IRRIGATION MANAGEMENT IMPROVEMENT PROJECT
FINAL REPORT

VOLUME II: ANNEXES

IIMI International Irrigation Management Institute
HR HR Wallingford

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ANNEX A

IRRIGATION MANAGEMENT IMPROVEMENT PROJECT
(IIMI/HRL R4702)

INCEPTION REPORT

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The International Irrigation Management Institute
Colombo
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HR Wallingford
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and

Irrigation Department
Government of Sri Lanka

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IRRIGATION MANAGEMENT IMPROVEMENT PROJECT
INCEPTION REPORT

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IRRIGATION MANAGEMENT IMPROVEMENT PROJECT

INCEPTION REPORT

1. BACKGROUND TO THE PROJECT

The Irrigation Management Improvement Project (IMIP) was first developed in July 1990 during a visit to the International Irrigation Management Institute (IIMI) in Sri Lanka by staff of HR Wallingford (HR). At that time, despite several discussions between IIMI and HR, there was no formal linkage between the two institutions. It was therefore decided to seek special funding from the Overseas Development Administration (ODA) that would support a joint program of work in a developing country that would utilize the joint expertise of the two institutions.

Following these discussions a draft proposal was submitted to ODA in July 1990 that outlined a program of joint activities between the two institutions. The overall purpose of the project was to focus on ways to help irrigation agencies become more responsive to changes both in water supplies for irrigation and to changes in demand within irrigation systems. At the time of this proposal no firm decision had been made on possible project sites as this still required additional negotiations with potential collaborating agencies. Possible locations considered were Indonesia, Thailand and Sri Lanka. Discussions with the Irrigation Department in Sri Lanka were held in July 1991, and the Director of Irrigation confirmed the willingness of the Irrigation Department to participate in the project.

Following perusal of the proposal by ODA and its technical advisors and some exchanges of correspondence to clarify certain aspects of the proposal, a formal application for funding by ODA was submitted by IIMI in October 1991 that identified Sri Lanka as the site of project activities and had a total cost of £175,000. This was subsequently approved by ODA, and project activities started on 1 January 1992. Under the terms of the agreement, the project has a life length of 24 months. IIMI will provide overall lead for the project, using HR as a contractor for its components. For its part, ODA will make available funds from two sources: Natural Resources and Environment Division will provide 60% of the total costs (£105,000) with the Engineering Division providing the balance of £70,000.

2. PROJECT OBJECTIVES

> **The overall objective of the project is to better match scarce water supplies with crop demand through the application of modern technologies by irrigation agencies.**

The management of natural resources for irrigated agriculture on a sustainable basis is increasingly important as population increases and changes in resource utilization place greater pressure on land and water. Typically efficiencies of both water and land use are low, and with fewer opportunities to increase irrigated areas by the development of new systems it is essential that countries adopt more effective methods of management.

Sri Lanka is typical of conditions faced by irrigation agencies in the monsoonal climates. The 1960's and 1970's saw large overall increases in irrigated area through major investment programs that complemented the introduction of higher yielding modern rice varieties. From being a significant importer of rice in the mid-1970's, Sri Lanka has nearly achieved rice self-sufficiency. However, further increases in production based on expansion of the irrigated area cannot be expected in the immediate future. Not only are there fewer economically viable sites available for development; the capital required has also become scarcer and more expensive. There is therefore a need to ensure a steady but sustainable growth in food grain production through increased productivity per hectare.

At the same time, land and water resources in existing systems are rarely utilized to their full potential. Increases in farmer livelihood requires not only higher grain production but also the adoption of higher value cash crops that use less water than rice cultivation.

Irrigation agencies throughout Asia are not well equipped to make a transition from monocropping of rice at relatively low water and land use efficiencies to a more diversified cropping pattern that maximizes incomes for farmers. In this respect Sri Lanka is no exception: operational strategies of the different agencies responsible for irrigation have not incorporated many changes that foster the development of diversity in the irrigated agriculture environment.

> **A significant focus of activity therefore is to examine the operational strategies of agencies, and the supporting process of annual and seasonal planning.**
>
> **This is supported by closer integration of the water delivery function of the Irrigation Department with the goals and capabilities of water users through the Project Manager System.**

Current policy of the government of Sri Lanka is to turn over responsibilities for operation and maintenance of secondary canals to federated farmer organizations. The Irrigation Department retains full responsibility for operation and maintenance of reservoirs, diversion structures and the main canal system. A Project Management Committee, including representatives of farmer organizations, irrigation and agricultural agencies is the forum for planning overall system operational policies.

For this policy to be effective, there has to be an effective dialogue between different agencies and water users in the planning process. The Irrigation Management

Division has been moving towards this objective for several years through the Project Manager System (Appendix B) but there is still plenty of scope for more effective management and operation of most irrigation systems in Sri Lanka.

In general, the operational rules and strategies adopted by the Irrigation Department have not changed significantly despite changes in cropping patterns and the establishment of more formal farmer organizations. There is a tendency for the same operational strategies to be adopted in times of both water abundance and water scarcity. The introduction of computer-based management support packages that address water allocation, irrigation scheduling and irrigation operations permits planners and managers to assess the range of feasible operational alternatives before the start of each season, and to monitor actual performance during the season and make necessary adjustments in response to changes in water supply and demand conditions.

3. WORK PLAN

The Work Plan for the Project is divided into two phases, each of approximately 12 months duration. All activities are undertaken in direct collaboration with the appropriate agencies: in the case of Inginimitiya the primary collaborating agencies are the Irrigation Department and the Irrigation Management Division.

The following activities are included in each phase, with primary responsibility of IIMI and HR indicated for each activity:

Phase 1: January 1992 to late 1992

1. Site identification, plus rapid appraisal of physical conditions at site (IIMI/HR);
2. Modification of existing computer programs to meet site conditions (HR);
3. Training of agency staff in use of computer software (HR);
4. Determination of existing management structure, processes and communication paths both within the agency and between agency staff and water users (IIMI);
5. Training of agency staff in discharge calibration techniques and determination of conveyance losses (HR);
6. Development of plans for involvement of water users in monitoring programs and upgrading of data base in respect of agricultural conditions (IIMI);
7. Implementation of monitoring program for water conditions and agricultural practices during initial season of operations (IIMI/HR);
8. Survey of farmer attitudes to existing operational conditions and their expectations for improvements (IIMI);
9. Workshop to review data collection program, effectiveness of the computer-based support packages, and plan for intervention activities in Phase 2 (IIMI/HR);
10. Interim Report (IIMI/HR).

Phase 2: **Late 1992 to end 1993**

11. Adaptation of existing water allocation practices based on the upgraded information base established in the first phase (IIMI/HR);
12. Testing of alternative operational procedures by Irrigation Department staff in response to different water supply and demand conditions such as rainfall or water scarcity (HR);
13. Utilization of upgraded information by farmer representatives and agency staff in regular meetings of the Project Management Committee under the auspices of the Project Manager (IIMI);
14. Field surveys to asses the effectiveness of the new measures as viewed from perspectives of users, agency staff and planners (IIMI);
15. Final workshop to assess the appropriateness and effectiveness of the processes and procedures adopted by different agencies and by water users, development of modifications to permit sustained use of the technology following project completion, and development of plans for replication in other systems (IIMI/HR);
16. Final Project Report (IIMI/HR).

4. PROGRESS TO DATE

By the end of March 1992 substantial progress had been made in respect of computer software adaption, training of agency staff, and studies of existing management structure and operational conditions.

4.1 Site Selection

In discussions with Irrigation Department staff in Colombo several systems were considered as candidates for the project. Selection criteria included a reasonable condition of physical infrastructure to avoid any repair or rehabilitation, recurrent but not chronic water shortage, representative size of the command area (between 1,000 and 3,000 ha), and potential for diversified cropping. A reconnaissance visit was made in early January by staff of IIMI and the Irrigation Department following which it was agreed that Inginimitiya be selected as the project site.

Inginimitiya is a 2,500 ha system located in the North West Province approximately 60 km north east of Chilaw. It is relatively new, being completed in 1985 under a program of assistance of the Government of Japan. Details of water issues, cropping history and current management practices are provided in Appendix A.

A rapid appraisal of the site was conducted in February 1992 by HR and IIMI staff and a basic assessment made of existing conditions. This included a complete walk through the Right Bank Canal to assess actual conditions of all structures, and determine suitable locations for discharge and water level monitoring.

A program of secondary data collection of water and agricultural conditions was initiated at this time. These data include reservoir levels and storage, issues into the two halves of the system, rainfall data from both the Irrigation Department and the Meteorological Office in Colombo, seasonal cropping conditions since the start of operation of the system in April 1985, and areas under each secondary and field canal.

4.2 Installation of Computer Programs

The INCA software developed by HR during studies of systems in Thailand and Sri Lanka was installed successfully on computer equipment purchased for the project. The first set of equipment was taken to Inginimitiya project site and used in the first phase of training. Adaptation of the model and installation of the basic system configuration proved straightforward so that there were no delays in the start of training.

A parallel computer model (COMA) developed by IIMI staff to determine the management requirements for different operational strategies was completed during this period, and is ready for use later in the project.

4.3 Computer Training

An intensive three-week course in utilization of the computer software was undertaken in March 1992 by HR staff. Three levels of staff were included in this training activity: Irrigation Engineers (IE) responsible for all aspects of system management, Technical/Divisional Assistants (TA) who have day to day responsibility for system operations, and Draughtsmen for purposes of routine data entry into the computer program.

The training program was kept on schedule, and it proved relatively easy to reach a stage of proficiency in use of the software.

4.4 Management Study

The study to assess existing management structures, processes and conditions was initiated during this period. Data have been collected on the size and location of each of the Distributary Canal Organizations (DCO) and their constituent field canal groups. Initial plans for a set of joint activities with the Project Manager, the Institutional Development Officer and the Institutional Organizers (IOs) have been drawn up. (Six IOs have recently been posted in Inginimitiya to strengthen the farmer organizations.) Implementation of these plans will occur during the next cropping season. The duties and areas of responsibility of all field staff in the Irrigation Department have been determined, and their individual tasks clearly identified to determine who is responsible for which operational decisions.

Plans have been drawn up to place a full-time IIMI Research Officer in the study area during the next cropping season.

4.5 Other Activities

In anticipation of water releases for the next season, water gauging equipment and rain gauges have been purchased and installed in the Right Bank portion of the system. Similar installations will occur in the Left Bank later in the year when water releases into that area have been confirmed.

5. MODIFICATIONS TO THE ORIGINAL PROPOSAL

A few minor modifications have been made to the original proposal submitted to ODA that are mentioned below. So far there has been no need to make substantive changes and none are envisaged at the present time.

5.1 Changes in Project Timetable

Bar Charts for 1992-93 and 1993-94 included in Appendix 5 of the original proposal have had to be modified to more accurately reflect the cropping calendar of the selected system. The activities scheduled for July and August 1992, including the mid-term review and the development of the Phase 2 work plan have been postponed until October and November. This was necessitated by the delay of Yala (Dry Season) cropping activities until mid-April. The season had originally been planned to commence in late February or early March but was put off several times because of adverse water conditions. This change means that the inputs planned for Mr. Cornish have been moved back.

The Bar Chart for 1993-94 shows a minor change for month 3. Originally it had been planned for Mr. Bird to come at this time, but it has been proposed to send Mr. Cornish instead. The work at this juncture is largely related to the use of the INCA model, and it is more appropriate for Mr. Cornish to undertake this task.

Neither of these changes affect the overall project timetable or the annual budget.

5.2 Project Management Conditions

At the time of proposal submission the final site selection had not been made. The selection of Inginimitiya was influenced by its inclusion as one of the Irrigation Management Division systems, and the presence of a special program of institutional strengthening scheduled for 1992 using the six IOs. This provides a better opportunity for integration of the activities of the Irrigation Department with those of the Project Manager and his staff. Areas of work that will therefore be given more emphasis in the project than initially expected will be the active involvement of Distributary Canal

Organizations (DCO) in the monitoring of agricultural and water conditions during the season. The current staff of the ID are poorly equipped to determine detailed agricultural practices: involvement of DCO members in periodic surveys will prove an additional bonus. It is also proposed to use DCO members on a trial basis to monitor water conditions at distributary and field canal level, and report this information to the ID.

It is expected that these tasks will give the DCOs a clearer knowledge of their operation and maintenance responsibilities, and will greatly enhance their capacity to make effective and knowledgeable inputs into the annual and seasonal planning process.

No other changes to the Work Plan are anticipated at this stage.

6. POSSIBLE CONSTRAINTS

It is inevitable that the project will come across conditions that may hamper project progress. To date only two potential constraints have been identified that may have adverse consequences.

6.1 Drought Conditions

At the time of writing (March 1992) Sri Lanka is experiencing severe drought throughout the island. Various causes have been suggested, including the erratic behavior of El Niño in the Pacific Ocean and the eruption of Mount Pinatubo in the Philippines. Whatever the cause, almost every reservoir is far below normal levels and it is estimated that 1992 Dry Season production will be as much as 70% below average.

Inginimitiya is no exception. Water in storage is insufficient to meet water requirements for rice cultivation throughout the Right Bank (the original plan for this season) and it is currently hoped to convince farmers of the necessity to grow crops with lower water requirements such as chillies or gram.

The low water conditions now mean that decisions for the Wet Season crop will almost certainly be delayed. Inflow into the reservoir is normally not significant before November, and it is unlikely that farmers will risk land preparation or planting until the reservoir has filled significantly.

However, there is no benefit to be gained at this stage from contemplating a change in project site: the same conditions are being experienced in almost every other major system in Sri Lanka.

6.2 Staff Transfer

This is a perennial problem in all irrigation systems in South Asia. Training of staff at Inginimitiya has been done in the expectation that some of those trained will be transferred later in the year to other systems. While this is not a complete loss it may create some difficulties. To overcome this, IIMI staff have become familiar with the INCA model so that they can provide some supplemental back-up training during the year if that is necessary.

Staff who are transferred will have benefitted to some extent. Those trained have already expressed their interest in the approach adopted and it has greatly enhanced their interest and knowledge in the operational requirements of a system under different cropping and water conditions.

7. ACKNOWLEDGEMENTS

The Project has been able to make significant progress during the first three months due to the full cooperation and support of the Irrigation Department.

In Colombo there has been full cooperation from Mr. Yoganathan, Director of Irrigation, and Mr. D.W.R.M. Weerakoon, Senior Deputy Director for Operation and Maintenance. They have been instrumental in providing the transport for HR staff, and facilitating arrangements for data collection from within the Irrigation Department and from the Meteorological Department.

At Inginimitiya full support has been provided by Mr. Wimalachandran, Chief Resident Engineer, by freeing his staff for training and providing office and residential accommodation at site.

The Irrigation Management Division, through Mr. Ratnayake, Project Manager at Inginimitiya, has also afforded full cooperation in gaining basic knowledge concerning the farmer organizations in the project area.

APPENDIX A
INGINIMITIYA IRRIGATION SYSTEM

1. Background to the Project

Inginimitiya Irrigation System is situated in the North West Province of Sri Lanka some 60 km north east of Chilaw. It is well within the Dry Zone of the country which means that it receives reliable rainfall only in the north east monsoon (50 % of the total annual rainfall of about 54 inches or 1380 mm falls between October and December). For most of the rest of the year there is insufficient rainfall for crop production, and irrigation is essential if more than one crop is to be grown.

Although initially identified as a potential site for a dam and irrigation system during the early 1950's, Inginimitiya was not seriously evaluated until the 1970's. As part of the drive by the government of Mrs. Bandaranaike to achieve rice self-sufficiency, a request was made for assistance from the Government of Japan for financing the project. The feasibility report for the system was produced in 1977, financing arrangements agreed, and construction finally completed by early 1985. The first water issues for irrigation were made in April 1985.

Inginimitiya was constructed on the site of a small village tank which had probably been present for several centuries. The smaller reservoir was replaced with a 4 km long embankment impounding a reservoir of 57200 ac-ft (71 million cubic meters), commanding a total irrigable area of 6,300 acres (2550 ha). However, approximately 25% of the irrigable area was already developed under several small irrigation systems prior to construction, including Mahauswewa Tank that irrigated 900 acres (365 ha). The total new irrigable area is 4,660 acres (1890 ha), plus some assurance of double cropping in all of the pre-existing irrigation systems.

The total cost of the project was $23.6 million (in 1977 prices) of which approximately $5.0 million was for contingencies. Of the base cost of $18.6 million, $8.1 million were for civil works, the remainder being for equipment, technical assistance and administrative costs. This represents a cost of about $3750 per acre ($1500 per ha) for the full benefitted area.

2. System Design

Inginimitiya System is divided into two parts: the Left Bank Main Canal commands 3850 acres (1560 ha), and 2450 acres (990 ha) on the Right Bank which includes 200 acres (80 ha) of the original command area of Inginimitiya Village tank (Figure A.1). The maximum design discharges are 120 cusecs (3.4 cumecs) for the Left Bank and 90 cusecs (2.5 cumecs) for the Right Bank.

The design principles adopted at Inginimitiya represented a break from earlier designs of the Irrigation Department. It was the first system to be designed by the Irrigation Department from the start using the 1-cusec (28.3 l/sec) canal approach (some systems under the Tank Irrigation Modernization Project, TIMP, were being retrofitted with 1-cusec field canals at about the same time that Inginimitiya was being constructed).

The 1-cusec canal design includes some important design criteria. The most important criteria are:

- all field canals are designed to operate with a discharge of 1.0 cusec (28.3 l/sec), limiting the total command area of a field canal to 40 acres (16 ha), the discharge to include all tertiary losses;

- if the total area of a field canal is less than 40 acres, the discharge remains constant but the number of days of irrigation per week is reduced in proportion to the command area;

- the designs for all field canals and their structures are identical, with each field canal commanded by a sliding head gate and a 6-inch (150 mm) diameter culvert;

- distributary (secondary) canals are sized to meet maximum demand from all field canals simultaneously, plus a small allowance to meet losses along the distributary canal;

- the main canals are provided with sufficient cross-regulators that water surface elevation along the entire length of the canal can be kept at or close to design elevations irrespective of total discharge entering the canal.

This type of design allows for a relatively simple set of operational rules to be developed. It is anticipated that a flow of 1.0 cusec in a field canal will be shared by adjacent pairs of farmers for 12 hours each, a delivery rate of approximately 3.0 inches (75 mm) per week. Field canal gates are adjusted to meet the required flow, and closed when all farmers have had their turn for the week. Distributary gates will only be operated when there is a change in discharge due to the rotational pattern among field canals along a single distributary. In practice, large distributary canals will have continuous flow, as will the main canal.

The main canal operations are simple: discharges are kept more or less constant except when there is sufficient rainfall to justify closing the system down. Because of the presence of large numbers of cross-regulators, it is possible in theory to meet the full demand of the system with discharges way below design discharge.

Actual operational practices may be significantly different. The design calls for complete control over every offtake along the main canal to ensure that discharges are at target level. Although the design guidelines discourage field canals offtaking directly from the main canal, Inginimitiya has a high proportion of these direct offtakes because the topography forces it. In a long thin system it is not possible to construct a hierarchical system of secondary and tertiary canals. Thus, on the Right Bank, there are 13 distributary canals and 23 field canals along the 13 mile (20.8 km) main canal and 10 distributary and 28 field canals along the Left Bank Main Canal.

The implications of this type of design for monitoring and regulation of discharges are obvious. With current staffing allocation for operations at Inginimitiya of 1 irrigation engineer, 3 technical assistants and 8 irrigators it becomes impossible to closely monitor the entire infrastructure to ensure discharges are as they should be at any given time. The situation is made worse when water supplies are less than expected.

3. Water Conditions at Inginimitiya

A summary of the water conditions at Inginimitiya can be seen in Figure A.2. Since filling of the reservoir commenced in late 1984, water conditions have been extremely variable. In the 1984-85 maha (wet season) the Reservoir reached about 35,000 acre-feet (43 million cu.meters), about 61% of its capacity. During the next wet season rainfall was abundant and the tank filled by January 1986. The rains continued into April so that despite releases for the maha rice crop, the reservoir was still full for the 1986 yala (dry season) crop. However, the failure of the 1986-87 rains meant that the reservoir hardly experienced any inflows, and a limited 1986-87 maha season was possible. 1987 saw a continued drought and the cancellation of both the yala and maha seasons.

The 1987-88 rains were, however, quite favorable: although the reservoir filled too late for a maha season, the next two seasons proceeded as planned. The reservoir spilled for the second time in early 1988 and there was sufficient water in storage to permit a full cultivation for the first (and only) time in the 1988-89 maha season. This was achieved despite the failure of the 1988-89 rains.

