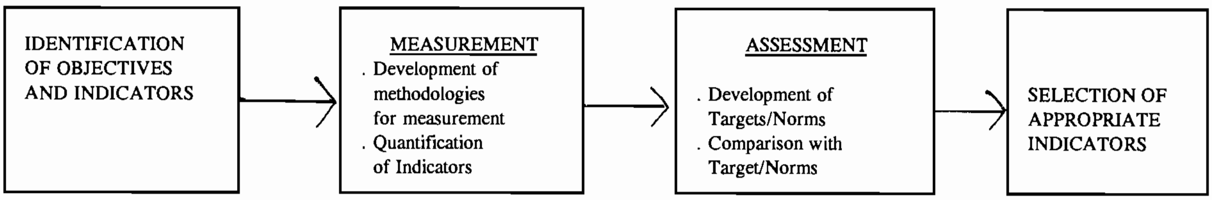
Quantification (measurement) of these performance indicators in selected systems;

Development and specification of targets or assessment norms/standards against which the actual values of performance indicators are to be compared;

Comparison of "actual values" of performance indicators with targets and assessment norms to derive conclusions regarding the "performance level" of the scheme/sub-scheme (or a group of schemes) for a given year and/or changes over time.

Selection of "appropriate" indicators for a given scheme.

Figure 2
Steps in performance assessment



It is essential to use performance indicators which are optimally appropriate for the objectives of the user. For example, the objectives of the policy maker may be one or more of the following : maximizing irrigated area from given supplies of water; maximization of productivity per unit of land/water/labour; meeting targets of food self-sufficiency, employment; providing benefits to small farmers, and for livelihoods of rural people including women; enhancing farmers' profitability and ensuring environmental and financial sustainability. The performance indicators will have to be so selected as to reflect such concerns. Table 1 illustrates some of the linkages between various objectives and corresponding performance indicators. The selection of "relevant" performance parameters will depend on the interest of the policy maker in assessing the contributions made and to be made by irrigated agriculture.

In contrast to the policy maker, the concerns of the irrigation manager, would relate to more specific aspects of system management e.g. adequacy and predictability of water supply to the farmers; equitable distribution of water supplies between head and tail-enders; and the effectiveness of infrastructure. On the other hand, the farmers' concern will be the effect of water supply on his productivity and net profitability. The indicators for these concerns are given in Table 1.

Field-testing of these indicators will generate information about the costs of quantifying various indicators, the ease of data collection and the replicability and robustness (in terms of variability) of these parameters. The relationships among various performance indicators will be quantified to identify groups of indicators which give similar results. This information will be useful for selecting a set of practical and cost-effective indicators for a given irrigation scheme.

It may be emphasized that an irrigation manager or a policy maker will require a small number of performance indicators for which data can be collected in a timely and cost-effective manner. This "preferred" set of indicators will vary depending upon agro-ecological conditions, methods of water delivery and allocation and the size of the system. However, to enable an irrigation manager and policy maker to select an appropriate set of indicators, there is a need to carry out field research to quantify the cost of measuring various indicators. In view of the fact that methodologies for practical measurement of performance in terms of various indicators over large systems do not yet exist, the design of such field research will be a challenge.

1.4.2 Measurement

Thus, during the first phase, efforts will be concentrated on the development and application of a comprehensive performance assessment system. This will require field-testing a relatively large number of indicators in order to generate the desired information on the ease and cost of data collection by alternative methods such as field sample surveys, participatory rural appraisal (PRA), Geographical Information Systems (GIS) and Satellite Remote Sensing (SRS). These data will enable a policy maker and/or an irrigation manager to "select" a practical and cost-effective set of performance indicators for a given system.

Field sample surveys will be designed using stratified random sampling techniques so as to minimize the costs of data collection (Lenton 1986; Seckler, Sampath and Raheja 1988; Malhotra, Raheja and Seckler 1984) . These sample surveys will cover the entire command area of the system and will generate agricultural production information including crop patterns, cropping intensities, crop yields, value of output per unit of land/labour/water. These large scale sample surveys will be supplemented by in-depth case studies of sample households (say 50 to 100) in order to quantify the relationships among water delivery, water allocation, input use, agricultural output and profitability. These case-studies will provide insights into farmers' response to alternative methods of water allocation (fixed rotation, demand-based, presence of water markets), and changes in input and output prices. These in-depth case studies will also provide information on the impact of changes in irrigation management on livelihoods of poor farmers and agricultural workers including women. Information collected from large scale surveys and in-depth studies will be correlated and analyzed to draw conclusions regarding sample size, the size and type of questionnaires and the number of seasons for which field data should be collected.

Participatory Rural Appraisal (PRA) methodologies will be used to (i) understand the way farmers' perceive their irrigation water supply and, (ii) analyze how participation in water market activities improves the quality of farmers' irrigation supply. Field surveys and PRA methodologies will be used to identify and document linkages between improvement of irrigation (water delivery) performance, and the presumed impacts (benefits) on incomes, equity, livelihoods and well-being of people.

1.4.3 Assessment

Once the type of performance indicators have been identified, the next steps are to develop and quantify targets and/or norms which will be used for a comparison with the actual values of each performance indicator. These norms will include, inter alia, parameter values (i) based on the design values used in the project report; (ii) maximum values obtained in the project in the past; (iii) a range of values obtained by measuring these indicators in a number of schemes in similar agro-climatic conditions (rainfall, type of water source) and project characteristics; and (iv) estimates of the "potential performance" of the system.

In order to generate adequate data to develop assessment norms/standards for irrigation schemes (in various agro-ecological and water regimes), it is proposed to collect information on a limited set of indicators for a relatively large number of irrigation schemes. This set of indicators will include : irrigated area per unit of water (diverted from surface water source plus pumped groundwater); intensity of cropping on irrigated land; gross value of output per ha/M^3; area under waterlogging and salinity and changes in groundwater table over time. These data will be collected from completion reports of country projects; IIMI country offices for schemes studied so far; published papers and reports (Garces 1983; Wijayratna 1986; Muralidharan and Krishna 1993; Thiruvengadahari et al 1994; Mao Zhi 1989; Bos et al 1991; Kelly and Johnson 1991; Plusquellec et al 1990); and from World Bank documents (World Bank 1993).

To use "potential performance" as a norm will require developing a methodology for quantifying such a potential norm based on system characteristics in terms of agro-climatic, infrastructural, technological and managerial variables. One possible approach may be to use simulation models to "estimate" the potential performance of an irrigation scheme.

These assessments will be used to identify the determinants on account of which the performance falls short of the design values or potential values. This information will be used in the "diagnostic analysis" and for identifying management interventions which could be implemented for improving performance.

For the **first phase (1994-1995)**, a comprehensive Performance Assessment System will be applied and field-tested in the following major irrigation schemes:

(i) Chishtian Sub-division of the Fordwah-Eastern Sadiqia irrigation system, Punjab, Pakistan;

(ii) Muda Irrigation Scheme in northern Malaysia.

1.5 Part II: Developing a Package of Tested Management Practices/Interventions

During the second phase (1995-1998), activities would aim at using the Performance Assessment System for evaluating a set of management practices/interventions in terms of their impact on performance improvements. In these evaluations, the following hypotheses will be tested in a variety of systems in several countries:

1. Decision support systems for operating staff at various levels of the water delivery and disposal system can contribute substantially to better system performance;

2. Where water is scarce, supply-based systems operating simple rotational schedules induce higher productivity per unit of water and more equity of distribution than demand-based systems;

3. Reliability of irrigation supply is correlated with the simplicity of operation; and,

4. In river-basin systems with substantial re-use of irrigation water, water conservation (e.g. canal lining) in irrigation is less cost-effective than in other water-using sectors.

In evaluating these hypotheses, two types of empirical studies are planned. The first type evaluates the impact of an existing management practice (e.g. fixed rotational water supply) in an irrigation scheme with another scheme which does not use this practice (e.g. demand-based water allocation) in India and Pakistan. A comparison of various performance indicators of the two schemes, one **with** and the other **without** the fixed rotation of water supply, will provide empirical information regarding the agronomic, infrastructural and management/institutional pre-conditions for fixed-rotation to achieve performance-enhancing results. Another way of assessing the impact of fixed-rotation of water supply is to quantify the performance parameters **before** the management intervention is actually introduced and compare these values with performance parameters **after** the management intervention has been introduced.

It is proposed to carry out both types of empirical work. The first type of analyses (comparing with and without a management practice) will yield results within a year or so. The second type (comparing performance indicators before and after a management intervention) of empirical work will require data collection and analysis over three to four years.

1.6 Outputs and Publications

1.6.1 Outputs

At the end of 1995, the following outputs will be available :

(i) A package of performance indicators which has been field-tested and modified on the basis of feedback from irrigation managers, policy makers and researchers;

(ii) A methodology of selecting cost-effective and relevant performance parameters for a given irrigation scheme;

(iii) Setting up a process within irrigation agencies under which data are routinely collected to apply a Performance Assessment System on a regular basis;

(iv) Empirical estimates of "value of water" in irrigated agriculture under high rainfall rice systems and semi-arid multicrop schemes under a variety of management situations;

At the end of 1998, the following outputs will be available :

(i) Empirical estimates of "value of water" in irrigation regimes under various conditions, such as rainfall, crop patterns, size of irrigated area, contributions from groundwater, type of surface water system (reservoir or diversion scheme) and management situations;

(ii) Database for a number of country-wide irrigation schemes giving information on irrigated area; productivity per unit of land, water and labour; index of equitable distribution of benefits; financial viability; economic profitability and environmental impacts.

(iii) An analysis of the "performance levels" of selected systems in terms of design and "potential performance" in their agro-ecological and infrastructural settings.

(vi) Alternative methodologies for measurement of performance indicators along with the ease of data collection, cost and statistical reliability.

1.6.2 Publications

During the first phase (1994-1995), the following reports/working papers will be prepared:

A comprehensive Performance Assessment System for Irrigated Agriculture: An Evaluation of Alternative Methodologies for Measurement and Assessment. : July 1995.

How to select "Appropriate" Performance Indicators for Irrigated Agriculture? December 1995.