Since the failure of the rains in 1989 the system has experienced almost perennial drought. At no time has storage been above 50% of total capacity, and the reservoir has been functionally empty at the end of each dry season. The result is that it requires heavy and prolonged rains to fill the reservoir up to a useful level, and rains of this type have been more or less absent. There is no sign that this drought period is over, the 1992 situation being critical throughout the island.

The data collected over the past eight years indicates that filling of the reservoir is limited to one or two brief periods in each year (Figure A.3). The most reliable filling occurs in November when following sufficient rainfall to soak the catchment, a heavy storm is sufficient to fill the tank by several thousand acre-feet in a day or two. By the end of December further filling is unlikely, unless there is a prolonged rainy season. This has occurred twice: in 1986 and 1988 the rains continued with sufficient intensity to lead to a second round of filling in March-April. In terms of reliable inflow, however, these rains cannot be readily predicted and it appears unwise to depend on this second filling. To all intents and purposes, the storage by mid-January determines water availability for the next 9 months.

4. Agricultural Performance

The basic consequences of the irregular water conditions are clearly reflected in the cropping history of the system (Table A.1). During the first four seasons of operation it was possible to grow between 3,000 and 5,000 acres of rice (Figure A.4). Given that much of the irrigated area had never before been under rice, it is inevitable that water consumption was on the high side, particularly for land preparation, and this may have restricted the total area that could be irrigated. Total water consumption of over 6.0 feet (1800 mm) is on the high side for a wet season crop, even allowing for rainfall included in this total, but it is realistic for a new system. In 1986-87 maha consumption was less, but this may have been because the reservoir was reaching critically low levels by the end of the season.

The drought of 1987 was so severe that no cropping was possible at all for two full seasons. This clearly had an adverse effect on the momentum of agricultural activities, so that it took some time to get started again when the rains finally came.

There was no 1987-88 maha season even though there was adequate water in the reservoir by December. This is explained by a recommendation of the Agriculture Department not to plant during December because of adverse climatic and pest conditions. However, although it is possible to have a late maha or <u>meda</u> season starting in January, it was decided instead to have a full season starting in March 1988 and a subsequent maha for 1988-89. Some effort was made to encourage farmers to grow crops other than rice in the 1988 yala season: by switching to crops that use less water than rice it should be possible to increase the number of farmers who benefit. 378 acres (153 ha) of chillies were cultivated, which produced an estimated yield of about 1,800 lbs/acre (2,050 kg/ha).

The 1989 drought again broke the agricultural momentum. A limited area of non-rice crops was tried: 679 acres (275 ha) of chillies was cultivated but many farmers expressed concern that production was not particularly high: yields were estimated to be around 1,250 lbs/acre (1,400 kg/ha). This poor experience discouraged many farmers from growing non-rice crops in subsequent seasons.

The 1989-90 maha was again canceled due to delayed rains, the second time in three years that a wet season crop was not cultivated. This lack of rice cultivation further strengthened farmer resistance to growing non-rice crops in the dry season. Thus in the 1990 yala, despite unfavorable filling of the reservoir, most farmers opted for rice cultivation. Although some 700 acres (285 ha) of chillies were planted, 3300 acres (1340 ha) of rice cultivation meant that only just over 60% of the system was cultivated.

The poor rains of 1990 meant that yet again the wet season crop was delayed, and that farmers would have to rely on the 1991 yala season for their rice crop. However, the lack of adequate water in storage prevented all farmers from being able to get permission to grow rice. Instead, it was decided to try the "bethma" system of cultivation, in which farmers share land. Each farmer would allow another farmer from an adjacent canal to cultivate half his land, thereby sharing scarce water among the entire community.

The experience with this "bethma" system proved to be disappointing. It was difficult to prevent farmers from cultivating all their land themselves, many canals received water even though they were not authorized to do so, and there were significant problems in getting water to the tail end of the main canals.

As a result, a different approach was adopted when the 1991-92 rains were also below average. A sharing system was adopted by which the Left Bank would get a maha crop, and the right Bank a yala crop. The 1991-92 maha therefore provided water for all areas of the Left Bank, and the Right Bank farmers patiently waited for the yala season. At the time of writing no decision had been made on the 1992 yala crop, however, because there was less storage available than required to grow rice in the full extent of the Right Bank. Given that some portions of the Right Bank had not had a rice crop since yala 1990 (and some none since maha 1988-89) water requirements for land soaking and land preparation would be higher than normal, a factor in delaying the start of cultivation until the water situation became clearer.

This sequence of events is clearly the result of adverse climatic conditions. Given that the length and intensity of the current drought is almost unprecedented it is inevitable that agricultural performance has suffered. There is every reason to believe, however, that when the drought breaks agricultural performance will rebound to the 1988 levels.

5. Irrigation Water Deliveries

The continued poor storage conditions have made operation of the system much more complex than expected. Under the design guidelines it would be expected that discharges into each canal were more or less constant throughout the season, apart from a slightly higher set of issues for land preparation. Discharges into each distributary canal, particularly larger ones, would be also more or less constant, and there would be a lot of rotation at field canal level.

In practice the situation appears to have been very different in most of the seasons so far completed. Three aspects are worth particular mention as they all indicate areas where management improvements could be made.

(a) Response to Water Levels in the Reservoir

There has been a tendency, particularly in water short years, to let the available storage dictate the discharge into the main canals. This situation suggests that during the seasonal planning process there is insufficient attention paid to actual water demand and supply, and the operational plans required to implement the plan. With rice cultivation, at least following land preparation, crop-soil-water demand is more or less constant. A typical pattern of deliveries should therefore look like maha 1988-89, the first season when the entire command area was irrigated (Figure A.5).

More commonly, however, discharges show significant changes between early and late season conditions. These changes frequently reflect the actual storage in the reservoir, such as the pattern for maha 1986-87. By the end of this season the water conditions had become sufficiently unfavorable that the operational focus appears to have been one of stretching water supplies through to the end of the season (Figure A.6).

The same basic patterns can be seen in the yala seasons, such as those for both 1990 and 1991 (Figure A.7 and A.8). Although evapotranspiration increases as the season progresses, the actual issues decline in response to the declining storage in the reservoir.

In all of these cases it appears that the actual demand was higher than allowed for in the planning process preceding each season, either because of conservative estimates of water requirements or because the actually irrigated area was somewhat higher than that authorized. In either case, it ends up with reservoir levels dropping to dangerously low levels.

(b) Variability in Discharges

The design guidelines would, if strictly adhered to, lead to fairly constant discharges except when rainfall merits closing the sluices. Again, the actual data suggest that discharges are more variable than might be expected, and that the Right Bank has much more variable discharge than the Left Bank. Three factors appear to combine to create this variability: response to rainfall, presence of intermediate tank storage, and water shortage.

With perennially scarce water conditions there is a tendency to response rapidly and severely to any rainfall that occurs. In maha 1986-87, for example, a relatively small storm of 7.6 mm in January led to the system being closed for seven days, a much more rigid response than could be justified by the total rainfall (Figure A.6). Following rainfall, however, discharges were increased above their previous levels to compensate for the lack of water. The same pattern can be seen in many other seasons, suggesting that rainfall is used more as a way of conserving scarce reservoir water than carefully matching rainfall and issues into the system: saving of water by reducing discharges in response to isolated rainfall events may not be effective.

Intermediate tank storage allows for discharges to be modified within the system itself. On the Right Bank there is no effective storage (Konkadawewa is included in the Right Bank Main Canal but has little effective storage and has to be kept more or less full) so that most variation in demand or response to rainfall has to come from the Right Bank sluice itself.

Issues into the Left Bank Main Canal are more constant. It appears that water is delivered to Mahauswewa Tank which then be used to make issues both into the command area of the tank and into the continuation of the Left Bank Main Canal independently of the volume of issues into the tank. However, there are no data to enable this assumption to be verified.

(c) Discharge Levels

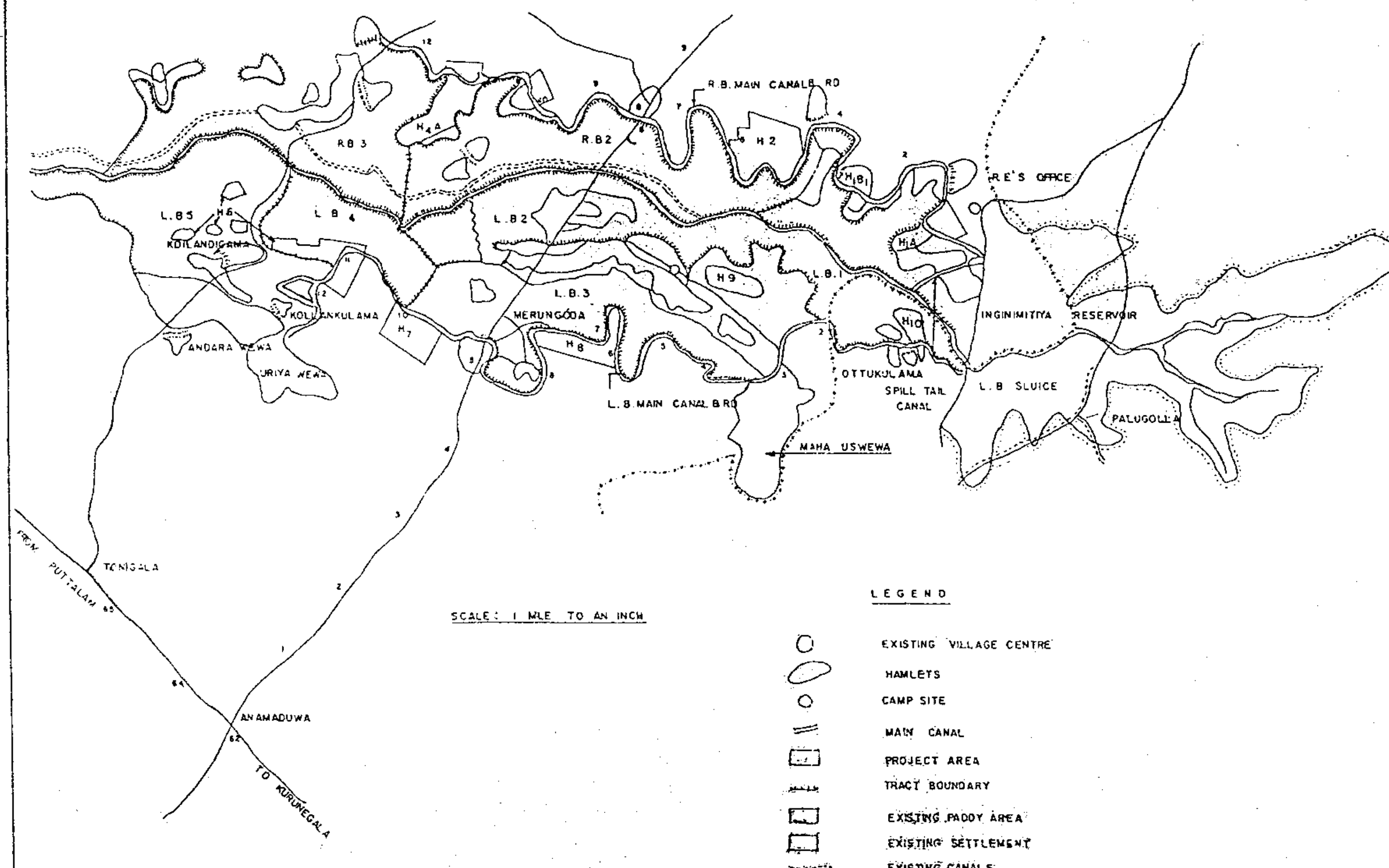
The third operational aspect is that neither main canal is operated at or close to design discharge. Typically issues are less than half of design discharge (Figures A.9 and A.10). The only notable exception to this was in maha 1988-89, the only season when the full command area was irrigated. On the Left Bank issues exceeded 60% of design discharge about 80% of the time, while on the Right Bank issues were above 60% of design discharge for half the time.

Although it is quite possible to operate a cross-regulated canal at discharges far below design discharge, this requires close supervision of discharges into upper end offtakes to ensure that water deliveries are more or less proportional to the discharge along the canal. If they are not it is very hard to achieve equitable distribution of water.

An alternative method of achieving equity under water short conditions is to implement rotations where the canal is run at or close to full supply for limited periods of time. The only times that rotations have been attempted at main canal level appear to be yala 1989 (Figure A.11) and the latter part of yala 1990 (Figure A.7), and in both instances water was in such short supply that full discharges could not be given.

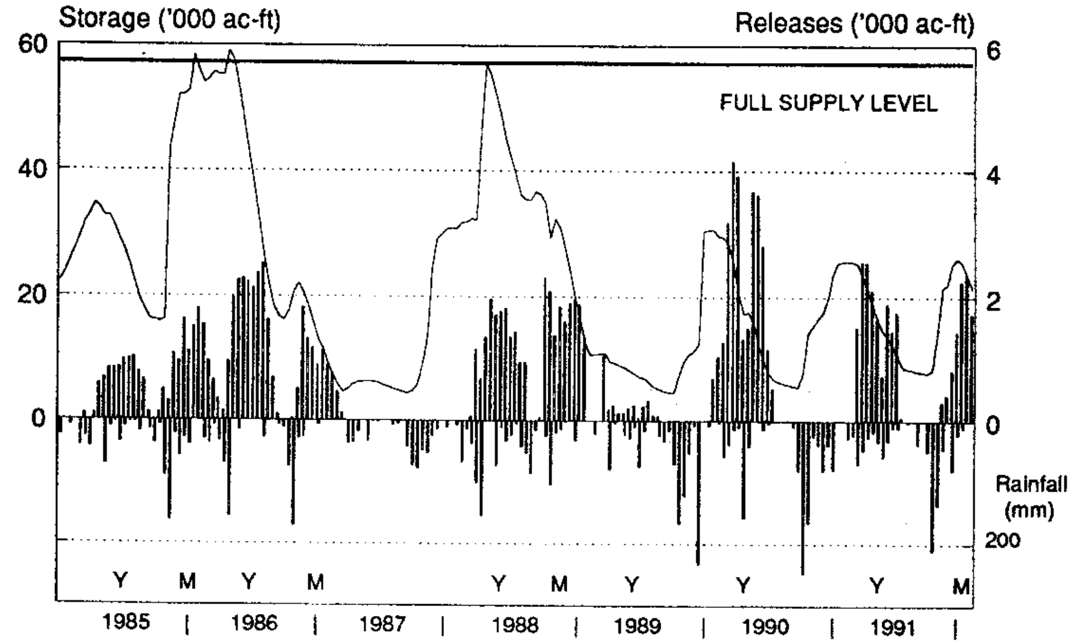
The lack of data on actual discharges and rotations within the command area makes it impossible to determine what actual operational conditions are, and what the equity effects of the current operational patterns have been.

Figure A1



INGINIMITIYA RESERVOIR PROJECT MAP

Figure A2
14-Day Storage, Issues and Rainfall
Inginimitiya, 1985-1992



Note: Y: Yala (Dry Season) M: Maha (Wet Season)

Figure A3
Weekly Storage
Inginimitiya, 1985-92

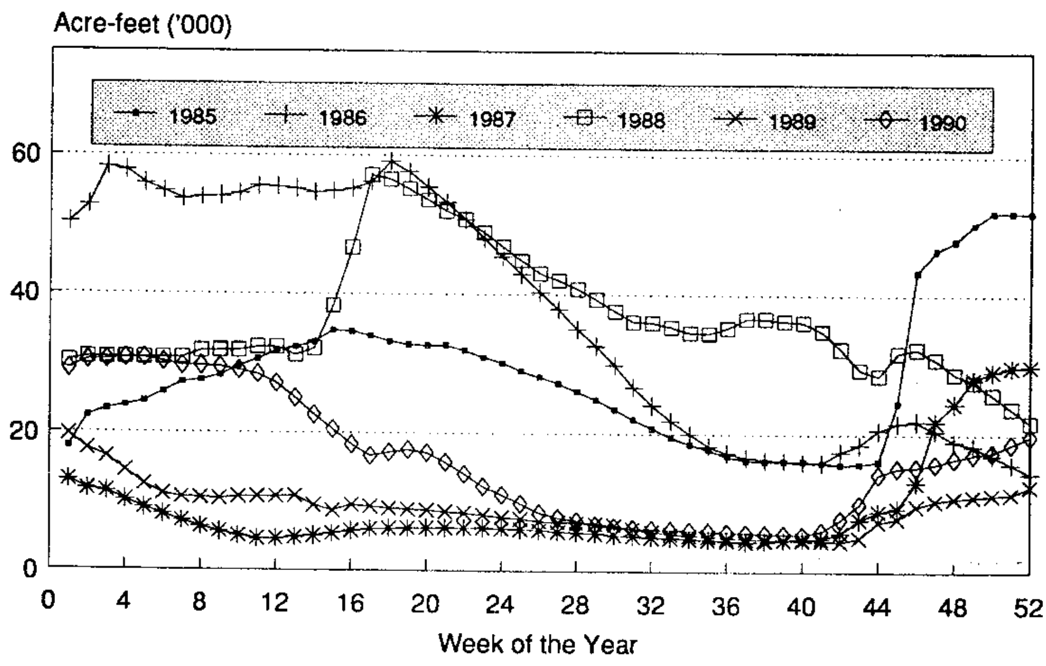


Figure A4
Cropping Patterns
Inginimitiya, 1985-1992

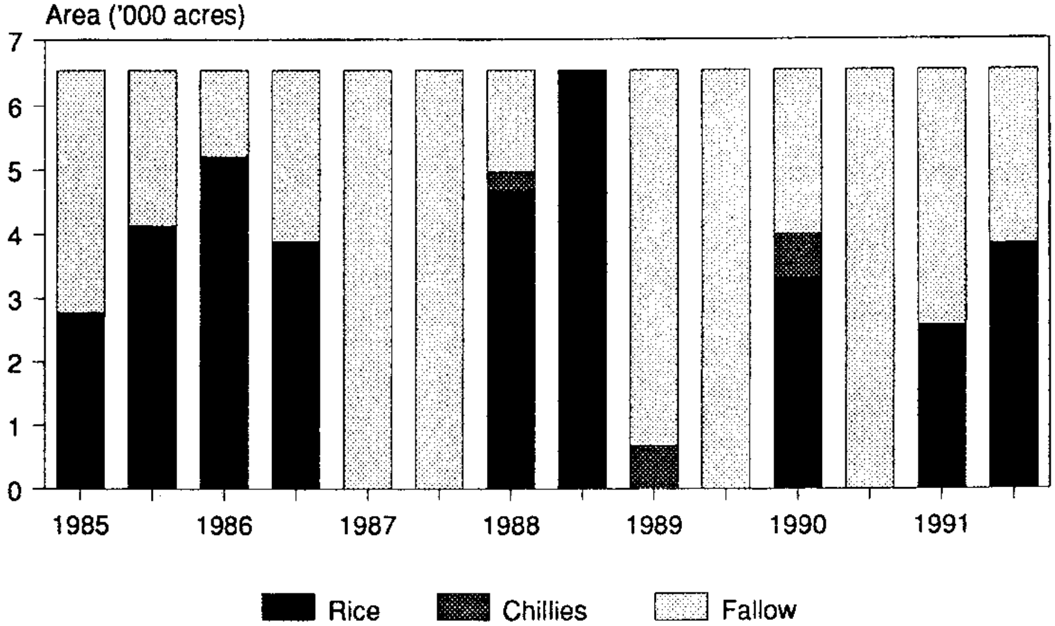


Figure A5
Maha 1988-89
Inginimitiya

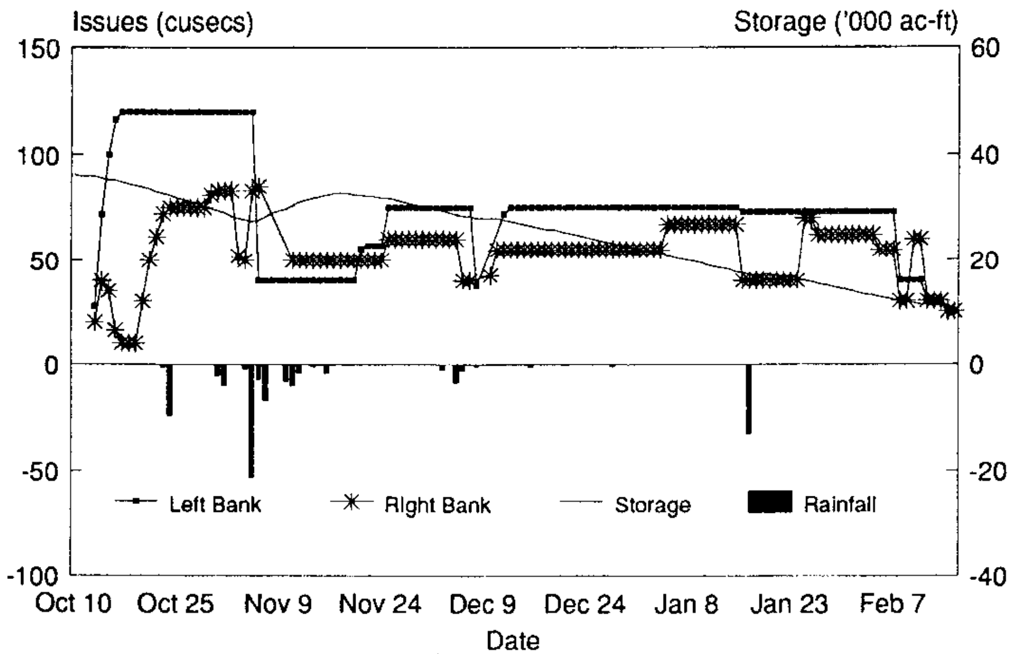


Figure A6
Maha 1986-87
Inginimitiya

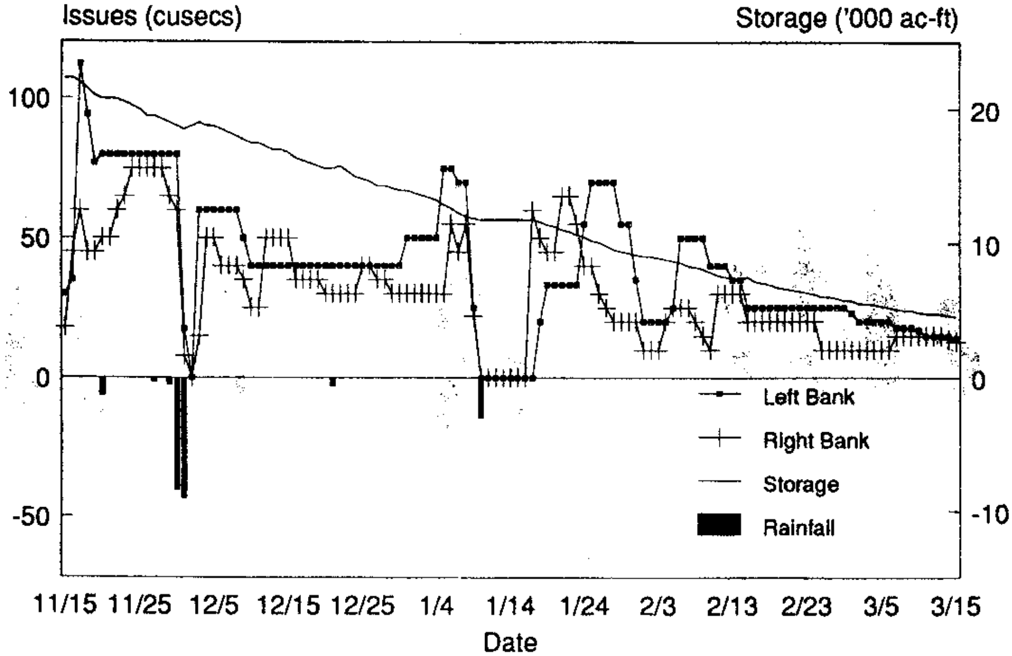


Figure A7
Yala 1990
Inginimitiya

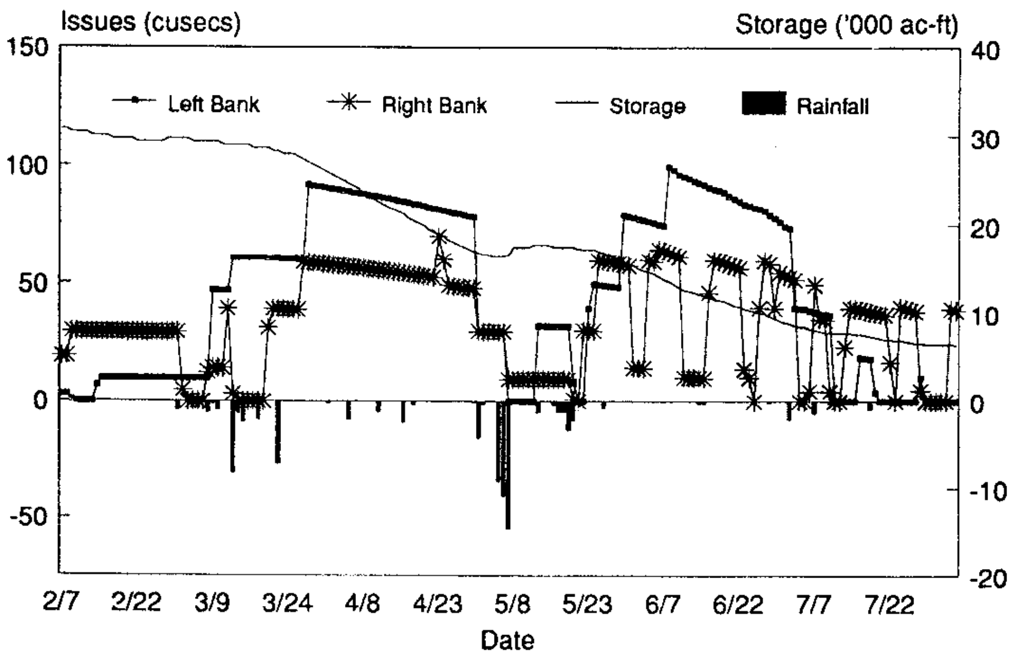


Figure A8
Yala 1991
Inginimitiya

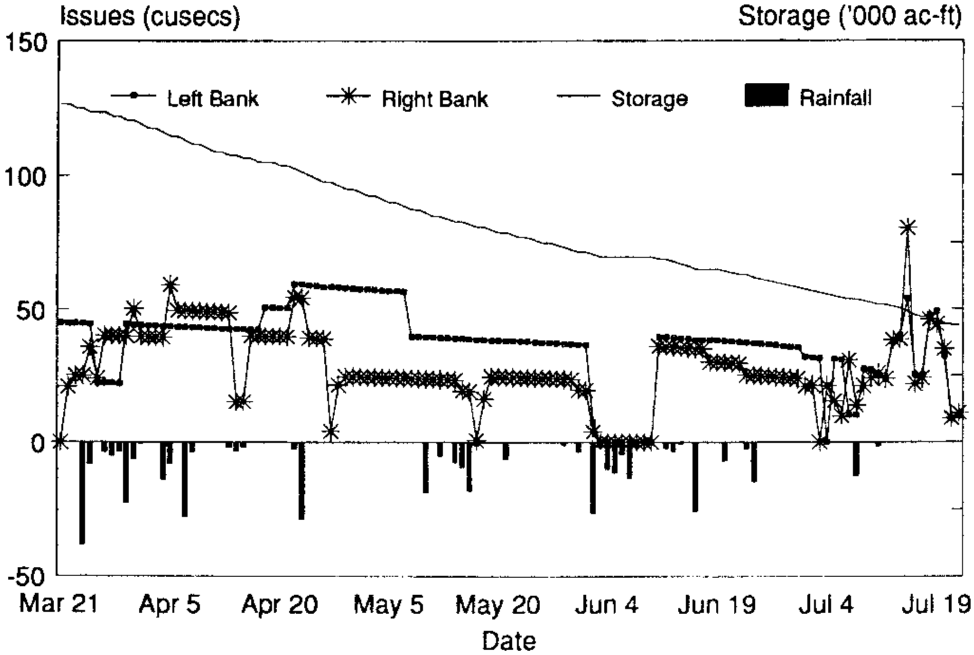


Figure A9
% of Design Discharge
Inginimitiya Left Bank, Maha Seasons

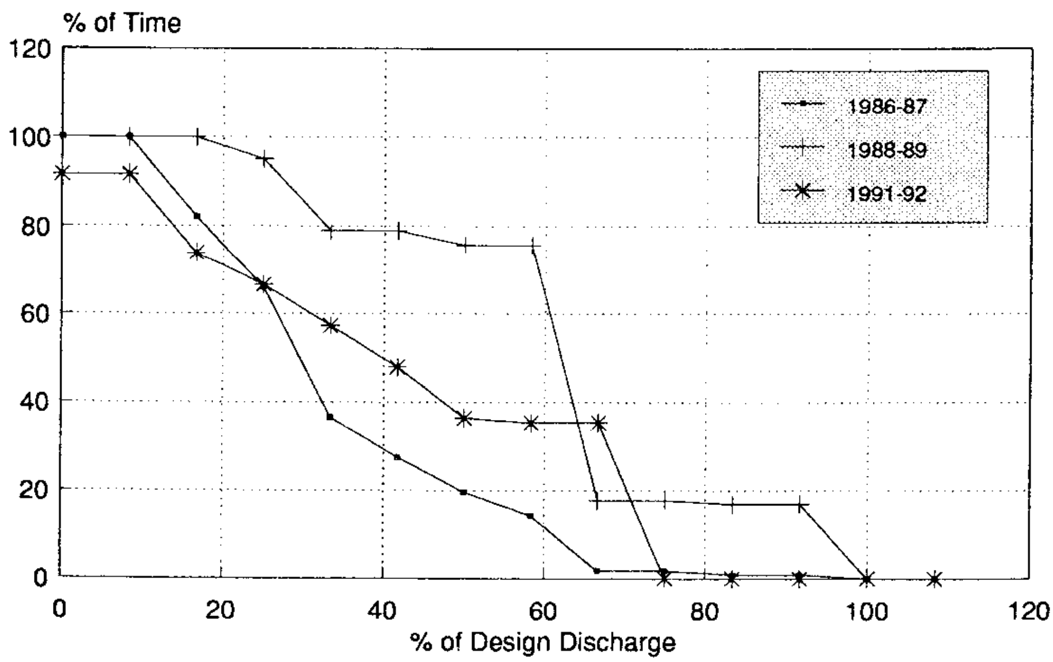


Figure A10
% of Design Discharge
Ingininimitiya Right Bank, Yala Seasons

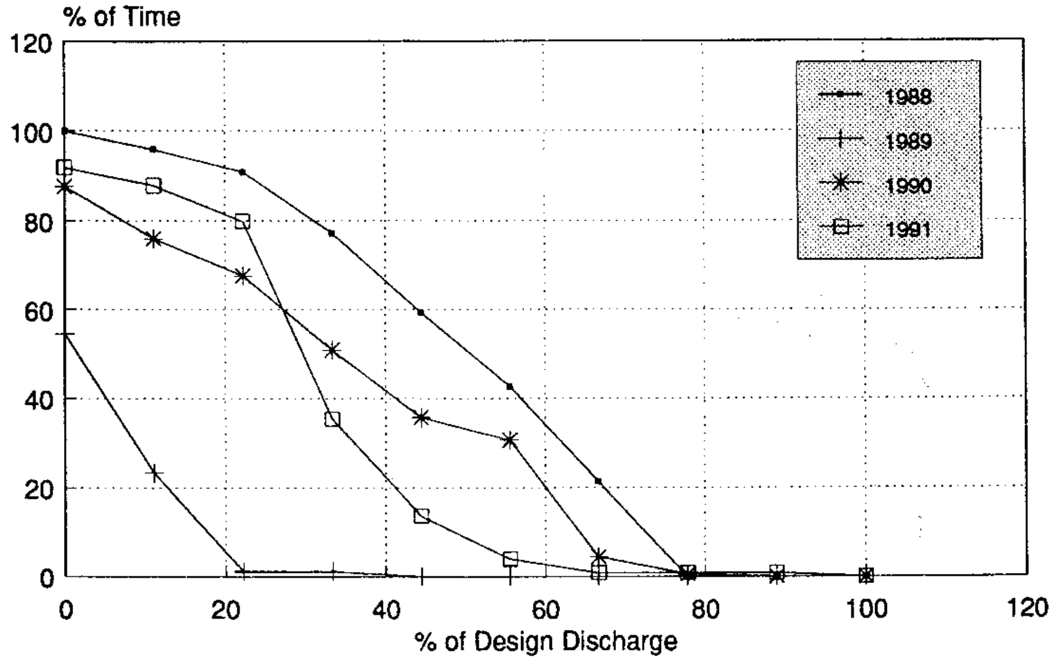
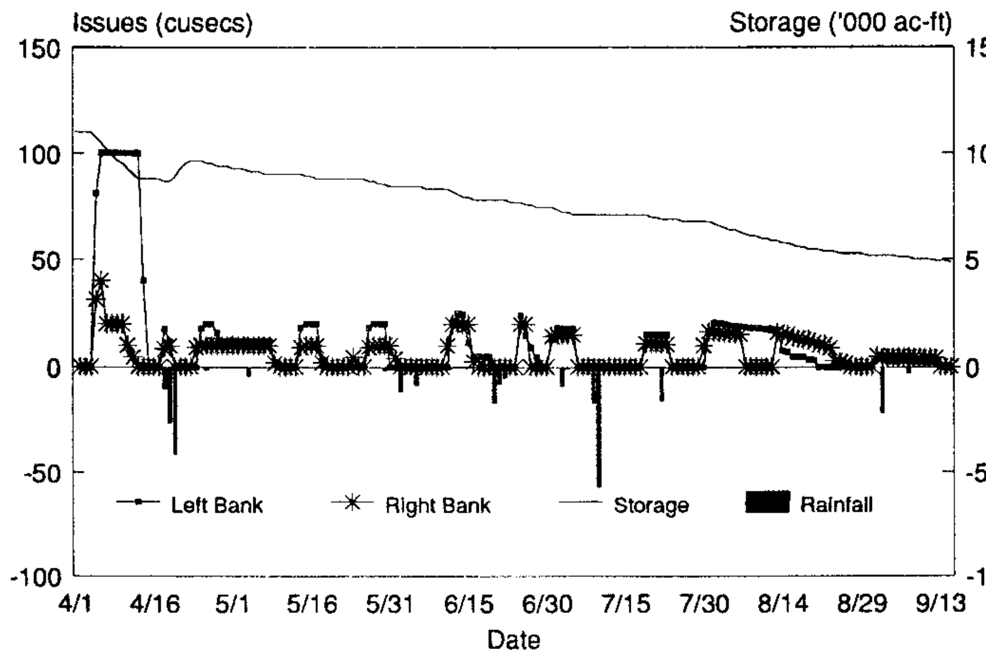


Figure A11
Yala 1989
Inginimitiya



Only chillies grown this season

Table A.1

Area Cropped and Water Use
Inginimitiya, 1985-91

Crop Season		Area Planted Rice	Chillies	Fallow	Water Use (ft)
1985	Yala	2784	0	3746	6.04
1985/86	Maha	4133	0	2397	6.10
1986	Yala	5200	0	1330	7.22
1986/87	Maha	3890	0	2640	4.71
1987	Yala	0	0	6530	-
1987/88	Maha	0	0	6530	-
1988	Yala	4680	288	1562	5.88
1988/89	Maha	6530	0	0	4.93
1989	Yala	0	672	5858	5.11
1989/90	Maha	0	0	6530	-
1990	Yala	3300	700	2530	6.83
1990/91	Maha	0	0	6530	-
1991	Yala	2585	0	3945	6.19
1991/92	Maha	3850	0	2680	

Total Cropping Intensities:

Maha	41.7%
Yala	45.8%
Total	87.6%

APPENDIX B
THE PROJECT MANAGER SYSTEM[1]

The past two decades have seen a dramatic change in attitudes towards the management of irrigation systems in Sri Lanka. Prior to the mid-1970s operation and maintenance in major irrigation systems from water source down to the first half mile of field canals was the responsibility of Irrigation Department officers. There were few mechanisms for the direct involvement of farmers except at the seasonal planning meeting which was little more than a process to get farmer concurrence with official decisions, although Cultivation Officers of the Land Commissioners Department were expected to work with farmers and obtain information from them on crop plans.

Several factors led to this change in attitude. In the World Bank funded Tank Irrigation Management Project efforts were made to establish Tank Committees which would meet more frequently than the traditional seasonal meeting, and focus on operational issues. Although this effort was not sustained, it set the scene for changing the process by which farmers could become more involved.

Parallel with this were two more individual efforts. At Kimbulwana Tank the Technical Assistant, Mr. A.M.S. Gunadasa, decided that the rehabilitation activities being undertaken there would not be successful without farmer involvement. Farmers were encouraged to participate in rehabilitation work and later in regular operation and maintenance.

In Minipe Mr. N.G.R. de Silva implemented a committee system for farmer involvement in a much larger system. The Minipe model had many lessons for how to get farmer involvement in a large and complex system, and has formed the basis for many subsequent innovations. Both this experiment and that at Kimbulwana demonstrated that farmers could play an active and constructive role in system management, but also showed that there were no effective institutional arrangements to fully develop these contributions.

In 1979 USAID supported the Gal Oya Water Management Project that used for the first time the concept of Institutional Organizers to help form field canal and subsequently distributary and area organizations for purposes of planning and participating in rehabilitation activities, as well as in operation and maintenance following reconstruction. The creation of committees at field canal and distributary canal level, each with a representative to higher level committees, represented a major shift in the institutional pattern for irrigation management.

By 1984 it was obvious that some more formal institutional arrangements were necessary, and the Irrigation Management Division (IMD) was created within the Ministry of Lands and Land Development to provide a national basis for improvement of system management.

The primary vehicle which IMD has used is the INMAS program. In the 35 systems covered by INMAS each field canal is used as the basis for a three-tiered system of representation. Field canal groups choose a representative to sit on the Distributary Canal Organization (DCO), and each DCO provides a representative to the Project Management Committee. This committee also has representatives of irrigation and agricultural agencies but farmers are expected to be in a majority. The

[1] This Appendix draws heavily on a paper by Dr. Douglas J. Merrey entitled "Irrigation Management Institutions in Sri Lanka" published in the Economic Review of Sri Lanka in the February/March 1991 edition. The willingness of the author to let this be used in this way is greatly appreciated.

DCO is a farmer group that can invite government officers to meetings, but is fundamentally a forum for farmers to make joint decisions on seasonal planning, operations and maintenance.

To help establish and then maintain the strength of these organizations, IMD provides a full-time Project Manager based in each of the 35 (now increased to 44) systems. The role of the Project Manager includes assistance in the coordination of inputs by different agencies in accordance with agreed schedules for planting and irrigating, to help field canal and DCO organizations to become self-reliant, and to report on water and agricultural conditions to Colombo. In many systems the Project Manager is assisted by an Institutional Development Officer who works closely with the organizations.

The Project Management Committee meets monthly. One of its most important roles is to hold early discussions with farmer representatives about possible cropping patterns so that these can be discussed among the general membership before the formal seasonal meeting. It is now normal for the final seasonal decisions to have been made prior to the seasonal meeting through this process of consultation and discussion.

Recent changes in government policy make the role of the Project Management Committee of increased importance. It is anticipated that within a few years the DCOs will take full O&M responsibilities not only for field canals but also the distributary canals themselves. This will clearly increase their responsibilities, and will need support and assistance from Project Managers and their staff to ensure they have the technical and organizational capacity to undertake these new roles. In some smaller systems the farmer organization will take over the complete management of the system.

Appendix C
IRRIGATION WATER MANAGEMENT - DATABASE AND SCHEDULING SOFTWARE

Computer hardware has been set up in the Inginimitiya Project office and the irrigation water management database and scheduling software, developed by HR Wallingford, has been installed on it. Three weeks intensive training has been given to the Irrigation Engineers (IEs) who will use the software as a management tool and to the draughtsmen who will be responsible for routine data entry. An outline of the training programme is given at the end of this annex.

The database describing the scheme's characteristics - water source, canal network and structures, command areas, evapotranspiration demand, expected rainfall, crop characteristics - has been built up over the training period drawing data from rapid site appraisals, existing project records and agricultural research data.

Figure C.1 is a print out of the schematic map of the scheme which forms an important part of the software with many of the data entry, monitoring and water scheduling operations being carried out by the selection of objects from the map.

The offtakes to individual distributary canals on the Right and Left Banks are shown together with their command areas. Field channels with offtakes directly off the main canals are also shown although in some cases several field channels have been aggregated into one block. The map also shows key locations where flow can be monitored and controlled together with the position of intermediate village tanks and rainfall stations.