Productivity, equity and environmental sustainability of Fordwah Irrigation Scheme in Pakistan : August 1995

How direct sowing and tertiary development resulted in improved performance in Muda irrigation scheme in Malaysia? : Analysis of time series and block-level data. : December 1994 and September 1995

How do irrigation agencies measure performance? A review of experiences in California, Australia, India, Malaysia and Pakistan. June 1995

How to evaluate the linkage between irrigation performance and sustainable livelihoods? A comparison of field survey approach and Participatory Rapid Appraisal (PRA). : December 1995

Performance Assessment of Six Irrigation Schemes in Sri Lanka. : December 1994

At the end of the first phase of applying the Performance Assessment System, a feedback mechanism will be used to learn from the experience and refine the methodology of quantifying indicators and selecting a small set for further application. Some of these Working Papers will be revised and published in refereed journals.

Chapter 2

Muda Irrigation Project

2.1 General Description

Muda Irrigation Project is located in the north-west of Peninsular Malaysia. Total area under the scheme is 126,000 ha which includes towns, forests and swamp areas. Area irrigated for rice double cropping is 95,856 ha, which is about 28% of the irrigated area in Malaysia. Annual rice production in the project area is approximately 860,000 tons, which account for about 45% of the total rice production in Malaysia.

For management purposes the area is divided to four districts. The area is further divided into 110 irrigation blocks to facilitate water management.

The project area is lying in an extremely flat, low and ill drained coastal plain, with a gradient of 1/10,000 to 1/5,000. The soils mainly consist of marine and riverine clays with high contents of montmorilonite.

Being in the equatorial zone, the average temperature here is about 27^{00}C. This area gets most of the rainfall from South-West monsoon, which prevails between April and September. Annual rainfall is approximately 2000 mm with a dry season from December to March. The peaks of rainfall occur in May and October. Figure 3 illustrates the monthly variation of rainfall in Muda area, using the data from 1948 to 1993.

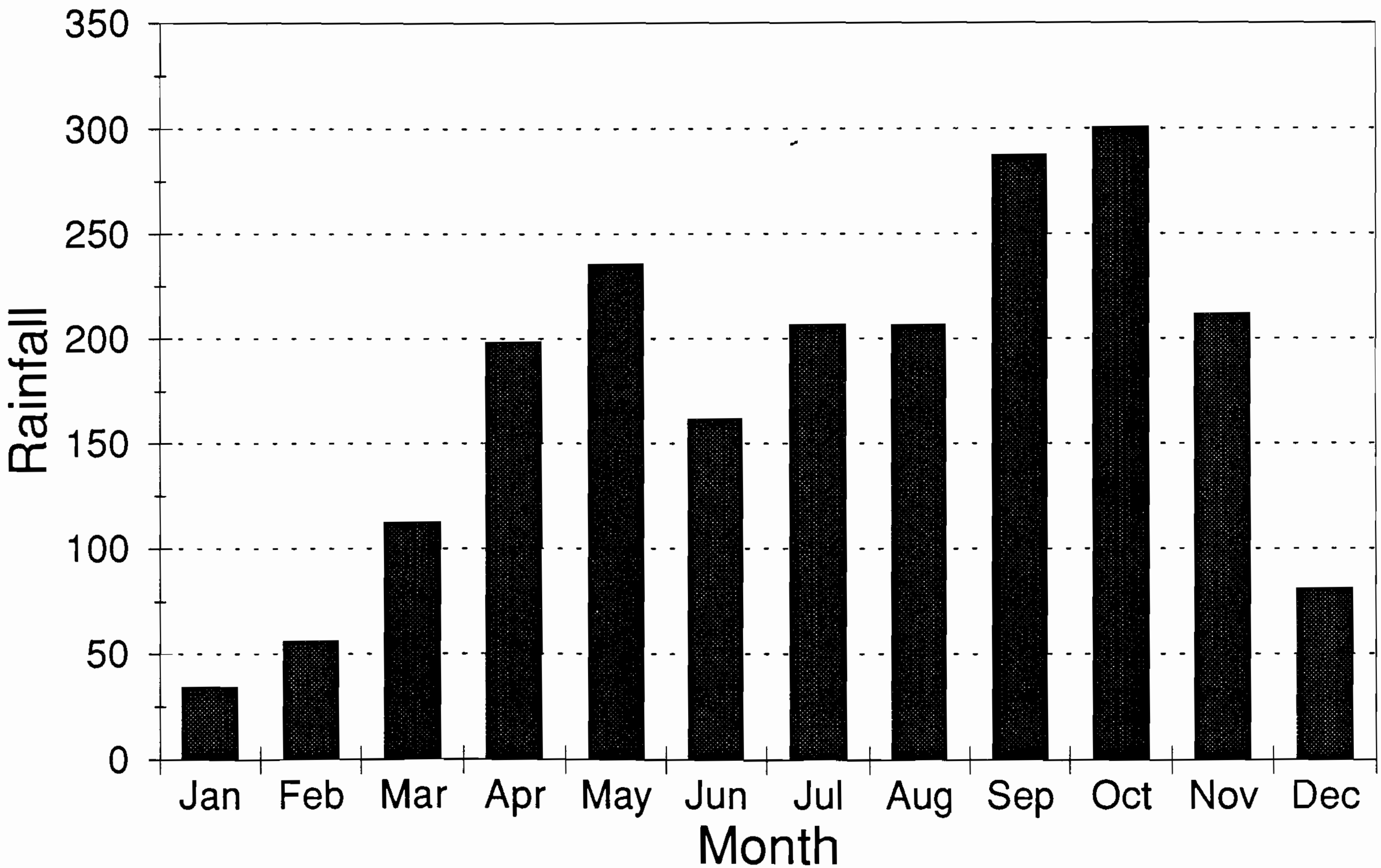
Figure 4, which describes the variation of annual rainfall at Kepala Batas rainfall station, indicates a steady decline in average rainfall in the last two decades.

This area is known as the largest rice granary in Malaysia. Average farm size in 1991 was 2.0 ha (Wong, 1992a). About 63,000 farm households depend on rice cultivation for their living.

Irrigation supply is facilitated by two reservoirs called Muda and Pedu, with a total capacity of 1,232 MCM. These two reservoirs are connected by a 7.2 km long tunnel. The irrigation water is conveyed through a river channel to Pelubang headworks and is augmented on the way by the catchment inflow. The water is diverted through a Northern canal and a central and Southern canal to the rice fields.

Figure 3. **Monthly Rainfall Distribution**

Averages for 1948 to 1993

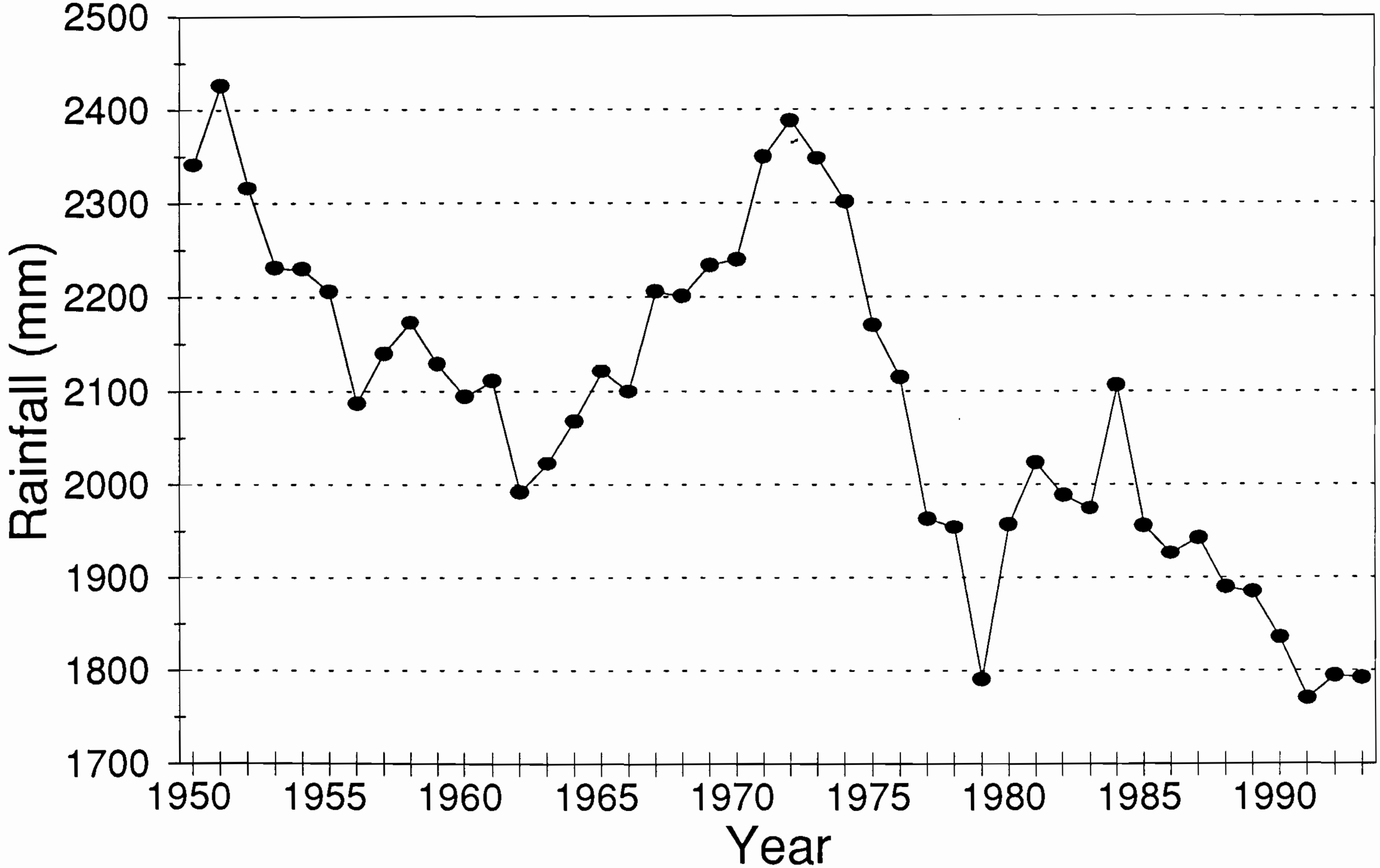


Source: MADA records at Kepala Batas rainfall station

Figure 3. Monthly rainfall distribution, averages for 1948 to 1993

Figure 4. Variation of Annual Rainfall

Five Year Moving Averages



Source: MADA records at Kepala Batas rainfall station

Figure 4. Variation of annual rainfall, five year moving averages

2.2 Management of Muda Scheme

2.2.1 Functions of Muda Agricultural Authority

Muda Irrigation Scheme is managed by Muda Agricultural Development Authority (MADA), which was established in 1970. Some of MADA's responsibilities are as follows:

a. Operation and maintenance of irrigation facilities;

b. Establishment of farmer organizations (e.g. Kelompoks and Mini-estates) and water users' associations;

c. Monitoring irrigation performance; and

d. Extension of new technologies, providing loans and implementing subsidy programs to help the farmers.