The IEs and draughtsmen have received training allowing them to use the water management software for:

Systematic data storage and reporting
- relating to, reservoir levels, rainfall, ETo, discharge measurements and cropping activities.

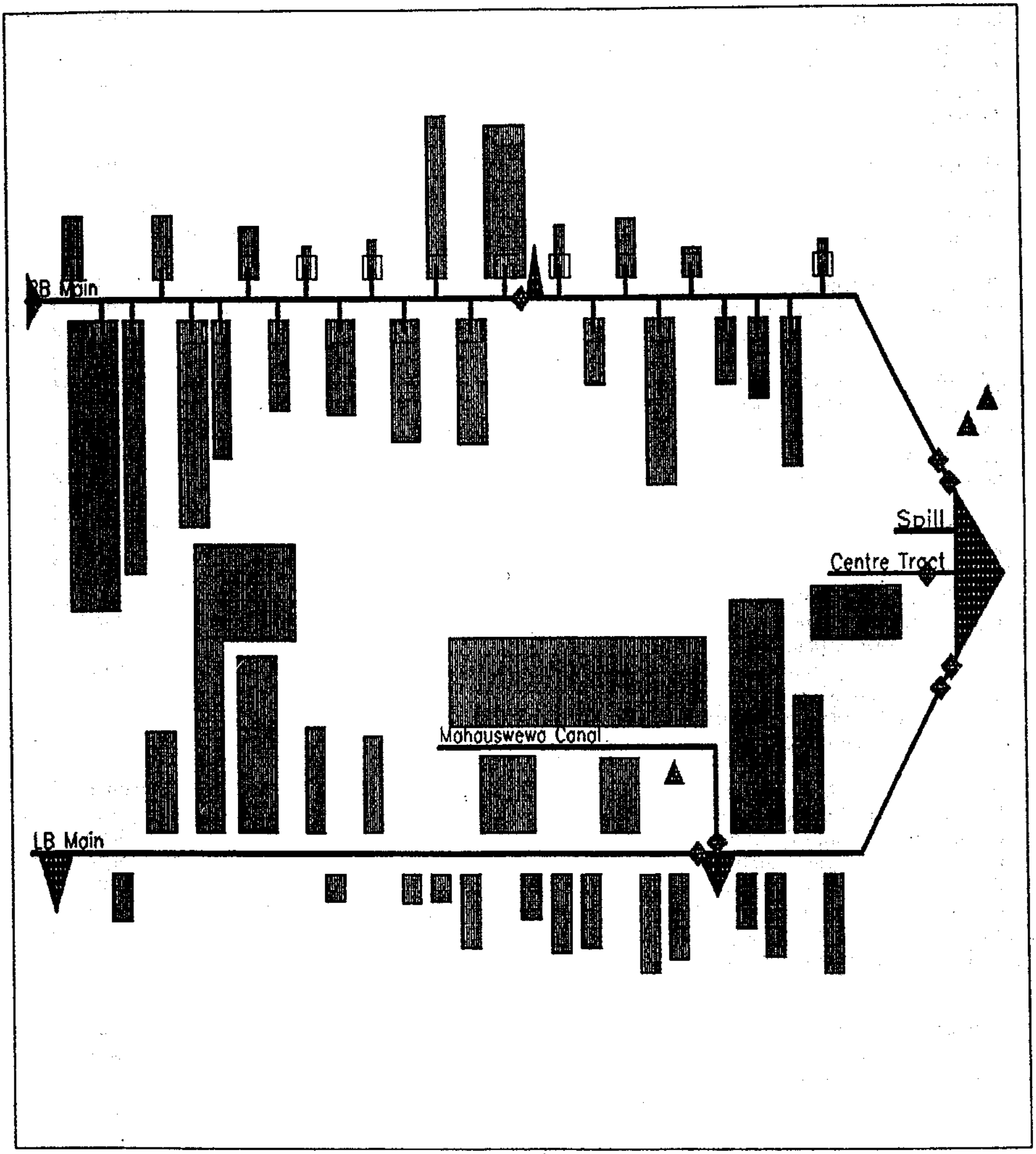
Pre-season planning
- allowing comparisons between water demand and water availability to be carried out for a ranging of cropping options.

Within-season water management
- allowing scheduling of water allocations and monitoring of actual releases.

In order to establish a programme of routine and accurate flow monitoring a number of key structures have been located on both main canals which will be suitable for calibration. Flow monitoring and control will take place at the Parshall flumes at the head of each canal, at outlets from the intermediate tanks and at a selected number of offtakes to the larger distributary canals.Both Left and Right bank canals are contour canals with a number of cross regulators along their length. The cross regulators comprise one or two adjustable gates and small fixed weir sections. This combination of weir and gates makes them difficult structures to calibrate and include in the network of monitoring locations. Due to the extensive backwater effects between regulators it would also prove difficult to use rated canal sections for reliable flow monitoring.

Gauge boards are being installed at the sites selected for flow monitoring. These sites will be calibrated after the commencement of irrigation releases, and a program of quantification of canal and field losses will then be undertaken.

Figure C1 INCA Schematic Map of Inginimitiya as installed in March 1992



APPENDIX D
TRAINING OUTLINE FOR INCA SOFTWARE

1. NETWORK DEFINITION

Review methods for network definition.
Procedure for backing up the database.

Practical exercises:
- Define and locate a rain gauge at the tail of the RB canal.
- Define and locate the Maha Usewewa canal and relevant structures.
- Define three management units on the LB canal.
- Define the Parshall flume on the LB canal.
- Back up the database on disk

2. ROUTINE DATA ENTRY AND PLOTTING

Creating Measurement Groups and Plot Groups.
Setting measurement times.
Using the Data and Plot menus for:

1. Entering structure level gauge readings, calculating flows and plotting the data.
2. Entering and plotting average ETo data.
3. Entering and plotting actual and expected rainfall data.

Practical exercises:

- Enter and plot rainfall data. Enter and plot daily rainfall for Inginimitiya for 1992.
- Enter and plot reservoir level gauge data. Enter and plot daily Tank levels of Inginimatiya tank for 1992.
- Enter example level data for a Parshall flume, calculate flows and plot results.

Note: The IEs should be equipped to train a draughtsman to do routine entry and plotting of rainfall, tank levels structure levels and flows at the end of this period.

3. MANAGEMENT UNITS, CROP DEFINITIONS, AND CROP HISTORY

The role of a management unit in the scheduling model.
The crop definition form.
- Water requirements for land preparation and seepage and percolation losses
- Irrigation methods and efficiencies
- Defining and plotting a crop Kc curve

Crop history information entered for each field.
- Area history of each crop
- Summaries of cropped area information.
- Nominal and actual planting profiles. How to enter and plot them and what they mean.
- The land preparation period.

Practical exercises:

- Check existing crop definitions
- Create crop definitions for any non paddy crops considered for irrigation on the scheme.
- Assign crops to the fields in tract 1 of the RB canal and define appropriate nominal planting profiles
- enter estimated cropping histories for fields in Tract 1 RB assuming Yala irrigation in 1992 starts middle of April.

4. IRRIGATION SCHEDULING

Using the scheduling model:

- Defining a season
- Rotations and period lengths
- The effective rainfall model and field wetness corrections
- Understanding the model log
- Scheduling locations and rain gauge weights

5. PRE-SEASON PLANNING

Review material covered.
Set up model to carry out a pre-season schedule for a Yala 1992 season.
Review past years' data to determine monthly tank inflows

Practical exercise:

- Run pre-season model

Plot and print results from pre-season model run.
Analyze run log
Continue calculation of historic tank inflows.

Practical exercises:

- Calculate monthly tank water balance and evaluate feasibility of the pre-season plan.
- Adjust plan according to results and re-run pre-season model

6. ADDITIONAL TASKS ACCOMPLISHED TO SUPPORT INCA SOFTWARE APPLICATION

1. Identify key scheduling/monitoring locations on scheme and make preparations for level gauge installation.
2. Establish an evaporation pan with daily recording.
3. Obtain data on past cropping areas - LB, RB and Mahauswewa.
4. Draw up recording sheets for recording gauge levels.

Appendix E

R & D Project Bar Charts

1992-93

Activity	1	2	3	4	5	6	7	8	9	10	11	12
						Month						
Monitoring	X	X	X	X	X	X	X	X	X	X	X	X
Mid-Term Review							X					
Preparation of Ph.II Workplan							X	X				
Interim Report								X				
Farmer Surveys			X			X			X			X
OVERSEAS TRAVEL												
Bird Sri Lanka											14	
Cornish Sri Lanka								10	25			

1993-94

Activity	1	2	3	4	5	6	7	8	9	10	11	12
						Month						
Monitoring	X	X	X	X	X	X	X	X				
Farmer Surveys			X			X						
Draft Final Report							X					
Final Workshop								X				
Final Report									X			
OVERSEAS TRAVEL												
Bird Sri Lanka								14				
Cornish Sri Lanka			21					14				

ANNEX B

IRRIGATION MANAGEMENT IMPROVEMENT PROJECT
(IIMI/HRL R4702)

INTERIM REPORT

November 1992

The International Irrigation Management Institute
Colombo
Sri Lanka

HR Wallingford
United Kingdom

and

Irrigation Department
Government of Sri Lanka

Supported by
The Overseas Development Administration
United Kingdom

FOREWORD

This Interim Report covers activities undertaken during the period January - November 1992 under the Irrigation Management Improvement Project IIMI/HRL R4702. This is a joint project between the International Irrigation Management Institute (IIMI), HR Wallingford, the Irrigation Department of Sri Lanka and the Irrigation Management Division of the Ministry of Lands, Irrigation and Mahaweli Development of Sri Lanka. It is being conducted in the Inginimitiya Irrigation System in the North West Province of Sri Lanka.

Project progress has been largely according to the Work Plan proposed in the Inception Report. The computer software developed by HR has been successfully installed at site and staff trained in its utilization. Initial involvement of farmer organizations in coordinated management of the system has commenced, and the process of attempting to better match crop water demand to scarce water supplies has begun through establishment of the INCA software, discharge calibration and meetings with system managers and farmer leaders.

The overall rate of project progress has been hampered by the severe drought conditions of 1992 that were widespread throughout Sri Lanka. The drought affected Inginimitiya sufficiently seriously that the entire 1992 Dry Season cultivation was canceled. Farmers proved reluctant to either reduce the cultivated area to match the very limited water available, or to switch to crops other than rice.

The cancellation of the season has had two direct impacts on the project. Firstly, the calibration and field testing of the irrigation scheduling software has been delayed until the 1992/93 Wet Season. With the onset of cultivation in October 1992 these activities are now in full swing. Secondly, the planned workshop to discuss the results of the program has had to be postponed until February to enable sufficient experience both in the use of the scheduling software and in the participation of farmer leaders in joint monitoring activities to be obtained. This workshop will, however, permit full application of the project activities for the 1993 Dry Season.

Despite this set back in project schedules, it is not expected that this will result in any delay in the final project timetable. The activities planned for the 1992/93 Wet Season have been compressed, and additional field staff provided to push the project ahead somewhat faster than initially planned. A further Interim Report, not originally anticipated, will be provided by late February to supplement information provided here.

IRRIGATION MANAGEMENT IMPROVEMENT PROJECT

INTERIM REPORT

1. Background to the Project

The Irrigation Management Improvement Project (IMIP) was first developed in July 1990 during a visit to the International Irrigation Management Institute (IIMI) in Sri Lanka by staff of HR Wallingford (HR). At that time, despite several discussions between IIMI and HR, there was no formal linkage between the two institutions. It was therefore decided to seek special funding from the Overseas Development Administration (ODA) that would support a joint program of work in a developing country that would utilize the joint expertise of the two institutions.

Following these discussions a draft proposal was submitted to ODA in July 1990 that outlined a program of joint activities between the two institutions. The overall purpose of the project was to focus on ways to help irrigation agencies become more responsive to changes both in water supplies for irrigation and to changes in demand within irrigation systems. At the time of this proposal no firm decision had been made on possible project sites as this still required additional negotiations with potential collaborating agencies. Possible locations considered were Indonesia, Thailand and Sri Lanka. Discussions with the Irrigation Department in Sri Lanka were held in July 1991, and the Director of Irrigation confirmed the willingness of the Irrigation Department to participate in the project.

Following perusal of the proposal by ODA and its technical advisors and some exchanges of correspondence to clarify certain aspects of the proposal, a formal application for funding by ODA was submitted by IIMI in October 1991 that identified Sri Lanka as the site of project activities and had a total cost of £175,000. This was subsequently approved by ODA, and project activities started on 1 January 1992. IIMI will provide overall lead for the project, using HR as a contractor for its components. For its part, ODA has provided funds from two sources: Natural Resources and Environment Division is providing 60% of the total costs (£105,000) with the Engineering Division providing the balance of £70,000.

Under the terms of the agreement, the project has a life length of 24 months. In accordance with the approved project proposal two narrative reports are due in 1992: an Inception Report which was submitted in March 1992 and this Interim Report.

2. Progress to Date

The overall Work Plan for the Project (Table 1) is divided into two phases, each of approximately 12 months duration. This Interim Report covers the period from January to the end of November 1992 and describes progress in each of the proposed activities.

As is noted in the following text, progress has been somewhat slower than planned because of the cancellation of the 1992 Dry Season. This situation was widespread throughout Sri Lanka following the partial failure of the 1991/92 monsoon rains. The delay in coming to the final decision to cancel the season at Inginimitiya meant that it was not possible to consider transferring activities to other locations. The implications of this delay for project activities are discussed in Section 3.

Following sufficient rainfall that led to slight improvement of reservoir water levels, irrigation deliveries commenced on 25 October along the Right Bank Main Canal, and this has enabled the project to continue with renewed vigor.

By the last week in November farmers had started land preparation throughout the Right Bank (1000 ha), and in the areas commanded by the two tanks included in the Left Bank Main Canal: Mahauswewa (400 ha) and Uriyawewa (30 ha). A final decision on cultivation of the remainder of the Left Bank has been delayed until December 01. There is an estimated shortfall of about 12 million cubic meters. If this water is received then full cultivation will be possible, but it is looking less likely that this will occur.

Table 1

Work Plan for the Irrigation Management Improvement Project

Phase 1: January 1992 to late 1992

1. Site identification, plus rapid appraisal of physical conditions at site (IIMI/HR);
2. Modification of existing computer programs (INCA and COMA) to meet site conditions (HR/IIMI);
3. Training of agency staff in use of computer software (HR);
4. Determination of existing management structure, processes and communication paths both within the agency and between agency staff and water users (IIMI);
5. Training of agency staff in discharge calibration techniques and determination of conveyance losses (HR);
6. Development of plans for involvement of water users in monitoring programs and upgrading of data base in respect of agricultural conditions (IIMI);
7. Implementation of monitoring program for water conditions and agricultural practices during initial season of operations (IIMI/HR);
8. Survey of farmer attitudes to existing operational conditions and their expectations for improvements (IIMI);
9. Workshop to review data collection program, effectiveness of the computer-based support packages, and plan for intervention activities in Phase 2 (IIMI/HR);
10. Interim Report (IIMI/HR).

Phase 2: Late 1992 to end 1993

11. Adaptation of existing water allocation practices based on the upgraded information base and computer simulations established in the first phase (IIMI/HR);
12. Testing of alternative operational procedures by Irrigation Department staff in response to different water supply and demand conditions such as rainfall or water scarcity (HR);
13. Utilization of upgraded information by farmer representatives and agency staff in regular meetings of the Project Management Committee under the auspices of the Project Manager (IIMI);
14. Field surveys to asses the effectiveness of the new measures as viewed from perspectives of users, agency staff and planners (IIMI);
15. Final workshop to assess the appropriateness and effectiveness of the processes and procedures adopted by different agencies and by water users, development of modifications to permit sustained use of the technology following project completion, and development of plans for replication in other systems (IIMI/HR);
16. Final Project Report (IIMI/HR).

2.1 Site Selection

In discussions with Irrigation Department staff in Colombo several systems were considered as candidates for the project. Selection criteria included a reasonable condition of physical infrastructure to avoid any repair or rehabilitation, recurrent but not chronic water shortage, representative size of the command area (between 1,000 and 3,000 ha), and potential for diversified cropping. A reconnaissance visit was made in early January by staff of IIMI and the Irrigation Department following which it was agreed that Inginimitiya be selected as the project site.

Inginimitiya is a 2,500 ha system located in the North West Province approximately 60 km north east of Chilaw. It is relatively new, being completed in 1985 under a program of assistance of the Government of Japan.

A rapid appraisal of the site was conducted in February 1992 by HR and IIMI staff and a basic assessment made of existing conditions. This included a complete walk through the Right Bank Canal to assess actual conditions of all structures, and determine suitable locations for discharge and water level monitoring.

A program of secondary data collection of water and agricultural conditions was initiated at this time. These data include reservoir levels and storage, issues into the two halves of the system, rainfall data from both the Irrigation Department and the Meteorological Office in Colombo, seasonal cropping conditions since the start of operation of the system in April 1985, and areas under each Distributary and Field Canal.

2.2 Installation of Computer Programs

The INCA software developed by HR during studies of systems in Thailand and Sri Lanka was installed successfully on computer equipment purchased for the project. The first set of equipment was taken to Inginimitiya project site and used in the first phase of training. Adaptation of the model and installation of the basic system configuration proved straightforward so that there were no delays in the start of training.

The purpose of the INCA software is to provide system mangers, from both the Irrigation Department and the Irrigation Management Department, with a flexible and comprehensive database and water management package which serves as a decision support tool both in pre-season planning and in operation during a season.

The introduction of the software aims to fulfil a number of objectives:

- It provides a means of accurately and rapidly collating, processing and analyzing a wide range of data which must be handled in order to schedule water releases in accordance with crop demands and to monitorsystem performance.

- To effectively match supply with demand requires data relating to climate, hydrology, crops and cropping calendars, storage volumes, canal network characteristics and field characteristics. The monitoring of actual water releases is also an essential element in quantifying system performance.

- Use of the INCA software serves as a catalyst in the implementation of a more comprehensive routine data collection program, highlighting the data which is required to accurately quantify water demand during a season.

- Installation of the software and training of Irrigation Department in its use as an operational and monitoring tool, are complementary to the task of calibrating selected control structures on the canal network. Again the object of the software is to provide a tool allowing managers to calculate required discharges at these locations and to effectively monitor the actual releases at these sites, thereby quantifying one aspect of system performance.

A parallel computer model (COMA) developed by IIMI staff to determine the management requirements for different operational strategies was completed during this period, and is ready for use later in the project. The COMA program is designed to analyze rotational irrigations plans and indicate to the system manager the management requirements of that plan. It determines the daily gate openings and closings required, quantifies the total number of gate operations on each day of the week, indicates the structures at which water conditions are likely to require particularly careful management (either exceeding design discharge or when discharge is very low) and predicts the likely performance in terms of equity if the plan is properly followed.

2.3 Computer Training

An intensive three-week course in utilization of the computer software was undertaken in March 1992 by HR staff. Three levels of staff were included in this training activity: Irrigation Engineers (IE) responsible for all aspects of system management, Technical/Divisional Assistants (TA) who have day to day responsibility for system operations, and Draftsmen for purposes of routine data entry into the computer program.

The training program was kept on schedule, and it proved relatively easy to reach a stage of proficiency in use of the software.

The training program covered the following applications of the software:

Systematic data storage and reporting
- relating to reservoir levels, rainfall, pan evaporation, water levels at structures and cropping calendars.

Pre-season planning
- methods for comparing between water demand and probable water supply for a number of different cropping options.

Within-season water management
- calculating scheduled water releases and monitoring actual releases during a season.

With the installation of the new version of INCA (version 2.00) in November, additional training of Irrigation Department staff is being carried out covering the extra capabilities of the new version and further improving their confidence in using the pre-season planning and in-season scheduling applications.

2.4 Management Study

The study to assess existing management structures, processes and conditions was initiated during this period. Data have been collected on the size and location of each of the Distributary Canal Organizations (DCO) and their constituent Field Canal groups (Appendix C). Initial plans for a set of joint activities with the Project Manager, the Institutional Development Officer and the Institutional Organizers (IOs) were drawn up during March but the implementation of any action plan was delayed until such time as the next water issues were confirmed. The duties and areas of responsibility of all field staff in the Irrigation Department have been determined, and their individual tasks clearly identified to determine who is responsible for which operational decisions.

By early October 1992 it appeared increasingly likely that there would be at least a partial wet season cultivation. Two national research staff (Mr. Lalith Dassenaike, a social scientist with considerable experience in management and Mr. Wasantha Kumara, an irrigation engineer previously employed with the Mahaweli Authority of Sri Lanka) were assigned to the project to work closely with Irrigation Department and Project Management Staff and with leaders of the Distributary Canal Farmer Organizations. These organizations, as described in Appendix B of the Inception Report, have responsibility for operation and maintenance of Field Canals and distributary canals, leaving main canal O&M to the Irrigation Department.

The management study is an on-going activity that will extend throughout the life length of the project. It took some time to get good cooperation from farmers because of the extended drought: the Right Bank Main Canal had not received irrigation water for two years, and it is therefore not surprising to find that neither farmers nor field staff of the Irrigation Department could not contribute detailed knowledge of current procedures. With the onset of irrigation it is proving easier to continue this study.

Given that there has only been a few weeks of irrigation it would be premature to make any assessment of the management conditions observed to date. This is more appropriate when there has been a longer period of observation. It is true that some difficulties in communication have been observed: some farmers feel that decisions made prior to the season were not implemented as anticipated, and during the first heavy rains there were frustrations on behalf of some farmers that water issues had not been stopped quickly enough to conserve water in the reservoir.

At present IIMI field staff are engaged in collecting a set of observations about current management conditions. The first formal activity observed was the seasonal cultivation meeting that decided on the main features of the irrigation season. The details of this meeting are provided in Appendix A. Subsequent field visits have all been documented, and the initial trip reports have been provided in Appendix B. Analysis of these reports will be undertaken prior to the review in February 1993.

2.5 Discharge Calibration and Conveyance Loss Estimation

This activity, originally scheduled for mid-1992 has been put back to November/December. With water issues now occurring discharge calibrations will commence on November 26th with the arrival of Mr. Ian Fish of HR Wallingford at Inginimitiya. In anticipation of this activity, the eight locations selected for discharge calibration have had gauge boards installed (in a few locations they had to be replaced due to damage in the off season). These are in addition to the gauges installed earlier at the Parshall Flumes at the head of both the Left and Right Bank Main Canals.

The total set of locations identified for calibration are:

LOCATION	COMMAND AREA (ha.)
Parshall Flume RB	921
T1 D2	47
T1 D5	78
T2 D1	59
T2 D2	58
T2 D3	45
T2 D5	44
T2 D6	99
T3 D1	80

This activity includes training for the appropriate staff of the Irrigation Department and it is expected that there will be more than adequate capacity within the Irrigation Department to continue to calibrate measurement points after the training program is complete.

2.6 Involvement of Water Users in Monitoring

With the start of irrigation deliveries in October the activity to involve the water users in the monitoring of system performance is now underway. The first task has been to collect information on actual dates of commencement of land preparation, estimated date of planting, and actual or expected variety of rice to be planted. This information is currently being collected for each Field Canal on the Right Bank (there are some 80 Field Canals each of 10-15 ha in this half of the system) and is being entered into the computer so that the first estimates of total seasonal demand can be made before land preparation activities are completed.

This is particularly important this year because no decision has yet been taken concerning the irrigation of the Left Bank (except for the 400 ha commanded by Mahauswewa Tank and the 30 ha. at Uriyawewa that can be irrigated using local storage without releases from Inginimitiya Reservoir). With water supplies still in short supply it is important to be able to accurately forecast weekly and season water requirements. At present the last date of water issues for the 1992/93 Wet Season is scheduled for February 15th 1993 but it is inevitable that there will have to be issues after that date due to slow commencement of land preparation.

With accurate information on dates when planting begins in different parts of the command area, together with data on crop type and duration, the INCA software can be used to predict the water volumes which must be released during each irrigation of the coming season, providing a more accurate assessment of the final release date and likely end of season storage.

A second task, that of getting the water users involved in two aspects of water delivery monitoring is now being initiated. The farmer leaders are being trained in taking readings from gauge boards to enable them to compare notes with field staff of the Irrigation Department.

Farmers are to be trained in monitoring water conditions at the head of each Field Canal within the Distributary Canal areas. In accordance with current policy of the government of Sri Lanka farmer organizations are expected to take full responsibility for operation and maintenance of Distributary Canals. In so doing they need to work out acceptable ways of sharing water among constituent Field Canal groups within the overall water allocation made to the Distributary Canal. To date this has frequently been done on an ad-hoc basis but requires a more systematic approach. Involvement in farmers in monitoring water levels, gate openings and time of irrigation for each canal will help them to develop more permanent and durable water sharing agreements.

2.7 Implementation of Irrigation Department Monitoring Programs

The routine monitoring of reservoir water levels, rainfall and evapotranspiration have continued since the inception of the project. The data have been entered into the INCA computer program on a systematic basis, and this has presented few problems for the Irrigation Department staff other than those caused by staffing matters: staffing issues are discussed in section 4 on possible constraints.

2.8 Farmer Surveys

The formal farmer surveys to be undertaken by the University of Peradeniya as a subcontract to the project were postponed from the dry season because of the lack of water. Without irrigation water for two years many farmers had temporarily left irrigated lands to focus on rainfed agriculture in adjacent areas, and it was decided that a survey at this time would be relatively less productive. They are now scheduled to commence in December once the highly labor intensive period of land preparation is completed.

IIMI research staff are undertaking farmer interviews on irrigation conditions as part of their routine work, and trip reports are attached in Appendix B.

2.9 Review Workshop

The cancellation of the 1992 Dry Season has meant that it has not been possible to have a full season of testing of the INCA model at Inginimitiya and use this in the overall process of upgrading existing management practices.

In the Inception Report it was indicated that a review workshop would be held in October 1992. The timing was intended to allow experience of the 1992 Dry Season to be incorporated into the plans for the 1992/93 Wet Season. This Review workshop has now been postponed until February 1993 which will allow the experience of the first three months of the current season to be incorporated into the planning activities for the 1993 Dry Season.

2.10 Interim Report

Although this document represents the official Interim Report as specified in the Project proposal, it cannot include all of the information expected. It should include the detailed results of the first season of testing of new procedures and have details of proposed activities for implementing alternative procedures.

To overcome the problems caused by the delay in agricultural activities, it is proposed to write a supplement to this Interim Report in late February 1993 based on the results of the workshop planned for mid-February.

3. Changes in Project Timetable

The postponement of the 1992 Dry Season has inevitably led to changes in the project timetable, and these are described in detail below.

Initially it was expected that the period from April to September would be used for a full trial run of many of the management innovations. Based on the data collected during the season and on the strengthened relationships between the Irrigation Department, the Project Management Staff and farmer leaders, it was intended to hold a review workshop in October or November that would finalize plans for the coming year. None of this has been possible.

The revised timetable attempts to compress some of these tasks by focussing on the experience of the first three months of irrigation of the 1992/93 Wet Season and presenting these results to a workshop scheduled for the second week of February 1993. The experiences would be used for planning the 1993 Dry Season activities, a process that normally commences at about that time. This would permit the full testing of the management procedures during the 1993 Dry Season, and finalization of revised procedures prior to the 1993/94 Wet Season that commences before the scheduled end of the project.

These changes do not materially alter the purpose or scope of the project. It will require a rapid and intense assessment of conditions before mid-February, but with the use of two rather than one IIMI researcher and significant senior staff inputs the February activities are expected to be both successful and in sufficient time to make up most of the time lost to date.

Bar Charts for 1992-93 and 1993-94 included in Appendix 5 of the original proposal have had to be modified to reflect these changes. These are presented in Appendix D.

4. Constraints to Project Progress

Two possible constraints to project success were discussed in the Inception Report. The situation with regard to both of them is now clearer and an update is provided in this section.

4.1 Drought

It was noted in the Inception Report that drought conditions might affect the project, and this unfortunately proved a correct assessment. At the time of writing the Inception Report there was almost sufficient water in storage to undertake full cropping of rice of the Right Bank as planned. The strategy of the Irrigation Department was to wait for rains that have a reasonable probability of occurrence in April, and make a final decision at the end of that month. The rains in April rarely augment the reservoir storage, but may be sufficient for initial land preparation.

When these rains did not materialize two options were proposed: partial cultivation of rice whereby farmers on adjacent Field Canals would share land half of their land, or full cultivation of dry crops such as gram, cow pea or chili. Farmers rejected both of these options: previous experiences with land sharing ("bethma") had been highly unsatisfactory, while there was little enthusiasm to grow non-rice crops that were perceived to have low market value. It was too late to grow chili which has about a 150 day crop life length.

By late May, when the final decision not to cultivate was made it was too late to seek an alternative location for this project, and in any case almost all other systems in the Dry Zone of Sri Lanka had similar or even worse water conditions. A change at that late stage would have required complete retraining of other Irrigation Department staff, and it was considered improbable that the lost time could have been made up for by seeking an alternative location.

4.2 Staffing

Some concerns were expressed in the Inception Report in this regard. A few Irrigation Department staff who were trained in use of the INCA software have indeed been transferred, but the primary participants have remained in their posts. In discussions with the Director of Irrigation in Colombo the stability of staff for the duration of the project has been discussed, and it does not appear likely that further staff transfers out of the project will occur.

The Director of Irrigation also recognized that there has been a slight conflict of interest between time required for this project and the pressure to complete construction work on a nearby diversion structure downstream of Inginimitiya on the Mi Oya river. This competition for scarce staff time has been exacerbated by the impending inauguration of the diversion structure by His Excellency the President of Sri Lanka in mid-December. In recognition of the need to focus attention on O&M activities in Inginimitiya the director of Irrigation has proposed to provide a full time Irrigation Engineer for Inginimitiya who would be the primary link for implementation of this project.

A different staff concern exists within the Project Manager office. It was noted in the Inception Report that there were six temporary Institutional Organizers assigned to Inginimitiya. Their contracts are due to expire on 31 December but in discussions with the Director of the Irrigation Management Division in Colombo ways have been explored to extend the contracts of at least some of these Institutional Organizers so that there is sufficient manpower to complete the first phase of farmer training in joint operation and maintenance activities. The Project Manager at Inginimitiya will retire on 31 December. His replacement has yet to be formally identified.

It should also be noted that the original project leader from HR Wallingford, Mr. Jerry Bird, left his post for a new assignment during the year. Current responsibilities for project implementation from HR have been assumed by Mr. Gez Cornish.

5. Acknowledgements

The Project has continued to receive the full support of national agencies.

In the Irrigation Department in Colombo there has been full cooperation from Mr. Yoganathan, Director of Irrigation, and Mr. D.W.R.M. Weerakoon, Senior Deputy Director for Operation and Maintenance. They have been instrumental in providing the transport for HR staff, and facilitating arrangements for data collection from within the Irrigation Department and from the Meteorological Department.

At Inginimitiya Mr. Wimalachandran, Chief Resident Engineer, has been instrumental in providing all required facilities at Inginimitiya, and releasing staff for training and other special activities. The efforts of Mr. Shanmugasivananthan in coordinating day to day activities, and taking the lead in the use of the INCA software is greatly appreciated, as are the efforts of Mr. Alwis, Mr. Karunathilake and Mr. Herath.

The Irrigation Management Division in Colombo through Mr. D. M. Ariyaratne, Director of IMD, and at Inginimitiya through Mr. D.J.D.W. Ratnayake, Project Manager at Inginimitiya, and Mr. Bandara, Institutional Development Officer has also afforded full cooperation in gaining basic knowledge concerning the farmer organizations in the project area.

APPENDIX A

Minutes of the 1992/93 Seasonal Planning Meeting for Inginimitiya

The seasonal planning meeting ("kanna" meeting) is a legal requirement for all systems which are operated by government agencies. The intention is to bring together government officials from all concerned agencies, including Irrigation Department, Department of Agriculture, Cooperatives, Civil Administration, and credit representatives, and farmers. All farmers are entitled to attend.

In principle the meeting is to discuss alternative plans for cultivation during the next season, to come to agreement on what activities will occur and their timing, and to issue instructions to all concerned agencies. In practice the size of the meeting tends to reduce its value as a democratic forum, and decisions tend to be somewhat stereotyped.

This appendix is a translation of the official minutes of the meeting held on October 1 for the Right Bank areas of Inginimitiya.

MINUTES OF THE 1992/93 MAHA KANNA MEETING - INGINIMITIYA PROJECT

DATE OF THE MEETING - 01 OCTOBER 1992

The 1992/93 Maha Kanna meeting for Inginimitiya project was held on 1st October 1992 at 3.00 pm at Welewewa Government school. It was presided by Mr. Lakshman Perera, Government Agent, Puttalam.

Participants

1. D.J.D.W Ratnayake	- Project Manager	Inginimitiya
2. T.G. Alwis	- Irrigation Engineer	Inginimitiya
3. D. M. Heen Banda	- Addtl. Divisional Secretary	Navagattegama
4. W.M.D.J. Fernando	- Addtl. Divisional Secretary	Anamaduwa
5. K.A.D. Peter	- Agricultural Manager	Anamaduwa
6. D.M. Ariyadasa Banda	- Divisional Officer	Navagattegama
7. J.A Gunawardhana	- Asst. Agri. Officer	Navagattegama
8.	- Divisional Secretary	Anamaduwa
9. Wimalaratne	- Asst. Agri. Manager	Puttalam
10.K.M.S. Dassanaike	- Development Officer	Peoples' Bank Anamaduwa
11.A.H.M. TikiriBanda	- Peoples Bank	Anamaduwa
12.R.M.Bandula Rajapaksha	- Development Officer	Bank of Ceylon Anam. Kachcheri
13.J.A. Stanley	- Subject Clerk	Puttalam
14.P.B. Kiribanda	-	Inginimitiya
15.M Maitripala	- Field Assistant	Inginimitiya
16.B.M.Sirisena	- Field Assistant	Inginimitiya
17.H.B.Jayapadma	- Field Assistant	Inginimitiya
18.H.M.R. Herath	- Work Supervisor	Inginimitiya
19.R.W.A. Jayathilake	- Technical Assistant	Inginimitiya
20.K.G. Fernando	- Technical Assistant	Inginimitiya
21.S.M.Wijewardhana	- Technical Assistant	Inginimitiya
22.E.M. Dingiribanda	-	Inginimitiya
23.S.A.M. Chandraratne	-	Inginimitiya
24.W.G. Saman Priyankara	- Institutional Organizer (IO)	Inginimitiya
25.A.H.M. Ranbanda	- IO	Inginimitiya
26.W. Abeysiri	- IO	Inginimitiya
27.E.H.M. Dharmadasa	- IO	Inginimitiya
28.Tissa Jayasundara	- IO	Inginimitiya
29.M.A.B.Senerath Bandara	- Institutional Development Off.	Inginimitiya

About 66 farmers including representatives of farmer organizations participated in the meeting.

After the religious activities, the meeting started according to the agenda. The project manger welcomed the government Agent (GA), all officers and farmers. The GA, who presided the meeting welcomed all the officers and farmers who were present at the meeting and said that the purpose of the meeting was to take a decision for the 1992/93 Maha Season.

The Irrigation Engineer expressing his ideas said that at that moment only 8348 acre feet of water was available in the reservoir and the minimum requirement for successful cultivation in Right Bank was 18,000 ac-ft. The GA said that during last Maha, Left Bank area was successfully cultivated and hence this time priority should be given to issuing water to the Right Bank.

Mr. Hubert Seneviratne of D6 DCO said that the farmers must take the lead now and by starting cultivation with rainfall, successful results can be achieved. He also reminded that the old day farmers had successful results by applying this method. Representative of the 4th Hamlet expressing his ideas requested to issue water to tail end first, because it would be difficult to drive water towards tail end. Assistant Agricultural Director, Puttalam said that according to the weather pattern, rains should fall by 15th October and therefore requested farmers to clear the canals before that. Further, he said that it would be better to cultivate 3 months paddy for this season. *(Note: this is the shortest duration rice variety available; normal Wet Season rice varieties are 4 month duration)*

The Agricultural Manager, Anamaduwa said that the duration between 15th October to 15th November would be suitable for cultivation and to implement the cultivation program, the assistance of the farmers would be required. Farmer representative of 8th Hamlet requested to take a decision about Left Bank if an excess quantity of water is received. At this point, it was decided to call for a special meeting of Project Management Committee, if the quantity of water in the reservoir exceeds 18,000 ac-ft.

Farmer representative of Mahauswewa said that they were ready to commence cultivation using the available water in Mahauswewa Tank. It was the idea of the farmers that the stray cattle damage their cultivations. It was decided to leave space for the cattle to move and to do fencing around those specific places. It was also decided to inform Grama Sevaka Niladharies through Divisional secretary to take necessary actions in this regard.

Bank Officers said that a large number of farmers have not paid back the loans taken and therefore to obtain loans for this season, insurance covers have to be produced. However, it was decided to make every possible effort to issue loans to farmers. Regarding the problem of obtaining paddy seeds, the Assistant Divisional Secretary, Navagattegama said that seeds can be provided by keeping Rs. 458/= from Janasaviya Fund as a security. However, he said that this concession can be made available for only those who have paid back their bank loans. It was said that for this season, BG 34/8 and BG 300 types of seeds could be issued. Also it was revealed that seeds could be obtained from Thabbowa scheme.

Then the following decisions were taken about the dates of cultivation.

1. Land preparation	Before 25th October with rain water
2. Cultivation to be completed before	15th November 1992
3. Date of first water issues	25th October (if no rainfall received by then)
4. Last date of water issue	15th February 1993
5. Type of paddy	3 months varieties
6. Last date of harvesting	within the month of March 1993

It was decided to stick to these dates in Mahauswewa and Uriyawa areas.

Mr. K.H.M. Kalu Banda, farmer representative of Mahauswewa colony proposed that the above decisions taken at this meeting are appropriate and Mr. Sirithunga Alankara of 3rd Hamlet seconded it.

Winding up the activities of the meeting GA requested the farmers to adhere to the decisions taken at this meeting and he wished a highly successful season for all.

D.J.D.W. Ratnayake,
Project Manager
Inginimitiya Project

W.D. Lakshman Perera
GA, Puttalam

APPENDIX B

Field visit Reports compiled by IIMI Research Staff

Mr. Lalith Dassenaike
Mr. Wasantha Kumara

These trip reports are verbatim accounts and observations made during various visits to the field site. The observations contained therein are used as a basis for discussion during routine project meetings held with senior IIMI staff. They are circulated as a matter of course to the Irrigation Department and the Irrigation Management Division staff for their information. They do not represent formal documents and are used merely as a form of communication between all the parties involved.

Trip Report #1

Report on Observations - Field Trip to Inginimitiya
October 21-23, 1992

Discussions were held with the following officers:

Irrigation Department Officers

1. Mr. Wimalachandran	-	Chief Resident Engineer
2. Mr. Shanmugasivananthan	-	Resident Engineer(Radavi Bendi Ela Project)
3. Mr. Alwis	-	Outgoing Resident Engineer (Neela Bemma Project) and Irrigation Engineer (Inginimitiya)
4. Mr. Karunathilake	-	Appointed Resident Engineer (Neela Bemma Project) and Irrigation Engineer (Inginimitiya)
5.Mr. Rohana Shantha	-	Technical Assistant

Irrigation Management Division Officers

1. Mr. Bandara	-	Institutional Development Officer
2. W.G. Saman Priyankara	-	Institutional Organizer
3. A.H.M. Ranbanda	-	Institutional Organizer
4. W. Abeysiri	-	Institutional Organizer
5. E.H.M. Dharmadasa	-	Institutional Organizer
6. Tissa Jayasundara	-	Institutional Organizer

The following initial observations were noted during the trip and relevant issues were discussed with the above mentioned officers.

1. A general consensus among the people living in Inginimitiya was that there has been a severe drought ever since the reservoir was built in 1985. These people are of the opinion that this shortage of rain has resulted because of the construction of the reservoir and dam, as this was not that severe a problem before 1985. However, they were unable to give a clear explanation as to why this could have happened.

2. An interesting issue that was discussed with the TA was the fact that the Inginimitiya reservoir is located in Galgamuwa area while the settlers are located in Anamaduwa area. This could result in administration problems because the civil authorities are based on administrative rather than hydrologic boundaries.

3. Transfer of officers: The transfer of trained officers and staff is a problem currently taking place, and one could expect it to be a perennial problem as mentioned in the inception report. Three Engineers have been trained on the use of INCA software by HRL namely Mr. Alwis, Mr. Shanmugasivanandan and Mr. Manoharan. Mr. Alwis has already been transferred to Colombo head office and Mr. Manoharan is presently attached to the DD's Office, Puttalam. The only officer who is remaining at the Inginimitiya project is Mr. Shanmugasivanandan and he is also expecting a transfer to Colombo head office from January 1993. Mr. Rathnayaka Project Manager, IMD is also scheduled to retire from the service at the end of this year.