For management purposes, the Muda command area composed of 110 irrigation blocks is divided into four districts and 27 localities. Area under each block is 900 ha in average ranging between 110-1400 ha.

In 1978, MADA selected 38 irrigation blocks with water supply and drainage problems for improvement, under the tertiary development so called Muda II project. These blocks were further divided into four to six Irrigation Service Areas (ISA), and each ISA was divided into approximately five Irrigation Service Units (ISU) (MADA, 1988). Area under each ISA varies between 100-150 ha, while area under an ISU varies between 20 to 30 ha approximately.

2.2.2 Farmer Organizations

Under Muda II project, it was intended to organize all the farmers in each ISU into a ISU work group, and to form an ISA committee from the leaders of each ISU group. The ISA committee was expected to regulate the schedules, coordinate machinery and labor usage and regulate water supply by operating and maintaining all minor field structures. However, the response of the farmers to this intervention was not encouraging (MADA, 1988).

As an alternative to water user groups as well as to serve as fore-runners to ISA organizations, MADA is organizing the farmers to groups called <u>Kelompok</u>. This system formally started in peninsular Malaysia in 1979. These groups consist of farmers who group together to carry out rice production. This method is expected to take over a part of the functions of the traditional form of family farm. In the areas under Muda II project, <u>Kelompoks</u> are organized based on ISU area.

Core staff under Kelompoks consist of the leader, sub leader, an accountant, and four members (managing staff) who attend to agronomy, plant protection, farm mechanization and water management. They are selected from the group through their meetings.
The group is formed of full time and part time farmers. It includes all three tenure status (i.e. owner-cultivator, tenant, owner cum tenant) as well. Total area cultivated by member farmers can be greater than the Kelompok area. Also the area covered by the Kelompok can consist of owned as well as rented-in areas.

There are about 400 Kelompoks in the project area according to the recent estimates. In 1990 there were 327 Kelompoks covering approximately 10,000 ha (10% of the area).

Mini estate is an advanced stage of group farming in terms of it's independence and viability in group activities. Some mini estates operate tertiary canals. But they are not basically water user associations. There are about 90 mini estates in Muda area (16% of the total Kelompoks in 1990).

In a mini estate, there is a group of farmers selected from the member farmers, who operate the land. Land is owned individually, but the profit is shared. This is one of the major differences between a Kelompoks and a mini estate.

The farmers in a mini estate are eligible to be given a government subsidy of RM 1000.00 per ha to improve their common infrastructure. They are also eligible to get RM 1000.00 soft loan from the government to be used for tractor ploughing and other inputs necessary for improving the production (Sivalingam, 1993).

Figure 5 illustrates the organization structure of MADA and its links with the farmer organizations. It also describes the different divisions in MADA headquarters and categories of staff in District and Locality offices.

Figure 5. Structure of MADA & Links With Farmers

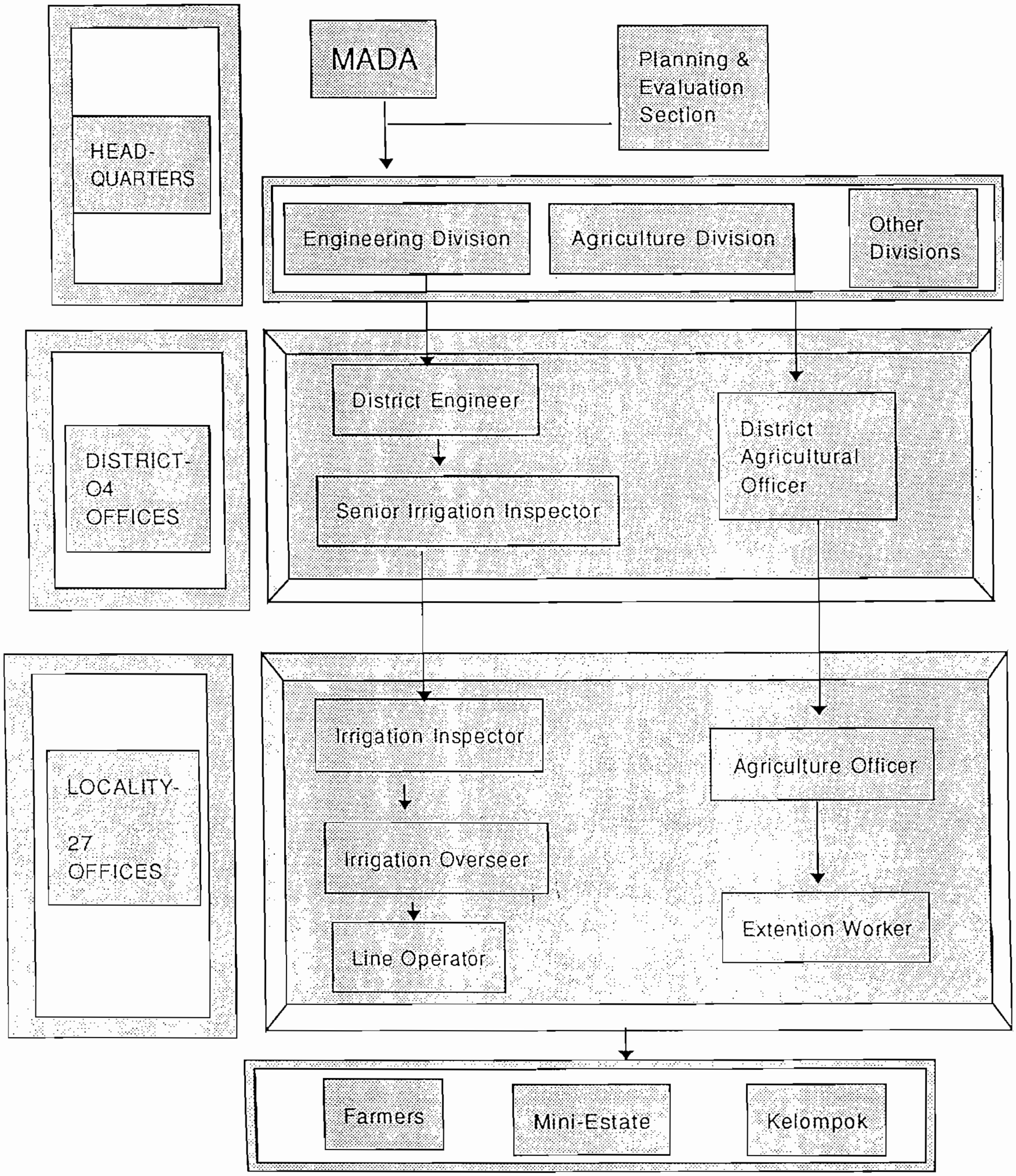


Figure 5. Structure of MADA and links with farmers

2.2.3 On-Farm Management Practices

In the 1st season of 1991, 83.6% of the eight granary areas in Malaysia was direct seeded (Chan et al, 1993). The direct sowing practice which covered 53 % of the Muda project area in 1984, expanded to almost 90% in 1990 (Ho et al, 1993).

The need to meet the rising cost of production and the labor shortage has motivated the Muda farmers to practice direct sowing. Although the yield from direct sowing is lower than that of transplanting, direct sowing is more profitable because of less labor input. Studies show that direct sowing lowers the labor demands by 33 % (Wong 1993) and the production costs by 40% (Wong et al, 1993).

There are two types of direct sowing, namely wet sowing and dry sowing. Wet sowing achieves stable and high production despite high water consumption. It is generally practiced in second season in which pre-saturation period falls in rainy season. Under this method, pre-germinated seeds are sown on once paddled and then drained field surface and water depth is gradually increased with seedlings growing. Pre-saturation for wet sowing requires management loss of about 100mm in addition to that of the traditional transplanting.

Dry sowing consumes less water in comparison with wet sowing because it does not require pre-saturation. It is generally practiced in first season in which land preparation experiences serious water shortage. In this method, seeds are broadcasted on dry field surface and plowed into soil. Seeds germinate by water supply or rainfall. Seedling establishment by rainfall is simultaneous and causes temporary shortage of combine harvesters and rice drying capacity in the harvesting period. Low water requirement for dry sowing enhances the cropping intensity under the strict observation of official irrigation schedule, though its yield is about 15% to 10% lower than transplanting (Wong 1992). The low yield is due to problems of weeds and non uniform seedling establishment.

A fertilizer subsidy system was introduced in 1979. Under this scheme, fertilizer is given free to farmers, upto a limit of 2.4 ha of farm land. The recommended application rate is 80 kg of Nitrogen, 30 kg of Phosphorous and 20 kg of Potassium. This is applied in the form of urea and mixed fertilizer. Surveys show that more than 96% of the applied fertilizer was provided under the subsidy scheme. Use of fertilizer inputs have gone up since the introduction of the subsidy scheme (Wong 1992b).

Studies also show that use of weedicides has gone up due to the spreading of direct seeding. In the first season of 1991, about 85% of the farmers applied weedicides. However, the application of insecticides and rodenticides is not as widespread as the application of weedicides. About 12% of the farmers applied incesticides and rodenticides in the first season of 1991 (Wong 1992b).

Land levelling, ploughing and harvesting activities are mechanized in Muda area. Large machines are used in these activities, such as four wheel tractors and combine harvesters are hired from contractors.

2.3 Canal Operation Procedures and Facilities

MADA adopted a new water management and control scheme in 1988. Under this new system, water depth is measured daily at five locations in each irrigation block.

MADA uses the following specifications of water depths as guidelines in releasing water.

a. Minimum Water Dept (MWD): Water depth in an irrigation block should be maintained above this depth. If the water depth is less than this, water from either the dam or uncontrolled flow can be used. This depth is specified as 5 cm.

b. Lower Control Depth (LCD): If the water depth is between MWD and LCD, only uncontrolled flow should be utilized. The LCD which varies according to the crop growth stage, ranges between 7.5 cm and 10 cm.

c. Upper Control Depth (UCD): Maximum water depth that can be maintained in the field. This also varies between 10 cm and 15 cm, in a similar manner to LCD (Teoh and Chua, 1989).

In 1986 a telemetry system was installed by MADA to increase the efficiency and effectiveness of water management and flood routing. These systems consist of rainfall stations and rainfall-cum-water level stations. They are located at appropriate locations to monitor the rainfall distribution in paddy fields, streamflow in uncontrolled flow catchment and rainfall and water level in Pedu reservoir (Teoh and Chua, 1989).

The engineering section of MADA monitors the relevant hydraulic data required for the operation of the irrigation system. There are 20 telemetric rainfall stations in the command area from which data are relayed to the headquarters. In the uncontrolled flow catchment area, 5 telemetric rainfall-cum-water level stations monitor and supply uncontrolled flow data and rainfall.

MADA is equipped with a mainframe computer to handle the data and other management related matters. Each irrigation district has the terminal facilities to send the data directly to the computer, which has proven to be effective in saving time and uninterrupted communication.

Discharge into each irrigation block is measured by a Constant Head Orifice (CHO) measuring device. Discharge and field water depth are recorded at each block.

Data collection and feedback system, further illustrated by figure 6, can be summarized as follows.

(1) A line operator monitors CHO discharge 3 times a day and daily water depth at 5 points in each irrigation block.

(2) The data are conveyed to the Locality Office.

(3) The irrigation inspectors in the Locality Office send the data to the District Office by 4:30 pm by VHF.

(4) The District Office enters the data into the LAN terminal which is on line with the computer in the Headquarters. This is done on the following day by 10 am.

(5) The data are processed by the computer and target discharge of each CHO is intimated by noon to District Office, Locality Office and the line operator through the network and VHF.

Water levels and gate settings at 17 major regulators in the main and major canals are also recorded in the same manner.

Telecoms Department has leased three VHF channels to MADA for data transmission. Channels 1 and 2 are used by the districts to convey the data to headquarters. Channel 3 is used by the control center at headquarters to convey the water levels and gate settings to the field. There were 110 VHF sets in use in 1989 (Teoh and Chua, 1989).

Figure 6. Decision Support System of Muda Scheme

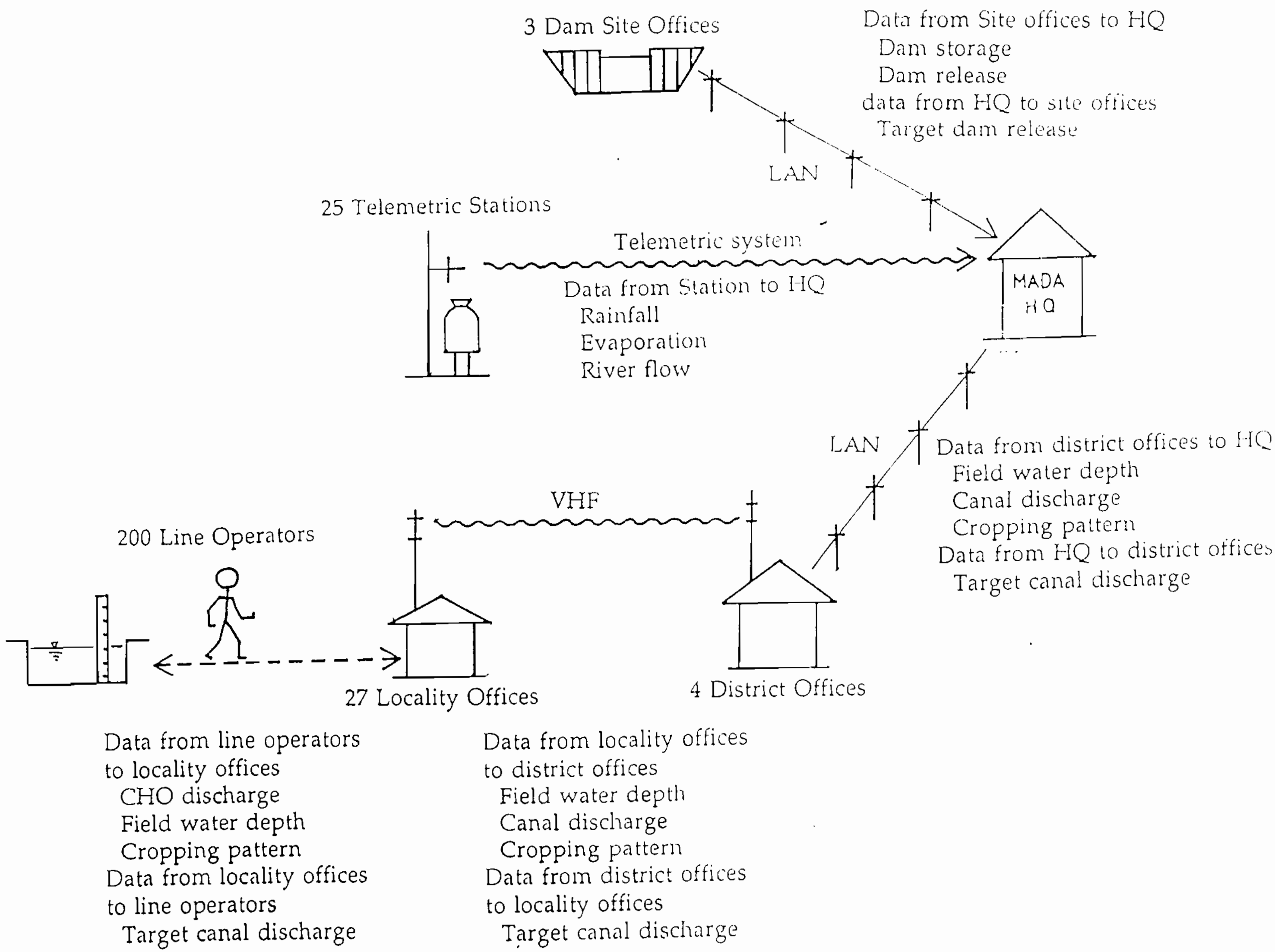


Figure 6. Decision support system of Muda Scheme

2.4 Water Resources

Table 1 describes the composition of water resources in Muda scheme during the period from season 2 of 1989 to season 1 of 1992. For the period considered, the average dam release was 684 MCM per year. The average intake at Pelubang headworks was 864 MCM, indicating an average gain in the river section equal to 180 MCM.

Average irrigation supply per year, estimated as the total of the volumes measured at secondary canal CHOs, was 732 MCM and recycled water contributed by 116 MCM.

Table 1. Composition of water resources in Muda area: season 2 of 1989 to season 1 of 1992

Dam release	Intake at Pelubang	Gain in river chl.	Irrigation supply	Recycled supply
684 MCM	864 MCM	180 MCM	732 MCM	116 MCM

It appears that, between the Pelubang headworks and secondary canals, there is a loss of approximately 132 MCM, i.e about 15% of the sum of the dam release and gain in the river section. The contribution of recycled water above the secondary canals was not considered here, because available information suggest that most of the recycled water was input below the secondary canals.

2.5 Current Procedures and Practices for Performance Assessment

Planning and Evaluation Section of MADA conducts socio-economic surveys to assess the impact of the project on farmers. Crop yield surveys have been conducted since 1970. Paddy price surveys started in 1973 and seasonal cost of production surveys started in 1975.

Following indicators are used to assess the performance of the scheme (Wong, 1992b and Wong, 1993).

a. Yield and yield distribution according to the cropping method, region and farm size etc.

b. Income per unit area, per farm, and income difference based on region, cropping method and tenurial status

c. Incidence of poverty

d. Gini Index of inequality of poverty distribution

e. Gini Index of income

f. Gini Index of farm size

Apart from that, the surveys collect data on problems faced by the farmers with regard to water, pests, weeds etc..

2.6 Performance Gains

Muda Agricultural Development Authority (MADA) has achieved significant performance gains through tertiary facilities development and changes in management practices in the Muda project. These changes were introduced in order to address the chronic water shortage problem in the area, and thereby increase the rice production. Direct sowing, which has expanded rapidly since 1985 and now covers more than 90% of the area, has been found to result in significant water saving, increased productivity, and cost reductions. In view of such significant gains, IIMI is carrying out a collaborative study together with MADA to draw generic conclusions on irrigation performance from this valuable experience in Malaysia.

Table 2 describes the performance gains achieved by the irrigation system in the recent past. The available data indicate that yield has increased significantly. The increase of yield and irrigation intensity both must have contributed to the increased production.

Table 2. Performance gains in Muda Scheme

Parameter	1981-83[1]	1989-92[2]	Percent Change
Irrigation Intensity[3]	186%	198%	+7%
Area Irrigated per season (000 ha)	89	95	+7%
Net production[4] per season(000 tons)	295	373	26%
Net yield (kg/ha)[4]	3319	3928	+18%
Water Delivered per season (MCM)[5]			
Dam release	366	342	-7%
Irrigation supply	n.a.	366	
Average Water Productivity(kg/M3)			
-per unit dam release	0.87	1.09	+25%
-per unit irrigation supply	n.a.	1.02	

Notes:
1. 1981-83 : Average of six seasons
2. 1989 season 2 to 1992 season 1: Average of six seasons
3. Irrigation Intensity = Actually irrigated area / Irrigable area
4. Net yield and production are based on weight of clean, dry paddy, which is 85% to 90% of relevant gross value
5. MCM= Million Cubic Meters
6. Economic cost includes input cost at economic prices (without subsidy), land rent and water tax

The import cost per ton seem to be fluctuating between US$ 274 recorded in 1981 and US$ 140 in 1986. The cost of production per ton has declined from US$ 309 for the period 1981 to 1983, to US$ 209 for the period 1988 to 1990. The average import cost for the period of 1988 to 1990 was US$ 233 per ton. Thus, the reduction in the economic cost of production has been so substantial (about 33 percent over less than a decade) that the current economic cost of rice production is about 11 percent lower than the import cost per ton.