4. Many staff members of ID are involved in construction work of the Radavi Bendi Ela Project and Neela Bemma Project. For example the RE for Radavi Bendi Ela project, who is also the person most familiar with the operation of the INCA software, is very much involved with the construction of the above project which is scheduled to be commissioned in December.

5. Land preparation by farmers: Only a few farmers (5-10%) have prepared the land for the initial issue of water which was scheduled for 25th of October. This could lead to a lot of wastage when water is issued. The main reason for this behavior could be attributed to the fact that the farmers are still doubtful of rain in the near future and expect the drought to continue. Therefore, they see no point in putting any effort to prepare land this early. Rainfall has been nominal since the seasonal meeting and inadequate for effective land preparation without additional irrigation supplies.

6. Current work concerning the application of software package: Rainfall and pan evaporation measures are recorded and entered into the INCA program data base. The present plastic canal measurement gauges have been damaged and water level measurements at these places won't be possible till the new gauges are installed. Work related to installation of these new gauges was scheduled

to commence on the 23rd. Hopefully, all gauges will be installed before the issuing of water on the 25th in order to start updating the database soon. There seems to be no problem with regard to the actual collection and entry of data into the database. Training of the scheduling component of the software was repeated in October because of the lack of water issues for the Yala 1992 season.

7. Activities of the Farmer Organizations (FO's): There are 23 FO's for approximately 2,000 farmer families in the scheme. The average attendance at Kanna meetings is about 400 with a higher attendance at the monthly DCO meetings. Certain farmers show positive attitudes towards FO activities while some do not actively participate. Much progress has been made over the last year in improving farmer interest and motivation, and strengthening their organizational capabilities with regard to the FO activities, and with more time, the IO's see more potential in the future for such activities.

8. Activities of the Project Management Committee (PMC): All staff members of the PMC (IDO and IO's) are very interested and motivated to carry out FO related activities and training. They are optimistic about further increasing farmer response and behavior towards the FO programs, in the future. However, one of their main concerns is the possible termination of their contracts at the end of this year. Since the IO's were recruited in September of 1991, very limited FO work has been conducted due to lack of water and cultivation. This has resulted in lack of organizational experience to the farmer. They fear that FO work will not be continued by the farmers after they leave, because the training would not have been sufficient. Hence, at this point in time, it would be difficult to assess the sustainability of the performance of the FO activities in the future. They feel an extension of their contract periods without a break, would definitely help in the successful continuation of FO activities by the farmers.

Conclusions:

At this point, the IDO and the IO's were of the opinion that farmer response and attitude would be positive towards successful implementation of the INCA software. They do not foresee any major problems with regard to training farmers for accurate data collection and related activities, through the FO's, necessary for application of the software. Given enough time for training etc. they feel a successful study program could be implemented during the coming season, and thus IIMI/HRL project objectives can be successfully achieved.

Recommendations:

1. To request to ID for a possible extension of IO's contract with IMD so that the FO work will be more effective in the future.

2. When HR representative comes back with the updated version of the INCA software, a fresh training session should be conducted.

3. To request to ID to appoint a separate engineer to the post of Irrigation Engineer, Inginimitiya. One possibility is to appoint Mr. Manoharan who is presently attached to the DD's Office, Puttalam.

4. To arrange meetings with farmers to brief them the importance of the IIMI/HRL Project.

Trip Report #2

Report on Observations - Field Trip to Inginimitiya
November 03 & 04, 1992

Discussions were held with following officers

Irrigation Department Officers

1. Mr. Wimalachandran	-	Chief Resident Engineer
2. Mr. Shanmugasivananthan	-	Resident Engineer, (Radavi Bendi Ela Project)
3. Mr. Karunathilake	-	Resident Engineer (Neela Bemma Project and Acting Irrigation Engineer, Inginimitiya)
4. Mr. Herath	-	Work Supervisor, Right Bank Canal

Irrigation Management Division Officers

1. Mr. Ratnayake	-	Project Manager

The observations noted during the trip and the outcome of the discussions held with the above officers are discussed below.

1. Present status of water issue

Water issues to Right Bank canal started on 25th October 1992 as scheduled. At the commencement of water issue the reservoir capacity was 9800 ac-ft which is about 50% of the minimum requirement of water for cultivating a full season in Right Bank areas only. However, at the Kanna meeting, the decision has been taken to issue water expecting rains. Accordingly, the ID officers have taken actions to issue water commencing from 25/10/1992 at a rate of 80 cusecs. A fairly good rainfall (61 mm) was received on 03/11/92 and this caused a four inch increase in the reservoir water lever from 188'7" to 188'11". The effective capacity in the reservoir on 4/11/1992 was 8,895 ac.ft. More rains can be expected in the days to come.

As of 3rd November 1992, 9 days after commencing water issues, the situation was as follows.

Tract 1 - Water has been issued to all DCs. There were no problems reported. Canal was flowing almost full.

Tract 2 - There were problems towards the tail end. Farmers complained that beyond D3 canal, water has not been received.

Tract 3 - No water has been received so far.

2. Discussion with Project Manager, IMD

The Project Manager, IMD, Mr. Rathnayaka expressed his dissatisfaction about the way the water issues are being handled by ID officers. He said that at the Kanna meeting it was agreed that the DCs towards tail end will be fed first and once the full demand in tail end DCs is fulfilled, water issues to be started towards head end. However, according to him, ID officers have issued water to head end canals first, violating this agreement which has caused lot of difficulties towards tail end of the canal. According to the minutes of the kanna meeting held on 1st October 1992, this issue has been discussed although there is no evidence of a clear decision being taken on the matter. When talking to some of the farmers from this area, this same view was strongly expressed.

He also stressed the point that there should be a full time IE from ID in charge of water management. The Acting IE is at the moment busy with construction schedules and the TA assigned to Right Bank canal was on leave since Sunday, 01 November. The only officer who regularly visits is the Work Supervisor.

Mr. Rathnayaka also informed that he has received instructions from head office, IMD to terminate the employment contracts with IOs with effect from end of December 1992.

3. Discussions with ID officers

According to the ID officers, they were compelled to issue water to upstream DCs first, because the canals downstream were not cleared by the time the water issues started.

ID staff were informed about the visit schedule of HR specialists and the possibility of meetings and training programs during this period.

4. Installation of Measuring Gauges

Upstream gauges have been installed at the offtakes of following Distributary Canals.

Tract 1 -	D2, D5
Konkadawela Tank Sluice -	U/S and D/S gauges have been fixed but both gauges were submerged because the water level was more than 3'
Tract 2 -	D1, D3, D5, D6
Tract 3 -	D1

Gauges at the downstream of the structures have not been fixed so far except at the T1/D2 where a plastic gauge has been fixed. It was decided to fix plastic gauges at the downstream points of DC offtakes. At Konkadawela tank, it was decided to fix a plastic gauge to measure the depth in excess of 3 feet.

Measurements are also continuing at the Parshall Flumes on the Right Bank Main Canal.

Measurements have been taken at all points since the water issues started. At D/S points, measurements have been taken using a tape.

5. Meeting schedule with ID and IMD officers

The following schedule was agreed for the planned meetings with ID and IMD staff.

(i) Meeting with IMD staff	-	Thursday 12th November 1992 at 10.00 am at PM's office.
Participants	-	PM, IDO and IOs
(ii) Meeting with ID Staff	-	Friday 13th November 1992 at 9.00 am at CRE's Office.
Participants	-	CRE, REs, TAs and WSs

6. Installation of Stabilizer/UPS

CRE was informed that it is necessary to check wiring in the computer room before installing the UPS at the same time as the air conditioner. A voltage regulator has also been installed.

Conclusion

The observations during this visit could be summarized as follows.

(i) Installation of gauges - about 50% completed. However, measurements of water level have been taken in a continuous basis. Updating of data base has not been done due to the problems of operating the computer.

(ii) It was observed that all the officers of ID were very busy with the construction work since the President is due to arrive on 18th December 1992 for opening of Radavi Bendi Ela Project. It will be difficult for them to actively participate in the water management program until after this date.

Next Visits Next Visit will be on 12th and 13th of November to participate in the meetings with ID and IMD staff.

Arrangements are being made to attend the next PMC meeting which will be held on 26th November 1992.

Trip Report #3

Dates - 12 & 13 November 1992

1. Meeting with Irrigation Management Division officers

The meeting with IMD officers was held at 10.00 am on 12th November 1992 at PM's office, Welewewa, Inginimitiya as scheduled. Five IO's and IDO participated in the meeting representing IMD. Project Manager was absent on official business in Colombo.

Briefing the objectives of the IIMI's Irrigation Management Improvement Project undertaken by IIMI in collaboration with Hydraulic Research Institute in UK, Dr. Murray-Rust said that there are two main objectives of the project: One is to test and use the computer package installed at ID office as a decision support system and the other is to improve communication between farmers and the officers involved in management process to ensure the equity of water distribution.

To support the effective use of the computer program it is desirable to have a program of field data collection such as water level data, evaporation and rainfall. ID does not have sufficient staff to carry out such a program. Therefore, it would be best if we could get the farmers' participation in data collection; specially in collecting flow data. However we have to give some valuable thing in turn - probably a well managed main canal.

We hope to obtain the assistance of the DCO leaders for this after a brief training session to equip them with the necessary basic knowledge. The IO's assistance in this regard will be very useful for us.

ID officer's responsibility is to issue the minimum requirement of water so that a maximum area can be cultivated using the limited water resources available. However the farmers always want to get as much water as possible to their fields. So in arriving at a compromise, there will be lot of complicated issues in the process. Therefore, a mechanism has to be derived which will ensure the equity of share of water in the best possible way.

As the season progresses, the actual data thus collected can be fed in to the computer which will help us to plan for the remainder of the Wet Season by calculating likely weekly water requirements up to the expected date of the last required water issue, and then to prepare a pre-season plan for the next Yala season.

One of our long term objectives would be to help the farmers to effectively participate in the management process. It is best to eliminate the guess work in decision making.

The computer package will provide the basis for decision making thereby reducing decisions based on individual experience.

After the introductory speech by Dr. Murray-Rust, there was a discussion session where IO's participated actively. The following were some of the ideas expressed.

- According to IO's, as of the date of the meeting, the farmers were happy about the situation of water issue. Almost all the farmers have received water and they have started work. About 10% of the farmers have completed planting. There were no complaints. (However, during our site visit, it was observed that the situation was not so. It will be discussed later in this report)

- IO's assured that it will be possible to obtain farmer participation in our measurement program provided that basic training is given to them.

- The last date of planting as decided at the Kanna meeting was 15th November 1992. But it is obvious that this date will have to be revised. According to IO's a decision on new date will be taken in concurrence with DCO leaders and it will be conveyed to farmers through DCO leaders.

- IDO wanted to know whether there would be any alternative arrangements to cater for the adverse changes in weather in implementation of the seasonal plan derived from the computer package. It was informed that there will be such alternative plans and provisions are available to revise the plans to accommodate any natural changes.

IO's were informed that the representatives of HR will be visiting the site towards the end of the month. Dr. Murray-Rust emphasized that we should have some up to date data which can be used by them for testing the model. On a request made by us, IO's agreed to distribute a prepared questionnaire and to obtain the farmer response as soon as possible. (A questionnaire was prepared and handed over to them on the following day.)

<u>Meeting with ID Officers</u>

The meeting with ID officers was held on 13th November 1992 at 9.00 am at ID office as scheduled. Mr. Wimalachandran, Mr. Karunathilake (RE Neela Bemma and acting IE), Mr. Wijewardhana (TA), Mr. Jayaratne(TA), Mr. Herath (WS) and Miss Kulasinghe (Engineer) represented ID.

Dr. Murray-Rust, highlighting the important points of the project, said that the computer model will come out with alternative plans that could be adopted in effective water management making it easy for them to take a decision. The importance of the assistance from the part of ID was emphasized.

During this Maha season, the main concentration will be on testing and calibrating the model so that it can be used in planning the next season.

The arrangements for measurement program were discussed. Installation of measuring gauges has already been completed. It was decided to install 2 rain gauges at the IMD office and at Radavi Bendi Ela anicut site to supplement those already existing at the Irrigation Department office at Inginimitiya and at Mahauswewa Tank. (5 measuring gauges of 5'-0 length each were handed over to ID.)

Current water situation at Inginimitiya

	12/11/92	13/11/92
Water Level	191' 4"	191'9"
Sluice discharge	-	- (closed)
Rainfall	8 mm	25 mm
Effective capacity	13,583 acct	14,624 acct

Right Bank main canal was closed on 12th November 1992 because too much of water in head end of the canal due to rain. With the current reservoir capacity of 14,624 acct., the cultivation of Right Bank is certain. According to ID staff, if the reservoir receives another 10,000 acct of water before the end of November, cultivation of Left Bank will also be possible.

Observations at the inspection along RB main canal

It was observed that the tail end farmers (specially in Tract 3), have not received sufficient water. This was quite contrary to what was said by the IO's at the meeting with them. Many farmers were not seen working possibly due to rain. All the measuring gauges have been installed at the selected points (upstream - metal gauges and downstream - plastic gauges). At D6 of Tract 2, the upstream measuring gauge was not seen and it was informed to ID.

We observed the system at a particular interesting stage: there had been sufficient rainfall over the system to justify closing down the main canal. A decision had been made to close the sluice at the main reservoir at 0900 hrs. This decision was reported to have been made because many farmers had said that there was too much water available. It is not clear whether these requests from farmers were individual or channelled through the DCO leaders. The mechanism for communicating such information upwards from field to irrigation officers needs to be further investigated.

The gatekeeper at Konkadawela tank, which forms part of the right bank main canal, had been instructed to stop issues at 1500 hrs. The six hour time delay between closing the main reservoir sluice and the Konkadawela sluice is to ensure that discharge into the bank from the main reservoir is stopped before the tank sluice is closed. If it is closed while water is still coming from Inginimitiya the tank may spill and flood paddy lands in the vicinity. Most of the offtakes from Inginimitiya to Konkadawela appear to have been closed before the main sluice was closed that morning. There is no evidence that discharge at the head of the main canal had been reduced as a consequence of these off takes being closed.

Below Konkadawela the situation was more complicated. Prior to closing the sluice at 1500 hrs, the discharge from Konkadawela was estimated to be 60 cusecs. The first six or seven offtakes below Konkadawela had been closed long before the gate at Konkadawela was closed. As a result of this, the main canal was over topping in two locations. Given this situation, it would have been reasonable to expect that tail end water conditions would be more favorable. It turned out not to be the case. Water had not reached the tail end of the canal in any significant quantity. This conflicts with the reports from the Institutional Organizers.

There appears to be a fairly significant management problem at Inginimitiya. During land preparation the operational plan of the Irrigation Department is to deliver water continuously into every D canal offtake. This requires careful regulation of flow because if too much water is delivered into a Distributary Canal it is likely that insufficient water will reach the tail end of the Main Canal.

It appears that the canal capacity may be inadequate in the main canal if such control cannot be careful applied. At the same time there is more than adequate capacity in the Distributary Canals. During land preparation when water requirements may exceed 2 liters per second per hectare the main canal is undersized to meet this demand in all canals simultaneously. But at the D canal level, which is based on the 1 cusec principle, there will be excess capacity unless each Field Canal is close to 16 hectares.

It seems very clear to me that there is no control on the system at the D canal level, that the rotation intended to be implemented as part of the 1 cusec principle is not implemented, and no effective feedback exists between the D canal organizations and the Irrigation Department. I suspect the satisfaction of farmers reported by the IOs is merely a reflection of adequate rainfall not of adequate water deliveries.

Upcoming activities

Our next visit has been scheduled for 17th and 18th November 1992. The position of preliminary data collection will be followed up with IO's and a few interviews with farmers will also be held during this visit. Arrangements are being made to participate in the Project Management Committee meeting which is scheduled to be held on 26th November 1992.

Trip Report #4

The following activities were conducted during the field trip:

1. Meeting with the IO's and IDO at the IMD office.
2. Visits to two D canals and discussions with farmers of the respective DCO's.
3. Looked into available data and reports at IMD office.

1. Meeting with the IO's and IDO:

This meeting was arranged for the 17th to coincide with the IMD weekly meeting on Tuesdays. The purpose of this meeting was first to discuss the current situation of the farmers with regard to water availability, status of planting activities, canal gate operations and FO activities; and secondly, to follow up on the survey work that we initiated on the last field trip.

According to the IMD officers, in certain areas of tract 2 and 3, there is a severe problem of providing water to the tail-end farmers. DC1 of tract 3, which happens to be the longest D canal with the most number of farmers (200 farmers), seems to be the worst affected. In spite of numerous requests by IMD, DCO leaders and farmers to ID seeking help, nothing has still been done. The ID's response is that they don't have enough money to do the necessary maintenance and rehabilitation work of the affected canals. According to the IO's, the farmers have done whatever cleaning possible through "shramadana" (self-help work programs), but beyond this the work is too complicated and costly, and ID assistance is definitely needed. There are many problems with receiving the required amounts of inputs such as seed paddy, diesel (for land levelling) etc.

Many farmers, who have yet to start their cultivation activities, are still in debt with many loans yet to be settled, and as a result, they find it difficult to apply for any more loans. Since cultivation of this season also seems doubtful with the existing problems, many of them have leased out their lands and are not present on their fields.

The IO's had got 34 surveys completed from RB FC leaders and are in the process of completing the rest. Looking at these surveys, the responses do not seem to be very accurate, and there does not seem to be that much of variation in the data. i.e. in some of the surveys, the area expected to be cultivated and what has been actually cultivated is the same (100%). Thus this data does not seem to reflect the current problem of receiving water, especially in the tail-end areas of certain D canals. This was the case for a survey completed by the leader of FC33 in tract 3 DC5, a tail-end area which does not receive adequate water. Efforts will have to be made before the next survey to more carefully instruct farmers in what is really required of them.

2. Visits to D canals:

Important observations from the inspection of T3/D1

Current position

This is the longest DC in RB, feeding 17 FCs. The canal was flowing and was almost full at the head end. However, the flow was gradually reducing towards the tail end. There was a point at the middle of the canal at which the bund had been damaged. Therefore, even if they increased the flow, the water would have been wasted at this point. Farmers have temporarily repaired the place but it was not that effective.

Tail-enders were badly suffering from lack of water. Our best estimate was that about 40% of the farmers have not received water in sufficient quantities.

Canal maintenance

It was observed that a major part of the DC had not been cleared before the water issue. It was revealed that the DCO had organized a Shramadana campaign before the water issues to clear the canal but it had not been successful because some of the farmers were absent from their fields.

NOTE: ADB funded rehabilitation program

> A rehabilitation program for the irrigation schemes in North Western Province is being planned and is supposed to be implemented during 1992/93. About 13 M Rs. has been reserved for rehabilitation of Inginimitiya project. ADB would fund this project which comes under the North Western Provincial Council. A meeting with the farmer leaders to identify the rehabilitation requirements for this program is scheduled to be held on 20th November 1992.

Technical defects

The farmers were complaining about a possible technical error in the construction of the canal which could be constraining the water flow towards the tail end. However, they admitted that during the first water issue in 1985, there was no such problem and the water reached the tail end without any obstruction. This point disqualified the previous statement made by the farmers.

The canal has been damaged at many points. We observed that some of these damages were caused by the poor quality of construction. For example, FC11 has been totally damaged due to poor compaction of earth. Some of the damages were due to poor maintenance.

Apart from the damages caused by poor maintenance and construction defects, we observed that farmers have deliberately damaged some structures. Most of the weirs of the regulators have been damaged. Some farmers were totally against this activity but some of them admitted that to allow more water to flow, they had to break the weirs. Subsequently, this had become a usual practice. Answering a question about the possibilities of intervention of DCO's to prevent such activities, one farmer complained that some of the DCO leaders themselves were also involved in these activities. Some of the turn out structures were also badly damaged. Some farmers accused the outsiders (farmers from head-end), who came to share the lots under the Bethma program implemented two years ago, of deliberately causing these destructions.

We observed that the water issue to the right side of the command area was more effective than that of the left side. As we guessed, it could be probably due to wrong positioning of the canal trace. Even at first glance, a difference of levels is evident between the left side of the D canal and the canal it self.