2.7 Review of Past Studies

M.N. Mohd Adnan, Senior Engineer, Irrigation Division Department of Irrigation and Drainage (DID), Malaysia, studied paddy irrigation development in Malaysia in relation to real-time systems management and the role of performance assessment in the Muda Irrigation Scheme (Mohd Adnan, 1993). (Real-time system management consists of the entire process of monitoring the demand status at all demand points, data transmission to a demand center, analysis, decision making, relaying decisions to strategic control points and executing the decisions, which occur simultaneously, continuously and instantaneously). Study results showed that with performance assessment, managers are more prepared and able to respond quickly to issues faced in the day to day systems operations. He found that certain aspects of performance assessment such as roles in meeting cropping intensity targets, accurate demand-supply matching, meeting water savings target and alerting managers to potential crisis situations can be achieved through improved real-time performance.

Adnan's conclusions from the study were important in the context of Malaysia's future in irrigation investment. According to him, into the 90's and beyond, no major infrastructure investments are expected in irrigation systems improvement. Therefore, the immediate need and focus should be to make the best use of what already exists and this will only be possible through a firm commitment towards excellence in irrigation performance.

The Muda II Irrigation Project, financed by the World Bank, was a follow-up on the earlier Muda Irrigation Project which was also financed by the World Bank (Muda II Irrigation Project, World Bank Project Completion Report, 1988). The Muda II Project was designed to overcome the inadequacies, particularly in infrastructure intensity of the Muda area. Infrastructural irrigation and drainage development involved the construction of tertiary canals and tertiary drains to improve irrigation and drainage intensity. Further, Water-user groups were formed in all the tertiary irrigation blocks, organized around the ISU's, in an attempt to develop effective and efficient distribution and usage of water, and to involve farmers in the operation and maintenance of the infrastructure.

At the time of project appraisal in 1979, calculations showed that the Muda II project would yield an economic rate of return of 18%. A recalculation of the viability of the project in 1988, using actual expenditure,actual yield performance to date, revised estimates of future expenditure and crop yields, yielded a 6% rate of return. The main reasons for such a low economic rate of return were attributed to cost overruns, project expansion, low yields and low world prices of rice.

Many studies have been conducted in Malaysia by Tropical Agriculture Research Center (TARC) in collaboration with Muda Agricultural Development Authority (MADA). S. yashima (1982) has established a methodology to analyze water balance within an irrigation block using field water depth and total existing water in rice fields. It was found that, relative efficiency of irrigation supply on presentation is 25% against rainfall under Muda I condition (Yashima 1987). N. Kitamura (1990) studies water balance under Muda II condition and concluded that the relative efficiency of irrigation supply could be improved from 25% to 45% by the tertiary development. In 1993, a study was carried out for which the objective was to analyze the quality of existing water conditions in the Muda area and to investigate any water quality problems in relation to water recycling (Hata and Fujii, 1992). One of the study conclusions was that the COD (Chemical Oxygen Demand) value in the river water was low, although the same for paddy and drain water was slightly higher. The reason attributed to this was the organic matter, that was being produced in the paddy water or was being dissolved from the soil. However, given the short duration of the study, the research team recommended further studies and research in order to make firm conclusions regards the water recycling program in the Muda area.

The Kerian Irrigation Scheme in Malaysia was the focus of a study, which was one of a series undertaken by IIMI and the World Bank with the overall objective of improving the understanding of the design and management interactions of surface irrigation systems and the way they influence the performance of the systems (Valera and Mohd Desa, 1991). This study determined effects of the rehabilitation design and actual management interactions on performance and suggested ways to improve the existing level of system performance. The study also probed, among other things, such shortfalls as overly optimistic management assumptions and the declining interest of farmers in irrigated farming.

Chapter 3

Objectives of Collaboration

3.1 Objectives of the Study

This study proposes a hypothetical analytical framework of assessing and improving the performance of irrigated agriculture. This framework is to be verified in the proposed case study in Muda irrigation scheme, which has achieved substantial performance gains.

The main objectives of this collaborative study are as follows:

1. To apply and field-test a comprehensive performance assessment system for irrigated agriculture; and

2. To analyze the quantitative linkage between performance indicators and the following management interventions (including analysis of indices of management interventions and intermediate impacts):

   Development of tertiary canals, drains, and roads in 38 out of 110 irrigation blocks,

   Reducing irrigation supply period in the first season, in response to dry sowing (from 197 days for 1984-86 to 152 days for 1990-93),

   Decision support system, and

   Establishment of farmer organizations (Kelompoks and Mini-Estates).

The above mentioned management interventions are described in detail in section 4.1.

3.2 Performance Indicators and Objectives

The table below describes the performance indicators considered for the study, along with their sources of data. Three types of user groups, namely policy maker, irrigation manager and farmer, are identified in the table. They have differing objectives and performance indicators are identified to suit them.

Table 3. Performance Indicators, user groups, objectives and data sources

User Groups	Level	Type of Objective	Type of performance indicator	Data Source
Policy Maker	Sector/ Scheme	Food Security	-Food production as ratio of demand -Food imports as a ratio of foreign exchange earnings	Agriculture and Ministry of Agriculture and Engineering sections of MADA
		Productivity	-Irrigated area per unit of water, Irrigation Intensity -Gross value of output per ha/per m3/per worker	-do- -do-
		Poverty elimination	-Benefits to small farmers -Benefits to tail end farmers -Additional Employment	Field survey 94-95 -do-
		Economic Sustainaility	-Net value of output at Economic Prices -Cost of Production at Economic Prices	Planning and Evaluation section of MADA
		Financial Sustainability	-Total revenues as percent of O&M expenses -Revenues as percent of O&M expenses+capital charges	Planning and Evaluation division of MADA
		Environmental Sustainability	Water Quality Recycling	Engineering Division of MADA

Table 3. Performance Indicators, user groups, objectives and data sources (cont.)

User Groups	Level	Type of Objective	Type of performance indicator	Data Source
Irrigation Manager	Scheme	Water delivery	- Delivery Performance, Ratio, Water Delivery Performance, Relative Water Supply -Conveyance efficiency -Effective rainfall	Engineering section of MADA
		Production	-Cropping intensity -Yield -Total production	-do
		Economy	-Production cost -Rice price -Agr. income	-do
		Sustainability	-OM cost -Water productivity & profitability	-do-
		Predictability	-Ratio of actual Duration to planned Duration	-do-
Farmers	Farm	<u>Irrigation service indicators</u> Water delivery Reliability Timeliness Adequacy		
		Productivity	-Production per unit of water/land/worker	Field survey 94-95
		Profitability	-Net Value of Additional Output per ha/m^3 at farmers prices	Field survey 94-95

3.3 Methodology of Quantifying Indicators

3.3.1 Agriculture Output, Costs and Profits

The data for the block level analysis of agricultural performance will be collected through a combination of secondary sources and a randomly selected sample of tertiary developed irrigation blocks (Muda II) and random samples of farm lots. The non-tertiary developed (Muda

I) blocks and farm lots are selected in such a way to compare the performance of Muda I and Muda II blocks in the time period of data collection.

The Muda project area consists of 110 irrigation blocks and 38 of them are tertiary developed blocks. Due to recent urbanization, two of the Muda II blocks are excluded from the current study. The Muda II irrigation blocks receive water through secondary canals and distribute water to the farm lots through a series of tertiary canals. The agricultural performance is affected by natural features of blocks and quality of water management and farming practices such as soil type, soil quality and topography of the irrigation blocks, adequacy and timing of field water depth control and proper fertilizer and chemical application. To reduce the effect of variations of these features on the estimates of performance, Muda II irrigation blocks are stratified with respect to certain features and characteristics. Accordingly, the sampling design adopted for the study is stratified multi stage random sampling with groups of blocks as strata, blocks as primary sampling units and farm lots as second stage units.

The advantage of stratification is that, apart from ensuring selection of units with different types of characteristics, it also improves the precision of the estimates by the fact that error variance is based on within-strata variability. Larger the differences between strata, greater the gain in precision due to stratification resulting from reduction in error variances

It was observed that some Muda II blocks are undulating while the others are flat. As flat topography hinders uniform water supply to the fields in the blocks, topography was selected as one criteria for stratification. The other criterion that will be used in stratification is the existence of advanced group farming methods, called Mini Estates.

This gives rise to a stratified two-stage random sampling plan for the farm lot selections in Muda II irrigation blocks. In the first stage, a random sample of blocks is selected from each stratum. In the second stage, random samples of farm lots are selected from all selected blocks in the first stage.

The composition of the Muda II blocks in each stratum is given in the following table.

Table 4. Distribution of Muda II blocks in different strata

STRATUM NO./ SAMPLE	TOPOGRAPHY	EXISTENCE OF MINI ESTATES	NUMBER OF BLOCKS
I	Flat	Yes	7
II	Flat	No	8
III	Undulating	Yes	4
IV	Undulating	No	17

The sample sizes of surveys are normally determined by the degree of the variability of the parameters which are of interest in the study and the precision that required for the estimated parameters. Since the number of blocks in stratums I, II and III are small and the blocks in these stratums assumed to be homogeneous, only one block is selected from each of first three stratum. The last stratum has 17 blocks and which is more than twice the that of other stratums. Therefore a simple random sample of 2 blocks is selected without replacement from the last stratum. In the next stage, simple random samples of farm lots are selected with out replacement from the five blocks that were selected in the first stage.

There is no information available on the variations of water delivery and related aspects at field level in the Muda area. The absence of such information necessitates a sufficiently large sample of farm lots in the second stage selection for obtaining accurate estimates of parameters at block level. Therefore a simple random sample of 30 farm lots is selected without replacement from each of the 5 blocks that are selected in the first stage.

A similar method is used for sampling farm lots from the Muda I blocks for the comparison of the performance with the Muda II blocks. However to ensure that the soil characteristics and agro-climatic conditions are similar in two sets of blocks, Muda I blocks are selected so that they are adjoining the selected Muda II blocks. Again a simple random sample of 30 farm lots are also selected without replacement from the each selected Muda I blocks.

The following performance indicators are selected for the assessment of the agricultural performance:

a) Cropping Intensity

b) Land Productivity = Production(kg) per unit area(ha)

c) Water Productivity =Production(kg) per cubic meter of water

d) Ratio of area planted and area harvested

e) Cost of production at economic prices

f) Net value of output at economic prices

g) Irrigated area per unit water

h) Land Profitability = Profit per unit area (ha)

i) Water Profitability = Profit per cubic meter of water

Profitability can be defined in two ways. One is the Farmers' Profitability, and the other is Economic Profitability.

Farmers' Profitability will be calculated using prices received by farmers for the crops and the prices paid by farmers for inputs such as seed, fertilizer, labor etc. These will be calculated as indicated in Table 5.

Prices for economic profitability will be corrected for subsidies on input and output prices. These prices are usually referred to as Shadow Prices or Accounting Prices or Economic Prices. One approach to calculate these shadow prices is to estimate border prices (i.e. import prices for inputs such as fertilizers and export/import prices for rice) and multiply these by the Premium on foreign exchange (if any). Similar adjustments may be required for labor to reflect shortages and surpluses. In Table 5, Net Profitability has been calculated using economic prices.

Table 5. Estimation of farmers' profitability and economic profitability

Farmers' and Economic Profitability Per Season (With Irrigation)		
1. Net Irrigated Area(ha)		
2. Total water supply(m^3) Estimated		
3. <u>Value of Out puts</u>	Farmers Profitability(FP)[1]	Economic Profitability (EP)[2]
a). Total Gross Production(in kg)		
b). Price per kg		
c). Gross Value of Outputs		
d). Value of By-products		
e). Income from Labor inputs to others		
f). Income from Machine inputs to others		
Total Income		
4. <u>Cost of Production</u>		
a). Seeds		
b). Labor-Family		
c). Labor-Hired		
d). Machine Input		
e). Fertilizer		
f). Pesticide		
g). Weedicide		
h). Rodenticide		
i). Transportation		
j). Rent for Pumps		
k). Rent of Broadcaster		
l). Fuel		
m). Engine Oil		
n). Water Charges		
o). Others		
Total Cost of Production		
5. Net Value Output = Gross Output - Cost of Production = (3 - 4)		
6. Net Value Output/Ha = NVO / Net Irrigated Area = (5/1)		
7. Net Value Output/m3 of water = NVO / Total Irrigation Water Supply = (5/2)		
8. Gross Output Per Ha = (Kgs/Ha)		
9. Gross Output Per m3 = (Kgs/m3)		

[1] Farmers Profitability is calculated using prices received or paid by the farmers for outputs. Thus these prices reflect subsidized output and input prices.
[2] Economic Profitability is calculated using economic prices which reflects the benefits and costs to the society. (i.e, by eliminating subsidies or input and output prices).

3.3.2 Performance of Water Delivery

The water delivery data collected by MADA at present, will be utilized for the assessment of the performance of water delivery. MADA monitors the discharges at the intake of each secondary canal and tertiary canals in Muda II blocks. These data will be used to analyze the performance at different levels such as project, block and ISA. This analysis will include the data from 36 irrigation blocks and approximately 180 ISAs.

Following indicators will be used for the assessment of the performance of water supply:

a) Delivery Performance Ratio(DPR)

$$DPR = \frac{\textit{Actual total water supply}}{\textit{Target water supply}}$$

b) Relative Water supply(RWS)

$$RWS = \frac{\textit{Irrigation water supply} + \textit{Rainfall}}{\textit{Seepage} + \textit{Percolation} + ET}$$

c) Cumulative RWS

d) Water Delivery Performance (WDP)

This indicator can be used as a single value for the entire irrigation season in this form.

$$\text{WDP} = \frac{\text{Actual volume supplied}}{\text{Target volume supplied}}$$

This also can be aggregated over different time periods to measure the adequacy and timeliness of water supply, in the following manner.

where, $V_i(t)$ = Volume of water delivered to unit i during the time period t of cropping season

$$WDP_i = \sum_{i=1}^{n} \frac{K(t)\, V_i(t)}{V_i^*(t)}, \quad if \ \ V_i(t) \le V_i^*(t)$$

$$= \sum_{i=1}^{n} \frac{K(t)\, V_i^*(t)}{V_i(t)}, \quad if \ \ V_i(t) > V_i^*(t)$$

$V_i^*(t)$ = Target volume of water to be delivered to unit i during the time period t of the cropping season, calculated for actual crops grown and existing conditions of soil, rainfall and other sources of water, and

K(t) = Weighing factor indicating the relative importance of water at different stages of crop growth.

e) Gap between official and actual duration of water supply

f) Coefficient of Variation of weekly DPR

g) Theil's Information Measure

$$H(y) = \sum_{i=1}^{n} y_i \log\frac{1}{y_i}, \quad where \ 0 \le H(y) \le \log(n)$$

and, y_i = Fraction of water supply for the i^{th} unit from the total water supply

h) Modified Interquartile Ratio

- Ratio of averages of the best and poorest third of water deliveries
- Ratio of averages of water deliveries of the head end to the tail end
- Ratio of average water deliveries to the units with sizes(areas) in the upper two third to the lower one third.

From the above indicators, a,b,c and d will be used to measure the adequacy of water supply, e and f for the reliability and g and h for the equity of water supply.

Chapter 4

Evaluation of Management Interventions

4.1 Management Interventions

4.1.1 Tertiary Development

The Malaysian Government implemented the Muda Project during 1966 to 1970 to provide this rain-fed area with irrigation systems with 10 m/ha canal density, and successfully started the rice double cropping in 1970. However, a lack of field infrastructure and the shortage of water resources were among the major constraints to further development of the Muda agriculture. Surveys of irrigation and farm operation pattern showed that difficulties in independent farm water management and inadequate transportation facilities for agricultural machinery make the pre-saturation period longer (Yashima, 1987), resulting in high usage of water.

A main component of the Muda II Project launched by MADA in 1978 is the construction of tertiary field infrastructure. Up to date, 38 irrigation blocks out of the total 110, (25 % of the project area) are provided with tertiary facilities.

Through tertiary development, MADA planned to shorten the pre-saturation period. The objective is to make efficient use of local water resources, i.e. dam storage, uncontrolled river flow and rainfall (MADA, 1988). Researchers compared water consumption in a Muda I block and a Muda II block and found 20 % decrease in water consumption due to the tertiary development (Fujii et al, 1993).

The performance of the Muda II Project can be summarized as follows:

- Tertiary development has made possible direct access to Farm Irrigation Turnouts (FIT) and Drainage Outlets (DO) to about 80% of the farm lots in Muda II area, making it easier to obtain irrigation water and to drain away the excess water. This has provided opportunity to employ better on-farm management practices.

- Farm roads are the most appreciated feature of the project enabling efficient transport of farm inputs and produce and easy access for farm machinery. It was effective to shorten pre-saturation period and economize transportation costs.

- Yields have shown some signs of improvement in the Muda II areas, though trend is still unclear because of the adverse effects of pest problems, weed infestation, and water shortages.

- The objective of water savings through improvement in water management are not yet realized. But savings of water utilization are obtained by newly established performance-oriented irrigation management system in conjunction with dry sowing culture (MADA, 1988).

4.1.2 Irrigation Scheduling with Response to Direct Sowing

Following features of the direct sowing influence the irrigation scheduling with response to direct sowing.

a. Direct sowing does not require the nursery bed preparation and nursery water management as in transplanting.

b. Under wet sowing (wet direct seeding), field water should be drained after puddling so that the seeds can be sown. Water supply should be stopped for 10 to 15 days to allow seedling establishment.

c. For dry sowing, irrigation supply is initiated after the seedling establishment (Fujii 1993).

In view of the popularity of dry sowing and the need to meet the challenges posed by water shortages, MADA has started irrigation scheduling with due consideration to dry sowing since 1990. The estimated irrigation requirement and the number of irrigation days are compared for direct seeding and transplanting, in table 6.

Table 6. Estimated irrigation days and irrigation requirement for different cropping methods

	Wet Sowing		**Dry Sowing**		**Transplanting**	
	Season 1	**Season 2**	**S - 1**	**S - 2**	**S - 1**	**S - 2**
Irrigation Requirement	1491	904	961	-	1317	851
Irrigation days	135	120	90	-	125	115

Source: Yashima, n.d.

Figure 7 shows the effect of dry sowing on irrigation period. It can be seen that, under dry sowing conditions, the irrigation period starts after the start of crop growth period. As the irrigations are stopped prior to harvesting, the irrigation period under dry sowing is less than that under transplanting and wet sowing. As a result, the irrigation supply period in the first season is reduced from an average of 197 days for the three year period of 1984 to 1986 to 152 days in the similar period of 1990 to 1992.