Performance of DCO's

We observed that the performance of the DCO of D1/T3 was not that effective. The farmers' general consensus was that the contribution of the DCO towards an equal distribution of water was not satisfactory. It was also observed that the leaders of the DCO lack personal power to pursue the decisions taken.

Response to suggestions

Farmers responded positively to a suggestion to delegate authority of controlling gates to farmer organizations. However, they emphasized that the leadership must be more effective and efficient and they accepted the fact that it would be their responsibility to appoint such leaders. They assured their participation for the proposed measurement program.

Supervision of water issues by ID officers

Farmers were concerned about the general lack of supervision of water issues by Irrigation Department officers. They felt that the visits of the "jala palakas" (gate tenders) should be increased, and the Work Supervisor and other Irrigation Department officers should visit the field more frequently.

Farmers spoke highly of a TA who had been in-charge of the water issues for Tract 3 two years. They mentioned how this TA overcame the problem of illegal tapping of water by the head-enders, by locking the gates with padlocks. This ensured an equal distribution of water between the head and tail-enders. This proves that their criticism on the activities of the current officers was not baseless.

Important observations from the inspection of T2/D5

We observed that lot of water was being wasted in this canal. The canal was full at the head end but there was a section in the middle where a lot of water was overflowing. The bund was badly leaking because of poor quality of construction. Therefore, a few tail-enders were not receiving adequate quantity of water.

Some of the structures have been damaged by the farmers with the intention of receiving more water. It was revealed that it has been done with the concurrence of some of the farmer leaders.

Deteriorating relationships between farmers and the farmer leaders were observed here too. Farmer leaders were not very popular figures among the other farmers. This was quite contrary to the picture depicted by the IO's. IO's tend to have a better relationship with a select group of farmer leaders than with the farmers.

3. Available data at IMD office:

Our main objective in doing this was to see if there was any data available at IMD which would facilitate our study on performance of the scheme, in the last few years. The only data available was rain fall and the area cultivated. Nothing on harvest quantities, wholesale/retail prices for rice and other crops or farmer income was available. According to IMD, this data may be available with the Dept. of Agrarian Services. The DCO files which consisted of reports of minutes and other meetings, have not been updated. According to the IO's the respective DCO secretaries have the most current reports and should have forwarded them to IMD.

Personal Observations:

In general, we get the impression that the IO's comments do not reflect the true picture of the current situation. It could very well be that there is some truth to what they say with respect to certain issues, for example, the need for the ID to take a more active part in resolving the existing water flow problems in certain D canals, but not necessarily so for other issues, such as the strength of FO's and their organizational activities. The IO's seem to be taking it for granted and generalizing observations based on those organizations that are functioning rather better than others.

The IO's feel quite positive about the working relationship between the DCO leaders and the farmers, although this is not universally the case. It is interesting to note at this point, that the location of a DCO leader's field (if tail-end or head-end of DC), seem to have an impact on the contribution made by him to his respective DCO with regard to the smooth functioning of its organizational activities.

With regard to the communication path for complaints, there was mixed opinion. According to the IO's, there was no problem with the DCO leaders communicating with the ID staff, namely the WS's and/or TA's. However, according to one DCO treasurer, it was late in the evening, and the WS had still not visited the area for that day. There were instances when the DCO leaders had gone directly to the ID office to complain. Regards the opening and closing of the gates, we still need to investigate the effectiveness of the communication path on an individual DCO basis.

We are of the opinion that the presence of IO's tend to inhibit the farmers from expressing their true feelings about the current problems, and future field visits must include some discussions with farmers without IO's automatically being present.

APPENDIX C

Distributary Canal Organizations in Inginimitiya

D Canal Organization		Area (ha)
Right Bank		
1.	Center Tract	81
2.	Tract 1, D2 and FC6	51
3.	Tract 1, D3, D4, and FC 16	63
4.	Tract 1, D5, D6, FC 25 and FC 28	124
5.	Tract 2, FC 1 to FC 6	72
6.	Tract 2, D1, FC 13 and FC 14	85
7.	Tract 2, D2, FC 15, 16 and 20A	77
8.	Tract 2, D3 and FC 26	50
9.	Tract 2, D4 and FC 31	45
10.	Tract 2, D5	44
11.	Tract 2, D6 and FC 48	111
12.	Tract 2, D7	80
13.	Tract 3	120
Left Bank		
1.	Tract 1, D1, FC 1 to 3, FC 8 to 10	140
2.	Tract 1, D2 (upper)	101
3.	Tract 1, D2 (lower) and Tract 3, FC1 to 4	149
4.	Tract 3, D1, FC 5, 10, and 11	86
5.	Tract 3, D2, FC 11A to 14	106
6.	Tract 3, FC 21 and 22, Tract 4, D1 and D2	117
7.	Tract 4, D3	112
8.	Tract 5, D1	258
9.	Tract 5, D2	48
10.	Mahauswewa (Tract 2)	400
11.	Uriyawewa	15

Appendix D

R & D Project Bar Charts

1992-93

Activity	1	2	3	4	5	6	7	8	9	10	11	12
Monitoring	X	X	X	X	X	X	X	X	X	X	X	X
Mid-Term Review											X	
Preparation of Ph.II Workplan										X	X	
Interim Report											X	
Farmer Surveys									X			X
OVERSEAS TRAVEL												
Makin Sri Lanka											7	
Cornish Sri Lanka								10	15		14	

1993-94

Activity	1	2	3	4	5	6	7	8	9	10	11	12
Monitoring	X	X	X	X	X	X	X	X				
Farmer Surveys			X			X						
Draft Final Report							X					
Final Workshop								X				
Final Report									X			
OVERSEAS TRAVEL												
Makin Sri Lanka								14				
Cornish Sri Lanka			21					14				

ANNEX C

IRRIGATION MANAGEMENT IMPROVEMENT PROJECT

Review and Planning Workshop
Waikkal, 10-11 February 1993

Hammond Murray-Rust

This report is intended as a supplement to the Interim Report of the Irrigation Management Improvement Project which was submitted in November 1992. This narrative report is accompanied by two annexes: the workshop agenda and a list of participants.

Irrigation Management Improvement Project

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Opening Ceremony

Mr. D.W.R.M. Weerakoon, Senior Deputy Director for Water Management in the Irrigation Department made a presentation on behalf of the Director of Irrigation. He noted that over the past couple of decades Sri Lanka had made significant efforts to improve irrigation performance in the country, both through rehabilitation of existing systems and also through human resource development of both agency staff and farmers. He noted the success of HR Wallingford in the water short conditions experienced at Hakwatuna Oya, and reminded the audience of the catastrophic effects of the recent drought on overall production from irrigated lands. He hoped that with this planning workshop it would be possible to make the best use of the water resources available at Inginimitiya for the forthcoming season.

The keynote address was made by Mr. D. M. Ariyaratne, Director of the Irrigation Management Division of the Ministry of Lands, Irrigation and Mahaweli. In his introduction, Mr. Ariyaratne stressed the need for improvement in irrigation management in general, and at Inginimitiya in particular, as a way of raising the overall performance of the irrigated agriculture sector. In recognizing that Inginimitiya had a severe water problem, he hoped that the adverse situation would lead to cooperation among all involved. He briefly reviewed the formation of the Irrigation Management Division and the role of the Project Management Committee in bringing together the various government agencies and farmer organizations to discuss concerns and assist in the planning of activities for the future. The workshop was timely in this regard because of the persistent water shortage during the past couple of years, and the need to plan effectively for the 1993 yala season. Although the National Irrigation Rehabilitation Project was just starting, he still stressed that non-physical interventions were likely to remain of great importance into the future.

Ian Makin of HR Wallingford made a short introduction to the background of their involvement in Sri Lanka, starting with experiences in Kaudulla in the late 1970's, and then moving on to Hakwatuna Oya during the past few years. With their current involvement in Inginimitiya, a sequence of investigation, trial implementation of computer support for managers, and the introduction of more sophisticated and broad-ranging software, he felt that there had been a useful and important contribution over the past 15 years.

Dr. Murray-Rust (IIMI) thanked the participants for coming, and reviewed the overall purpose of the workshop. The event was designed to briefly look at progress made to date in the adoption of decision support tools for irrigation managers, and to assist in the overall process of planning for the next season. It was expected that following this workshop, various ideas that were discussed could be addressed both by the D Canal organizations and the Project Management committee prior to the holding of a formal Cultivation Meeting planned for late March.

Session 1: Strategies for Improving Irrigation Management

This session was intended to provide some background rationale for irrigation management improvements that places the current project into perspective.

The first presentation, by Hammond Murray-Rust of IIMI described an overall framework for irrigation management that addresses issues of objective setting, development of operational plans, provision of adequate financial and manpower resources to implement plans, implementation itself, monitoring and within-season adjustment, and seasonal evaluation. Without such a framework it is difficult for managers to recognize the utility of technological improvements, or to have a suitable mechanism for the monitoring of both short term and long term conditions within the system. A common characteristic of many irrigation systems that were not performing particularly well was the lack of a suitable performance-oriented framework. While it was recognized that there were institutional constraints in many places that made the adoption of a complete framework difficult, it was still possible for individual systems to improve their performance without having to wait for institutional change coming from the top down. It was hoped that the present project would help provide a framework that would permit managers to achieve better performance in Inginimitiya in the future.

The second presentation in this session was made by Ian Makin of HR Wallingford. He also stressed the need for an effective management framework that was based on the feedback of actual conditions in the field to system managers in a timely and effective manner. In various countries in Asia HR had been working with irrigation agencies to get such improvements made, and in so doing had used computer models and information management support with good results. The experiences of Hakwatuna Oya, where an earlier version of the INCA software had been used, had proved to be a useful basis for the current project at Inginimitiya.

Following the presentations there was a general discussion on the need to improve response to actual conditions of water supply and demand. There was consensus on the need to have a management framework, but also a need to have a framework that was simple and adaptable to local needs and conditions. It was widely accepted by different speakers that the reason for the failure to sustain many earlier monitoring programs was because there was no long-term framework that helped sustain interest in collecting data once the first intervention phase was complete. A few of the participants stressed that the elements requiring particular attention in Sri Lanka were those of objective setting and monitoring, the result being that implementation targets were frequently out of phase with system wide objectives, and with actual conditions in the field. The overall need to clearly identify objectives was seen by some as the single greatest cause of poor performance.

Session 2: Operational Management using INCA

This session was designed to focus on the role of INCA software as a Decision Support tool for Irrigation Managers. The main presentation was made by Gez Cornish of HR Wallingford. He started with a brief outline of the main objectives of the computer and its development based on experiences in a number of different countries. The model is based on a capacity to process two types of data simultaneously. The first type is the historical and background data that sets the framework for decision-making. It can store and process long term records of rainfall, river discharges, reservoir storage, evapotranspiration and other meteorological data, and determine the probability of different occurrences for each selected time period. The second type of data is the current condition of the system, including cropping patterns and cropping calendars, flows in canals, rainfall, soil moisture status, etc. Using these current data and the probability information derived from the background data set, the probably water requirements for each irrigation period for the remainder of the season can be estimated, and these used as a basis for assessing the actual performance in respect of water delivery.

This presentation was then followed by three shorter ones that reviewed and compared experiences with computer based decision support tools in different irrigation systems in Sri Lanka.

The first of these short presentations was made by Mr. Bandula de Silva from Hakwatuna Oya. He briefly described the measurement program currently being undertaken with 26 measurement locations, at which three readings are taken each day. It has proved possible to keep this measurement program going except when there was a period of severe civil unrest. Using this information, the computer model has been used for determining required discharges during each weekly irrigation period. Initially he used the spreadsheet program developed by HR Wallingford using Lotus 1-2-3, but is now using the INCA software. The model has been found to be very helpful, and farmers appear to be satisfied with the current water distribution program. In a few instances in the beginning there were complaints that the water delivered was inadequate, but these have been overcome through a combination of recalibration of structures program and by working with farmer organizations to try to be more effective in water management at field level.

The second short presentation was made by Mr. Manoharan, Irrigation Engineer, Inginimitiya. Although he had only been in this position for a few weeks, he said that he could see the benefits of the computer program in a number of different aspects of his job. The system had been initialized and routine data collection had been proceeding for several months. Manoharan said he found the capacity to have quick access to long term records of rainfall and reservoir inflows, together with probabilities for each irrigation period very useful. Given that there was perennial water shortage at Inginimitiya the capacity to closely monitor water issues was another big advantage, particularly when combined with the ability to make pre-seasonal runs to simulate different cropping options.

The final short presentation was made by H.A. Karunasena, Irrigation Engineer on secondment to IIMI at the Kirindi Oya Irrigation System. He said that during the past three years they had adopted the SIC computer model developed jointly between IIMI and CEMAGREF in France for assessing the appropriate gate settings to be made at each structure in order to deliver appropriate volumes of water to each canal. As the system design was more or less the same as that at Inginimitiya he saw that using such computer models was a considerable potential for improving irrigation management through computer based decision support models. Among the benefits at Kirindi Oya were the display of daily discharges at all major locations, systematic data collection and utilization, and transparency of water deliveries so that farmers and irrigation staff alike could see the situation at all locations.

Session 3: Improving Monitoring Activities

The first part of the discussions that followed were oriented towards assessment of the utility of computer models in assisting system managers improve overall performance. Concerns were expressed that the cost of the equipment required to run the software were high. It was accepted that it required considerable processing speed and hard disk space to operate efficiently, but this had been done on purpose insofar as the cost of computer hardware was dropping rapidly, and within a short period the costs would be considerably less.

A second set of issues concerned the benefits from using computer software in different systems. In Hakwatuna Oya there had been an increase in water use efficiency, while at Kirindi Oya there was better information for managers to minimize water wastage through inappropriate gate settings. Both of these system representatives felt that the capital cost of the model and the hardware required to run it were more than repaid by the improvement in performance already obtained.

The consensus was that such models were beneficial, and would become more commonly used as agency staff became more familiar with their potential.

The second part of the discussion session focussed on monitoring activities to support the INCA model at Inginimitiya. There was some concern that the model would dictate cropping patterns to farmers because of the desire to optimize water use. However, it was generally agreed that the models were flexible to adapting to farmers cropping patterns as long as the appropriate information was collected early in the season. There was also concern that a number of assumptions were required to make the model work well. The overall consensus was that this was true whether or not there was computer support for the system manager. If field data on conveyance conditions and other technical aspects were not collected, then the computer could not substitute for this lack of information.

There was no doubt in the minds of most of the participants that effective management could not occur without good information, although it was also widely accepted that current monitoring practices were relatively week. Although use of a computer model did have the potential to increase data collection workloads, it provided a systematic way of storing and using even relatively sparse data sets. Thus, in Inginimitiya, the initial size of areas included as a single irrigation block was about 200 ha, with only about 15 such units being included in both Right and Left Bank areas. Although this is not a very dense sampling framework, it can quickly build up to provide a realistic picture of water conditions throughout the system. If desired, it was simple to increase the sampling density, but this had not been done initially to allow the irrigation staff to get used to the procedures.

It was recognized that the Irrigation Department budget led to some staffing constraints that limited their capacity to collect large amounts of data. For this reason it was proposed that the farmer organizations should be included in the data collection process. If they could collect information of soil water status on a weekly basis, take water level readings at additional locations, and provide information on cropping calendars actually implemented in the field, this would greatly help in the process of building up a good data base for use by the system managers. As a result of these discussions it was agreed to discuss all of these potential contributions in the sessions to be held on the following day.

Also included in the agenda for the following day was small group discussions on what potential cropping patterns would be acceptable to farmers and irrigation staff in the event that there was insufficient inflow into the reservoir to permit paddy cultivation.

Session 4: Developing Monitoring Plans for 1993 Yala Season

The first session of the following day was intended to follow on from the discussions on monitoring activities but with the inclusion of farmer representatives from Inginimitiya. After a slight delay caused by the late arrival of the farmers because one of their members had been bitten by a snake, five separate working groups were established, each to discuss a different aspect of the monitoring program. Each of the working groups gave a small presentation to the full workshop session that followed. The main elements of these presentations are given below.

Working Group 1: Cropping Calendars

The chairman of this working group, Lalith Dassenaike gave a brief introduction that stressed the following points. Effective planning of water deliveries requires information on what the status of cropping activities is at any given time. INCA uses **cropping profiles** that reflect actual conditions such as crop type, duration from planting to harvest, land preparation period if any, and evapotranspiration crop coefficients. It also requires knowledge of the **actual dates** of land preparation, planting and estimated harvest date to make proper estimates of water requirement for the whole season and each constituent irrigation period. Inputs from farmers, therefore, are both useful and important.

The members of the working group agreed in principle that it should be the responsibility of the farmer organizations to provide appropriate information on the crops planted, the dates of commencement of land preparation and of planting, and the anticipated date of harvest. It was further agreed that two surveys would be undertaken for each season, one shortly after land preparation commenced, and one about one month later when all crops had been planted. The actual mechanisms for doing this would be included in a small training session for farmer leaders shortly before the season actually commenced.
Two main concerns expressed by faremrs in carrying out this activity were, firstly, the ability to obtain true and relaible data, and second, the absence of farerms when field surveys were being carried out. It was suggested that the information collected be discussed with faremrs before the final results were passed on to the Irrigation Department.

Working Group 2: Field Level Water Conditions

The second working group, led by Wasantha Kumara, addressed the capacity of farmers to collect information on a weekly basis on water conditions in sample fields. The information will be used in two main ways, one more useful to the system manager, one more useful for the D canal organization. The first use of the data collected is the determination of the overall level of water adequacy in a D canal area, equivalent to the moisture information used in the INCA model, so that the total water delivery required for the following irrigation period is known. The manager can also use the information to assess whether water deliveries are really adequate to meet actual evapotranspiration and rates of seepage and percolation. The second purpose is to assess the variation in access to water within a D canal area. If the D canal organization is really effective in managing water, all fields would be likely to have similar water conditions. If there are large head-tail differences it would appear that D canal management needs attention. The Irrigation Management Division should have interest in this data for trying to identify which organizations are being more successful, which ones less.

Following this presentation, the farmers agreed that such information could be collected. Selected farmers from each D canal organization would need to be trained in the visual method of assessing water availability and then enter this data on a simple form. A short training program for this activity would be held as soon as water issues started so that farmers could gain practical experience in the field. The main reservations expressed by farmers was that this information might be used to reduce their water supplies, but they accepted the explanation that this was a trial testing of a new procedure for monitoring water conditions, and did not mean that water would be reduced below the level of normal requirements. However, there was consensus that this technique could be used to reduce wastage of water that flowed into drains, particularly if the saved water remained in storage in the reservoir for use on the next season.

Working Group 3: Discharge/Water Level Readings

The group leader, Mr. H.A. Karunasena, explained that monitoring for this activity is already underway, at least as far as the Irrigation Department was concerned. For the Right Bank a total of nine locations are monitored twice daily for water levels and rating curves are under process of development. To date, however, the farmer organizations are not involved in any way. The small group was asked to examine a number of aspects in which they could play a useful role.

In principle the farmers agreed that monitoring of water at all key locations was important to achieve adequacy, equity and reliability of water deliveries. To this end they were willing to try out a system of joint monitoring at the nine sites, such as reading by Irrigation Department staff in the morning and by farmers in the afternoon so that both groups are satisfied as to the water levels being maintained in the main canal and the D canal. It was also agreed to increase the number of D canal locations at which water levels are taken without the direct assistance of the irrigation staff.

Farmers could also agree to monitor water levels in the field canals that comprise the D canal (especially those directly off the main canal) to check that the overall rotation pattern is being followed. The farmers all agreed that rotational irrigation was essential, and that it was very important to make sure all gates were open and closed in accordance with the agreed schedule.

To facilitate flow of information, it was agreed that farmers could keep a log book, and that the data would be given to the irrigator on a daily basis. He would make a round trip every day on the motorcycle purchased by the project to obtain this data in the morning, and then take it to the Irrigation Department office by mid-morning for use by the system manager.

Working Group 4: Alternative Crop and Water Delivery Options

This group discussed the type of water and crop delivery options that were acceptable to farmers. To facilitate the discussion a number of different alternatives were presented that represented a realistic set of options given the current water situation. These alternatives included:

- Only irrigating half of the Right Bank & half of the Left Bank
- Only irrigating Right Bank and Left Bank in alternative seasons
- Only irrigating every other field canal
- Only irrigating every other farm
- Only irrigating half of every farm
- Cultivating ¼ rice and ¾ non-rice on all farms
- Growing low water requirement non-rice crops on all land
- Growing higher water-requiring non-rice crops on half of the land
- Group farming on limited areas, with D Canal Organization being responsible for determining how to allocate land, water, inputs and marketing

The farmers generally did not like trying to share land among each other in the traditional bethma system more commonly associated with small village tanks. The farmers who had to give up part of their land for one season were not enthusiastic, while the others felt that they did not get a fair share of land or water. Previous experiences with bethma had been unsuccessful.