Figure 7. Effects of Dry Sowing on Irrigation Period

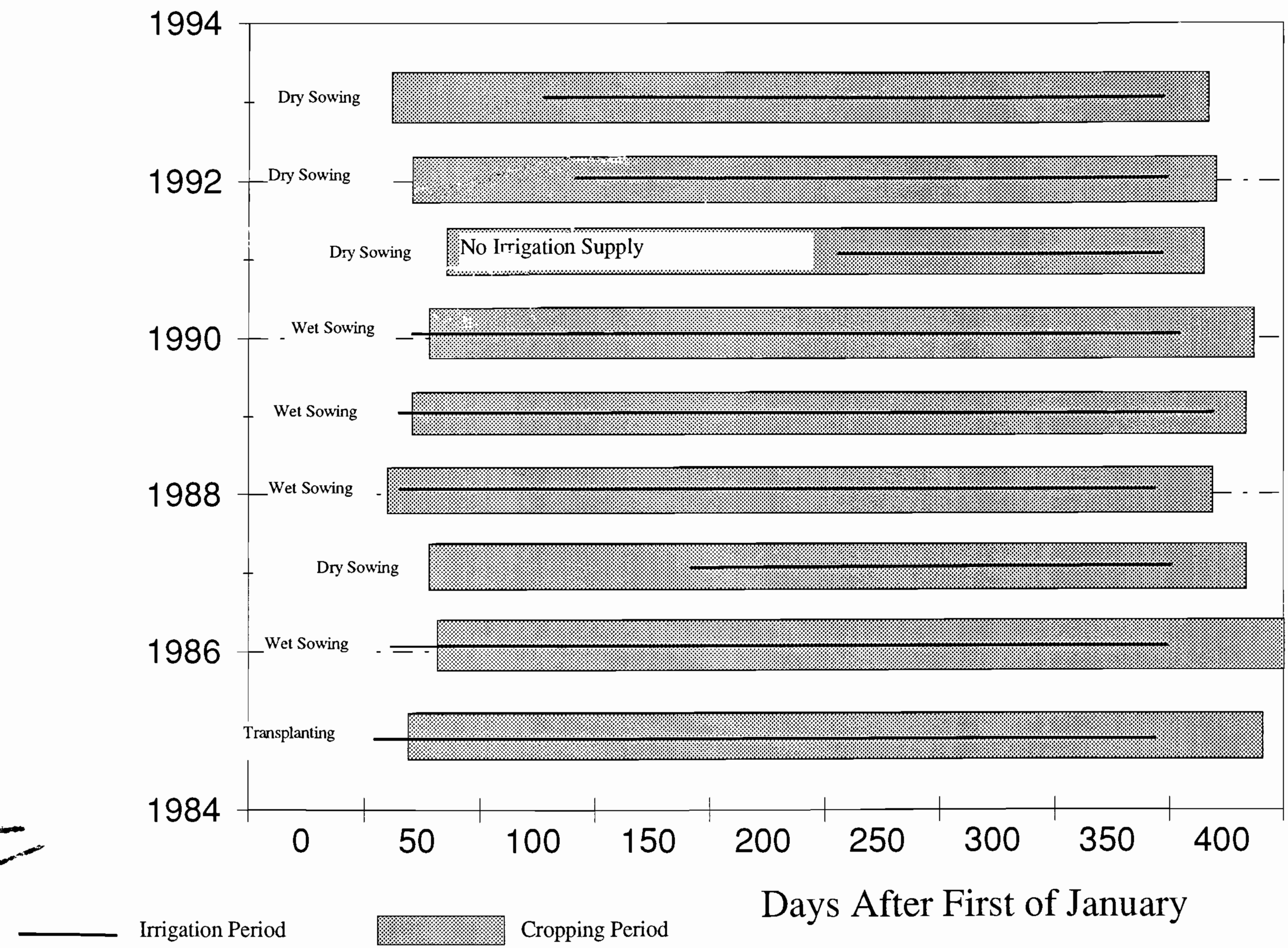


Figure 7. Effects of dry sowing on irrigation period

In addition, the management recently started fixing the last date of water issue, and persuaded the farmers to observe the official water issue schedule. Cropping schedule was arranged so that it matched the weather pattern. All these are expected to reduce the irrigation supply and maximize the use of rainfall.

4.1.3 Decision Support System

The facilities provided for data feed back was described in the section 2.3. The collected data are analyzed in the following manner.

1. Water losses due to consumptive use are calculated from the Evaporation Pan readings on the following day. Seepage and percolation losses are uniformly distributed over the area at 1 mm/day.

2. CHO discharge at each block and discharge at each major regulator is computed from the available data, on the following day.

3. Total water supply is computed using discharge through major regulators and offtakes from the main canals, rainfall and existing water. Then this is compared with the water demand, which is calculated using water losses and crop growth stage.

4. Gate settings are changed if required, based on the above comparison.

5. Based on the field water depths and a pre-set guidelines, water releases from the dam is determined.

The main improvements of the new water management and control scheme employed by MADA in 1988, over the earlier system, can be summarized as follows.

Table 7. Comparison of past and present decision support systems

Old system		New system	
1.	Telemetry system with land lines which frequently broke down.	1.	New telemetry system with less frequent failures.
2.	Telex system for reporting irrigation demand.	2.	VHF voice channels to report field data.
3.	16 KB punch card type compute to calculate the irrigation demands	3.	8 MB RAM main frame computer with terminals at each district to feed in the data.
4.	Monitoring of field water depths without reference to crop growth periods etc.	4.	Monitoring of field water depths with reference to guide lines which are based on crop growth stages field bund heights etc.
5.	No feedback from the field about actual CHO discharges.	5.	Daily feedback on actual CHO discharge.

With the improved facilities, MADA is able to monitor and process relatively a more comprehensive set of data which includes water front propagation pattern during pre-saturation, growth stages and cultural practices. With the improved communication, MADA plans to respond to the field situations in a timely manner. Overall objective of MADA is to optimize the use of all available water resources to meet the crop demand, with the new facilities (Teoh and Chua, 1989).

4.1.4 Kelompok and Mini Estates

MADA provides help and guidance to form Kelompoks (group farming). When farmers show interest, guidance is given through meetings and field trips. Then the group is pre-evaluated on their performance.

Due to labor shortages, farmers are resorting to using contractors to carry out farming activities. The Kelompoks facilitate this system by enabling the farmers to negotiate as a group with contractors. On one hand, this results in less machinery charge for the farmer. On the other hand, the contractor's machinery transport will be less because he is working in a number of farms located close to each other.

Duties of a leader of a Kelompok are:

1. Negotiation with contractors and mediators.
2. Transmission of information related to irrigation and planting times each season
3. Arrangement of cooperative works including meetings.
4. Keeping close contact with the head of ISU in collaboration with the ditch tenders of MADA.

It is expected that farmers will incur less cost of production and will receive more equitable and reliable water supply by being a member of a Kelompok or a Mini-Estate. The questionnaires of the field survey are designed so that performance of water supply and cost of production are linked with the membership of Kelompok/Mini-Estate.

4.2 Links of Management Interventions With Performance

This study plans to assess the contribution made by each intervention to the irrigation performance. For this purpose, two types of indices are proposed over and above the performance indicators already mentioned. They are as follows: Impact indices which measure the immediate impacts of the interventions and determinant indices which measure the extent to which the intervention is implemented.

For example, the percentage of tertiary developed area, tertiary canal density, tertiary drainage density, tertiary road density, whether direct access to canals, drains and roads exist or not are determinant indices for explaining the extent of tertiary development. Likewise the percentage of direct sowing area is an index for explaining the extent of direct sowing. The tertiary development and the direct sowing have a direct impact on the total water supply, the labor input, the machinery input, the fertilizer input etc. in Muda agriculture. The water delivery and input variables are examples of direct impact indicators of tertiary development and of direct sowing.

Some of the determinant indices that can be used in the Muda context are,

1.	Canal access index	=	Ratio of farm lots with direct access to canals
2.	Road access index	=	Ratio of farm lots with direct access to roads
3.	Drainage access index	=	Ratio of farm lots with direct access to drains
4.	Ratio of farmers in Kelompok	=	Ratio of number of farmers in Kelompoks to total number of farmers in the farm lot.
5.	Ratio of farmers in mini estate	=	Ratio of number of farmers in mini-estates to total number of farmers in the farm lot.

6. Wet sowing area index = Ratio of wet sowing area to total irrigated area

7. Dry sowing area index = Ratio of dry sowing area to total irrigated area

8. Transplanting area index = Ratio of transplanting are to total irrigated area

9. Tertiary development area index = Ratio of area with tertiary facilities

10. Duration of rice growth period

11. Capacity of recycling system

Some of the impact indices of interventions in the Muda context are,

1. Duration of pre-saturation supply period

2. Duration of supplemental supply period

3. Labor input

4. Fertilizer/Weedicide/Insecticide input

5. Agricultural machinery and transport input etc.

6. Time lag of data feedback

The figure 8 shows the expected linkages among these indicators and indices. It can be seen that some determinant indices such as Dry Sowing Area Index is linked with Area per Unit Water (performance indicator) through irrigation supply days (impact index), while the same determinant index is linked directly with performance indicators such as Cost of Production.

Figure 8. Linkage Among Performance Indicators and Indices

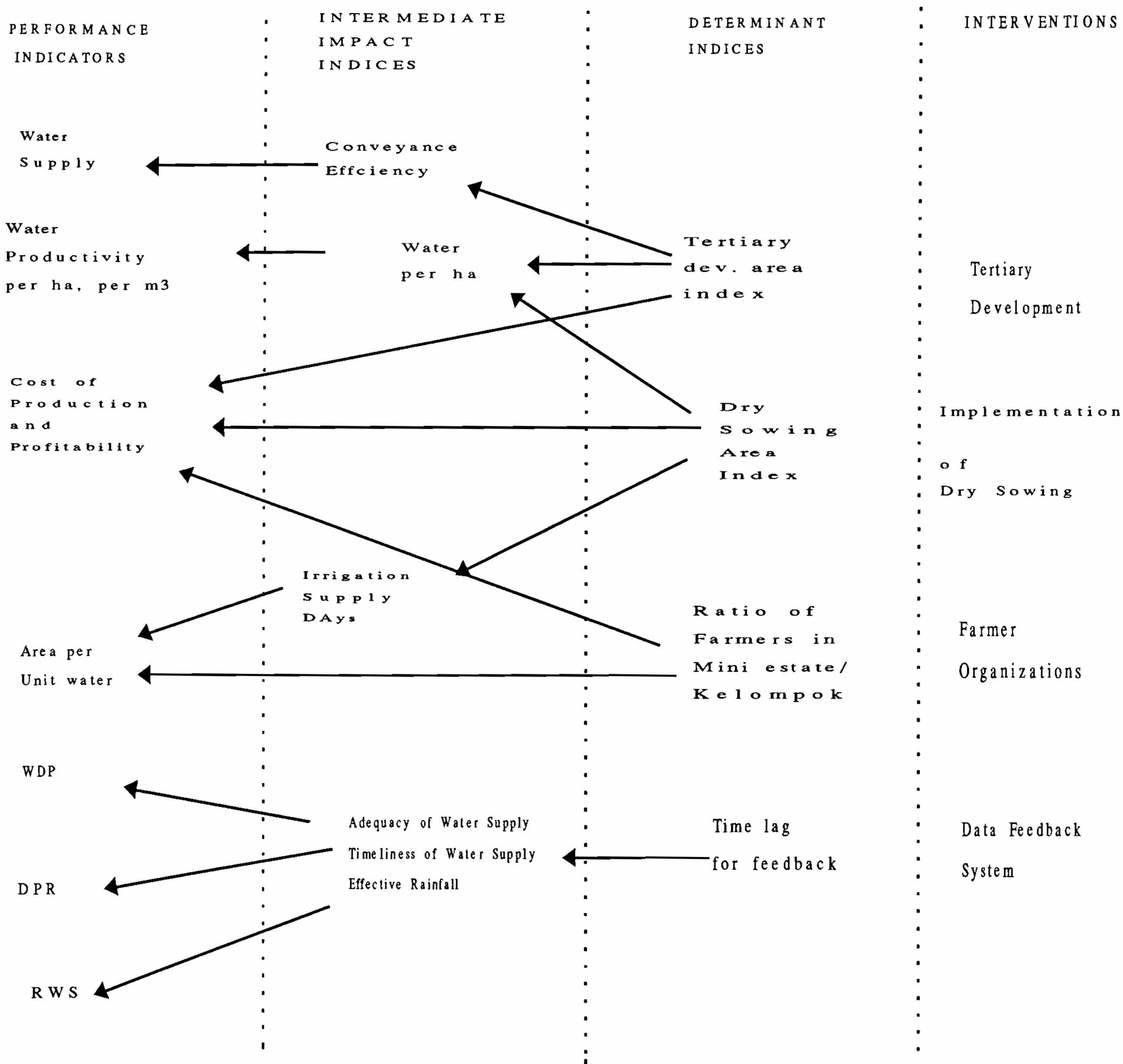


Figure 8. Linking among performance indicators and indices

The Box-Jenkins time series models intervention analysis is to be used in testing the significance of impacts due to interventions. The basic form of the model is as follows:

$$Y_t = N_t + I_t$$

Where Y_t is the time series observed at equal time intervals, N_t is the noise component, and I_t is the dynamic part of the model that contains the intervention component and any other deterministic components.

4.3 Methodology of Impact Assessment

4.3.1 Time Series Analysis at Project Level

The impacts of management interventions on the Muda irrigated agricultural system can be assessed by time series regression analyses on project level productivity, cropping intensity, profitability, water delivery performance etc. Four types of variables can be used for the time series analysis, which are as follows:

a. Performance indicators for the irrigated agriculture system;
b. Indices that measure the impact from management interventions (impact indices);
c. Indices that explain the extent of management interventions (determinant indices); and
d. Other exogenous variables such as rainfall, topography etc .

4.3.2 Block Level Analysis

The spatial variations of performance can be studied through a representative sample of Blocks, ISAs or farms in the Muda system in given period of time. With such a sample, the performance indicators can be quantified at block level, at ISA level or at farm level. The linkages between performance indicators and linkages between indicators and other exogenous factors affecting the performance also can be identified.

Table 8 further explains the proposed methodology to assess the impacts of interventions. Four levels of analysis is identified. They are:

a. Project level;
b. Block level;
c. ISA level; and
d. Farm level.

Different explanatory variables for different levels of analysis can be identified for each intervention. These will be linked with relevant performance indicators in the analysis. The independent variables for the analysis will be the performance indicators such as area per unit water, water productivity, cost of production, profitability, WDP, DPR, and RWS.

Table 8. Analysis of management interventions

Level	Project (95856 ha)	Block (800-1000 ha)	ISA (100 ha approx.)	Farm (2 ha)
Method	Time series analysis	Cross section analysis	Cross section analysis	Cross section analysis
Data source	Project level data	Field survey	Field survey	Field survey
Number of observations	Vary with variable	5 or 10	40	300
Interventions	Explanatory Variables			
Tertiary development	Percent area with tertiary irrigation facilities	Percent farm lots with direct access to: -tertiary canals -tertiary drains -tertiary roads	Percent farm lots with direct access to: -tertiary canals -tertiary drains -tertiary roads	Percent farm lots with direct access to: -tertiary canals -tertiary drains -tertiary roads
Irrigation supply period (thro' dry sowing)	Percent area under dry sowing	percent area under dry sowing	percent area under dry sowing	percent area under dry sowing
Decision support system	Number of stations per 100 ha			
Farmer organizations (Kelompoks/ Mini-Estates)	Percent area under farmer organizations	Ratio of farmers as members of farmer organization	Ratio of farmers as members of farmer organization	Ratio of farmers as members of farmer organization

Chapter 5

Implementation of Collaborative Study

5.1 Steering Committee and Working Group

For the Muda study, a Steering Committee has been constituted which includes the following:

General Manager, MADA, Co-Chairman
Director for Research, IIMI, Co-Chairman
Loke Kok Yan, MADA
S. Jegatheesan, MADA
Haji Hassan Lebai Mat, MADA
Charles Abernethy, IIMI
Ramesh Bhatia, IIMI
Chan Choong Cheong, DID

The Working Group consists of the following members:

S. Jegatheesan, MADA, Coordinator
Ramesh Bhatia, IIMI, Coordinator
Low Kean Leng, MADA
Wong Hin Soon, MADA
Shigeo Yashima, IIMI
Mohd Adnan Mohd Non, DID

5.2 Staffing

The activities under the program will be carried out by IIMI staff at HQ in partnership with irrigation agencies and local research organizations.

According to the arrangements for the collaborative study, MADA is contributing the staff time of three professionals on secondment basis. The HQ staff inputs include contributions from an economist, an engineer and an agronomist. In addition, the arrangements also include active involvement of officials from the Drainage and Irrigation Department (DID).

Expert advice on statistical and sampling techniques, survey methodologies, agronomy and agricultural economics will be obtained through consultants and staff in local research institutions.

5.3 Budget

Table 9 presents the details of the budget for this study. The estimated budget for the field survey is US$ 61,200. This includes wages and allowances of field staff, expenditure for workshops, office supplies and contingencies calculated at 10%. Major part of the expenditure, approximately US$ 47,000, will be incurred in 1994.

Total staff contribution from IIMI will be 25 man-months in 1994 and 22 man-months in 1995. Contribution from MADA will be seven man-months each for 1994 and 1995.

Table 9. Budget for the collaborative study

IIMI Staff Inputs & Budget			MADA Staff Inputs		
Cost Item	Man Months		Cost Item	Amount	
	1994	1995		1994	1995
1. Senior economist	4	4	1. Coordinator	1	1
2. Irrigation Specialist	9	3	2. Senior economist	3	3
3. Statistician	3	6	3. Irrigation Engineer	3	3
4. Irrigation Engineer	9	9	4. Senior Agronomist **	3	3
5. Consultants & travel (US$ 000)	30	20			
6. Field survey* (US$ 000)	47	9			
Total-Man Months	25	22		10	10
Total - US$ 000	77	29			

Notes: * To be reimbursed to MADA
** Included in the field survey cost
( ) Number of man-months

5.4 Timetable

Figure 9 shows the time schedule for these major items of work which are described as follows:

To ensure the use of common methodology for field studies, a Methodology Workshop was organized in January 1994, which included IIMI, MADA and DID staff.

Preparations for field survey have been made for 10 sample blocks and data collection started in February 1994. These data obtained from around 450 farmers will be analyzed to estimate "value of water" (i.e. net additional value of output due to irrigation) using (i) international prices for outputs and inputs and (ii) farmers' prices for outputs and inputs.

A workshop to assess the field testing of indicators will be held in January 1995. The project is planned to be completed in June 1995.

Figure 9. Timetable for IIMI-MADA Collaborative Study

Activity	1993 NOV	DEC	1994 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Planning	////////	////////	////////											
Field Survey						////////	////////	////////	////////	////////	////////	////////	////////	////////
Analysis of Project Level Data					////////	////////	////////	////////	////////	////////				
Analysis of Field Data								////////	////////	////////	////////	////////	////////	////////
First Draft Report											////////	////////	////////	////////
Workshops			///	///								///	///	
Second Draft Report														
Final Report														

Activity	1995 JAN	FEB	MAR	APR	MAY	JUN
Planning						
Field Survey	////////					
Analysis of Project Level Data						
Analysis of Field Data	////////	////////	////////	////////	////////	////////
First Draft Report						
Workshops						
Second Draft Report					////////	////////
Final Report						

Figure 9. Timetable of the IIMI-MADA collaborative study

5.5 Outputs

The study will quantify the effects of management interventions such as tertiary development on the performance. Apart from this, the following outputs will be generated.

Table 10. Outputs from Muda study

Output	Level of Quantification
Performance of irrigation service	project, block and farm
Area irrigated per unit water	Project
Production per unit water	Project
Cost of production	Project and farm
Profitability	Farm
Financial viability	Project
Environmental sustainability	Project

The following reports/working papers also will be prepared:

- How direct sowing and tertiary development resulted in improved performance in Muda Irrigation Project in Malaysia? : Analysis of time series and block-level data. : March 1995

5.6 Impacts

Since action research is carried out in a collaborative mode, a continuous interaction will occur among IIMI staff and Malaysian staff. This activity itself ensures an increase in the knowledge regarding methods of assessing performance and the determinants of performance. Irrigation managers and policy makers in Malaysia will be able to use a set of field-tested indicators to assess changes in the performance of systems other than those studied in collaboration with IIMI. It is expected that in Malaysia, performance assessment will be carried out in a "routine" manner and this information will be used in changing management practices and in implementing management interventions. Understanding the linkages between performance improvement, management interventions and policy changes will not only be useful for Malaysia, but will also provide systematized knowledge which will be of value to other countries. In particular, the proposed action research studies in the three countries will provide a better understanding of the relationships among short-term operational (water delivery) performance, crop production, social and economic impacts, and long-term sustainability.

Impact is also expected through the joint development of management innovations based on simple, practical recommendations with respect to water delivery; conjunctive regulation and management of groundwater and canal water; prevention of soil degradation and water conservation. Better management practices will result in higher productivity, equitable distribution of benefits and sustainability of irrigation investments.

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