The most widely accepted way of allocating land was to alternate between Left Bank and Right Bank in those seasons where water was inadequate for all. However, they would really only be willing to do this if they could grow rice.

Options involving non-rice crops were not so popular, and the farmers appeared divided between those who would rather forego a season and be assured to be able to cultivate rice the following season, and those willing to grow non-rice crops rather than have no crop at all.

Despite these differences, the group members were willing to return to their respective D canal organizations after the workshop and discuss what alternatives might be acceptable among the general membership.

Working Group 5: Alternative Crop and Water Delivery Options

The same issues were discussed by another group representing the perspective of the Irrigation Department. The discussion focussed on the extent to which alternative plans were easier or more difficult to manage. The general preference was for irrigation of rice in the upper half of the Left Bank if the current water situation did not improve. There was optimism among many members of the group that there would be substantial rainfall before or during April, despite rather pessimistic analyses of the historical rainfall data. This view tended to distract attention from consideration of the best use of existing water.

The relative difficulty of managing the main and D canal gates to support alternative cropping patterns was discussed, but there was a widely held view that all alternative patterns were more or less equal in terms of their implementation requirements. Part of this attitude clearly arose from a reluctance to move away from the standard operating rules even if a particular cropping pattern did not suit such operational conditions.

The approach to the current water problems at Inginimitiya proposed by the Irrigation Department was to decide on a pattern of non-rice crops, probably chili, by dividing available storage by a predetermined estimate of seasonal water requirements for that crop. This method which is considerably less sophisticated than the pre-seasonal run capability used by INCA, does not take any account of the operational requirements necessary to deliver water to different canals.

Session 5: Plans for 1993

The small group discussions were followed by a reporting of these results to the whole group. There was acceptance of the decisions made by each group, and little evidence of disagreement with any of the overall findings. There was widespread commitment made both by farmers and agency staff to work together to improve monitoring of water and cropping conditions to assist in improving management of the system.

It was agreed that the D canal organizations would discuss the results of the workshop with their members, and come to the Project Committee Meeting scheduled to be held on February 27.

Session 6: Closing

The workshop concluded with a brief closing ceremony. Votes of thanks were made by Mr. D.W.R.M. Weerakoon for the Irrigation Department, and by Dr. Hammond Murray-Rust on behalf of IIMI. In a closing address Mr. D.M. Ariyaratne stressed the need for all concerned, farmers and government officials alike, to continue the spirit of constructive cooperation that had characterized the workshop. If this cooperation was maintained he remained confident that there would be long term benefits for all involved with irrigation at Inginimitiya.

IRRIGATION MANAGEMENT IMPROVEMENT PROJECT
Mid-Project Review and Planning Workshop
10 and 11 February 1993
Dolphin Hotel, Waikkal

AGENDA

Wednesday, February 10, 1993

09:30 - 10:00 Registration

10:00 - 10:30 Opening Ceremony

Mr. Yoganathan, Director, Irrigation Department
Mr. Ariyaratne, Director, Irrigation Management Division
Dr. Murray-Rust, International Irrigation Management Institute
Mr. Makin, HR Wallingford

10:30 - 11:00 Tea/Coffee

11:00 - 12:30 Session 1: Strategies for Improving Irrigation Management

Management Framework for Improving Irrigation Performance: H. Murray-Rust, IIMI.

Use of Computers for Decision Support by Irrigation Managers: I. Makin, HR Wallingford.

General Discussion

12:30 - 14:00 Lunch

14:00 - 15:30 Session 2: Operational Management using INCA

Description of the INCA Model: G. Cornish, HR Wallingford.

Experience in Inginimitiya: ID staff from Inginimitiya and Hakwatuna Oya.

15:30 - 16:00 Tea/Coffee

16:00 - 17:00 Session 3: Improving Monitoring Activities

General discussion led by H. Murray-Rust

19:00- 20:00 Reception

20:00 Dinner

Thursday, February 11, 1993

08:30 - 09:00 Arrival of Farmer Leaders and briefing

Project Manager, Inginimitiya

09:00 - 10:30 Session 4: Development of Monitoring Plans for 1993

Five Small Working Groups to discuss monitoring for:

Cropping Calendars
Water Availability at field level
Water Delivery to D and Field Canals
Alternative Crop and Water Delivery Options (one group Sinhala, one group English)

10:30 - 11:00 Tea/Coffee

11:00 - 12:00 Session 5: Confirming Plans for 1993

Reports from Small Working Groups

Overview of Workshop Results

12:00 - 12:30 Closing Ceremony and Vote of Thanks

12:30 - 14;)) Lunch followed by departure of participants

LIST OF PARTICIPANTS AT THE REVIEW AND PLANNING WORKSHOP
HOTEL DOLPHIN, WAIKKAL - 10 AND 11 FEBRUARY 1993

Name of Participant	Designation	From
Ambalam	Deputy Director	Irrigation Department, Puttalam
D.M. Ariyaratne	Director	Irrigation Management Division
N.T. Atukorale	Deputy Director, O&M	Irrigation Department
Bandara	Irrigation Engineer	Inginimitiya
Gez Cornish		HR Wallingford
Chandraratne	Technical Assistant	Inginimitiya
Lalith Dassanaike	Research Associate	IIMI
K.S.R. de Silva	Deputy Director	National Irrigation Rehabilitation Project
Bandula de Silva	Irrigation Engineer	Irrigation Department, Ibbagamuwa
Manju Hemakumara	Research Associate	IIMI
Jayasundera	Institutional Officer	Inginimitiya
H.M. Jayatilake	Deputy Director	Sri Lanka Irrigation Training Institute, Galgamuwa
Jayatilake	Technical Assistant	Inginimitiya
H.A. Karunasena	Research Associate	Sri Lanka Field Operations, IIMI
Karunatileke	Irrigation Engineer	Inginimitiya
Wasantha Kumara	Research Officer	IIMI
Hemasiri Kotagama	Professor	Faculty of Agriculture, Peradeniya Unit
Ian Makin		HR Wallingford
Mangala	Institutional Officer	Inginimitiya
Manoharan	Irrigation Engineer	Inginimitiya
Douglas Merrey	Senior Management Specialist	IIMI
Hammond Murray-Rust	Senior Irrigation Specialist	IIMI
Pathirana	Institutional Officer	Inginimitiya
W.L.W. Premadasa	Project Manager	Irrigation Department, Giritale
RB	Institutional Officer	Inginimitiya
S.S.Ranatunga	Deputy Director	Irrigation Management Division
Jacques Rey	Associate Irrigation Specialist	IIMI
Somasiri	Deputy Director	Irrigation Department, Kurunegala
G. Uittenbogaard	DHV Consultants	National Irrigation Rehabilitation Project
Tom Vander Linden	DHV Consultants	National Irrigation Rehabilitation Project
D.W.R.M. Weerakoon	Senior Deputy Director, O&M	Irrigation Department
Wijewardene	Technical Assistant	Inginimitiya
Wimalachandran	Chief Resident Engineer	Inginimitiya

LIST OF FARMER LEADERS WHO PARTICIPATED IN THE WORKSHOP ON FEBRUARY 11, 1993

Ratnasiri
A. H.M. Jinadasa
B.M.P. Mudiyanse
M.H. Somapala
Hatana
Ariyadasa
Rabnjith
Lalantha
Danesh
A. Ariyadasa
Punchibanda
Jinasena
Premadasa
Bandara
Siyadoris
Ravi
Sirisena
Gunapala
Manatunge
Banda
Jagath
Induka
Kumara
Ajith

ANNEX D

Irrigation Management Improvement Project - Inginimitiya
Socio-Economic Study

An Assessment on the Potential to Adopt a Computer Based Irrigation Management Support Software

Hemasiri B. Kotagama

Department of Agricultural Economics and Extension
Faculty of Agriculture/Post Graduate Institute of Agriculture
University of Peradeniya
20-10-1993

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List of Abbreviations

CIMSS	Computer based Irrigation Management Support Software
HR	Hydraulics Research Ltd., U.K.
IIMI	International Irrigation Management Institute
IIS	Inginimitiya Irrigation System
INCA	Name of the CIMSS developed by HR

List of Local Terms

Bethma	Share
Chena	Shifting Cultivation
Janasaviya	A Welfare program
Kanna	Season
Maha	Wet Season
Pella	In sequence
Yala	Wet Season.

Summary

The Inginimitiya Irrigation Management Improvement Project was a pilot project to test a computer based irrigation management support software (CIMSS) developed by Hydraulics Research Ltd. of United Kingdom. The objective of the project was to assess the potential for sustainable adoption of the CIMSS (referred to as INCA).

This study is a component of the project. It addresses the project objective by examining the socio-economic aspects of farmers to assess the potential for sustainable adoption of INCA.

The study was based on sample surveys and participant observations. The sample consisted of 60 farmers, randomly selected on stratification based on farmer organization jurisdictions. Data was collected through structured questionnaires.

INCA was not effectively used for system management during the study period. The study found that adoptability of INCA-CIMSS depends partly on socio-economic factors that prevail in an irrigation system. In Inginimitiya Irrigation System the socio-economic factors have lead farmers to prefer a unique water sharing system referred to as *pella bethma*. Under this water sharing system water is supplied in alternate seasons to left and right banks to cultivate paddy. Since only 50% of the command area is cultivated it is administratively convenient and less risky to the management officials as well as to the farmers. It is also presumed to be fair by farmers. On *pella bethma* system of water sharing there would be often adequate water to supply to meet the demand for water. Also since only paddy is cultivated under *pella bethma* water management is less complex. Since both farmers (and irrigation officials) prefer *pella bethma* the utility of adopting INCA was low.

Given the above empirical observation it could be concluded that INCA was not adopted due to the unique socio-economic characteristics of IIS. The adoption of a CIMSS would depend not only on the technical appropriateness of the CIMSS but also on socio-economic characteristics of an irrigation system.

Acknowledgements

This study was done with the financial assistance provided by the International Irrigation Management Institute (IIMI), Sri Lanka. The author is thankful to the following individuals for the contributions they made to conduct this study.

Dr. Hammond Murray-Rust, Ms. Mala Ranawake, Mr. Lalith Dassanaike and Mr. Wasantha Kumara of IIMI for the logistical assistance, advice and friendly cooperation.

The Chief Residential Engineer, Project Manager and his support staff of Inginimitiya Irrigation Systems for their professional cooperation.

Mr. Sisira Kumara Udawatte, Mr. I.M.S.K. Idirisinghe, Mr. S.M.M. Samarakoon, Mr. J.P. Wannigama, Mr. Nirosh Gunasekare, Mr. Palitha Hadunge, Mr. H.P.W. Alwis, Mr. Tissa Bandara for efficient assistance provided to conduct field studies.

The Director, Post Graduate Institute of Agriculture (PGIA) and the Bursar, PGIA and his support staff for logistical assistance.

Chapter 1

1. Description of the Project

1.1 Introduction

The Inginimitiya Irrigation Management Improvement Project (referred to as the project here after) is a project of pilot testing a Computer based Irrigation Management Support Software (CIMSS), at the Inginimitiya Irrigation System (IIS) in Sri Lanka. The primary objective of the project was to assess the potential for sustainable adoption of a CIMSS. The CIMSS (referred as INCA) was developed by the Hydraulics Research Ltd.(HR) of the United Kingdom. The project was undertaken collaboratively by HR and the International Irrigation Management Institute (IIMI) Sri Lanka.

1.2 Project Rationale

1.2.1 Role of CIMSS in Irrigation System Management

An essential need for efficient management of an irrigation system is data on aspects of climate, hydrology, agriculture, socio-economics, finance and administration analyzed to provide information that is useful to guide management decisions. CIMSS is capable of meeting this need. CIMSS enables data storage and analysis to better "match demand and supply of water" which is a primary irrigation system management activity.

1.2.2 The INCA CIMSS

INCA the CIMSS that was pilot tested has been described by Bird and Makin (1992) as:

> " ... a generally applicable irrigation management database and main system scheduling tool. The irrigation management software INCA, is designed to be rapidly and easily applied to new irrigation schemes and provides a flexible and comprehensive tool for: storage and analysis of historic and operational data; investigation of alternative seasonal cropping plans; calculation of target discharges for gate operators, and assessment and reporting of system performance."

INCA has been pilot tested in managing irrigation systems in Sri Lanka, Thailand, and Bangladesh. It has been reported that the use of INCA has contributed to reduce variability of water supply, greater utilization of rainfall and fewer complaints from farmers (Bird and Makin, 1992).

1.2.3 The Rationale for use of CIMSS in Developing Countries

The irrigation sector of most developing countries (particularly asian) is presently faced with two economic changes that rationalizes the use of CIMSS. These are as follows.

[1] It has been realized that the vast investments made on irrigation infra-structure construction has not paid back, due to under-performance of irrigation systems. It is widely accepted that under-performance of irrigation systems is due to poor irrigation systems management. It is believed that use of CIMSS could improve system management decision making to improve system performance.

[2] Several asian countries that have substantial irrigated area have now achieved near self-sufficiency in rice production, which was the main irrigated crop. As a result cropping patterns in irrigation systems are being diversified from mono-cropping of paddy to the cultivation of a mix of several non-paddy crops. Despite the change in the cropping pattern, irrigation systems water scheduling and operation has not adequately changed, resulting to under-performance of systems. This is partly due to the increased complication with vast amount of information required to schedule irrigation for several potentially cultivable crops. It is believed that CIMSS is capable of mitigating this complication through data storage and analysis, thus provision of information to improve management decision making resulting to improve performance of irrigation systems having diversified cropping systems.

1.3 Description of the Project

1.3.1 Project Activities

The main project activities were the following.

[1] Installing INCA at IIS.

[2] Training irrigation system management officers of IIS to use INCA.

[3] Organizing an information network between farmers (who demand for irrigation water) and management officials (who control supply of irrigation water) to obtain input data for the use of the soft-ware and the implementation of output of INCA.

[4] Conducting a socio-economic study of farmers to provide baseline information on socio-economic status of farmers (that could subsequently be used to assess the overall performance of IIS) and farmer preferences, attitudes, knowledge and skills on water management (that could be used as input to the INCA and to guide decision making on system water management) and to assess the potential for sustainable use of INCA in irrigation system management.

Activities 1 to 3 were undertaken by IIMI and HR with the collaboration of the Irrigation Department of Sri Lanka.

1.3.2 Objectives of the Socio-economic Study

This study addresses the fourth activity of conducting a socio-economic study of farmers to achieve the following objectives.

[1] Provide base line information on socio-economic status of farmers in IIS (that could subsequently be used to assess the overall performance of IIS).

[2] Provide farmer preferences, attitudes, knowledge and skills on water management (that could be used as input to the INCA and also guide decision making on system water management).

[3] To assess the potential for sustainable adoption of INCA for system management from the farmers socio-economic perspective.

1.3.3 Project Area

1.3.3.1 Physical Aspects

The project was implemented in the IIS. This irrigation system is situated in the northwestern province of Sri Lanka (see figure 1). The area is in the dry to intermediate zone of Sri Lanka, where the total rainfall (54 inches) and it's temporal distribution (75-90% of total rainfall during October to December) prevents successful agriculture without irrigation. The average annual temperature at Inginimitiya is 81^0 F.

The Inginimitiya reservoir has been constructed on the site of a village tank which is believed had existed for several centuries. The present reservoir could store 57200 ac.ft of water to irrigate 6,300 acres. The reservoir receive water mainly from the Mee oya (stream). The lay-out of the irrigation system is schematically shown in figure 2. The two main sluices and channels supplies water to the left and right bank. A small sluice provides water to a small area in between the left and right bank command areas. This center area is the original command area of the small tank that existed earlier.

1.3.3.2 Socio-economic Aspects of Inginimitiya prior to the Commissioning of IIS

The project area had been extremely underdeveloped (compared to national socio-economic standards) prior to the commissioning of IIS in 1985 (Statistics and Planning Division, 1982).

According to a socio-economic survey conducted in 1982 prior to the construction of IIS (Statistics and Planning Division, 1982) the average family size had been 4.7, which has been higher than the Puttlam district's average. The dependency ratio (population below 15 years and above 60 years) has been high as 79% of the population.

The housing and sanitary standards have also been very poor, with 1110 semi permanent or temporary houses to 370 permanent houses and only 7% of households having latrines. Drinking water has been scarce with only 321 wells in the area. Water borne diseases have been widely prevalent during the dry season.

Eighty five percent (85%) of the population have had education up to only eight standard. Only one person have had university education.

Figure 1 Location Map

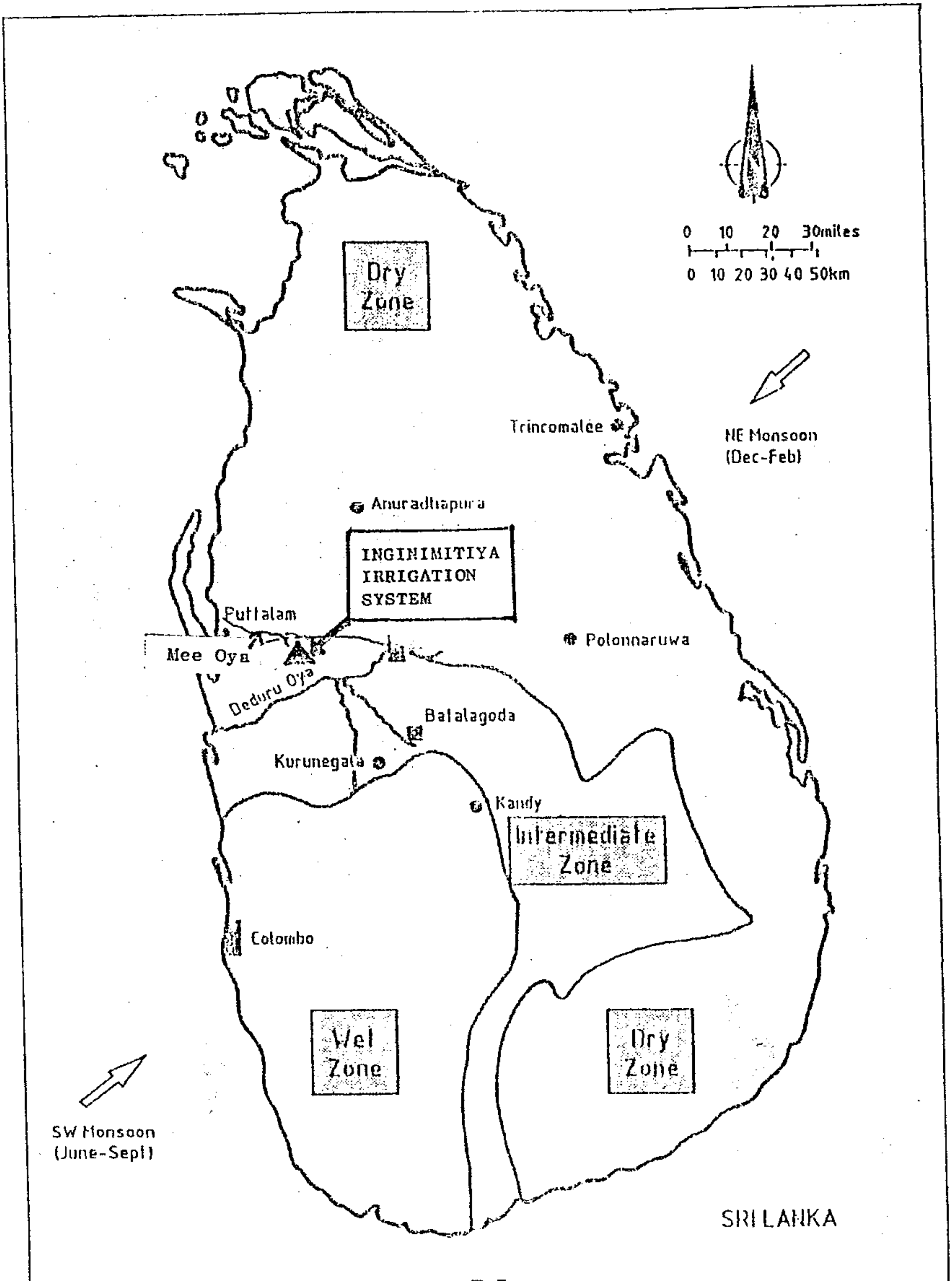
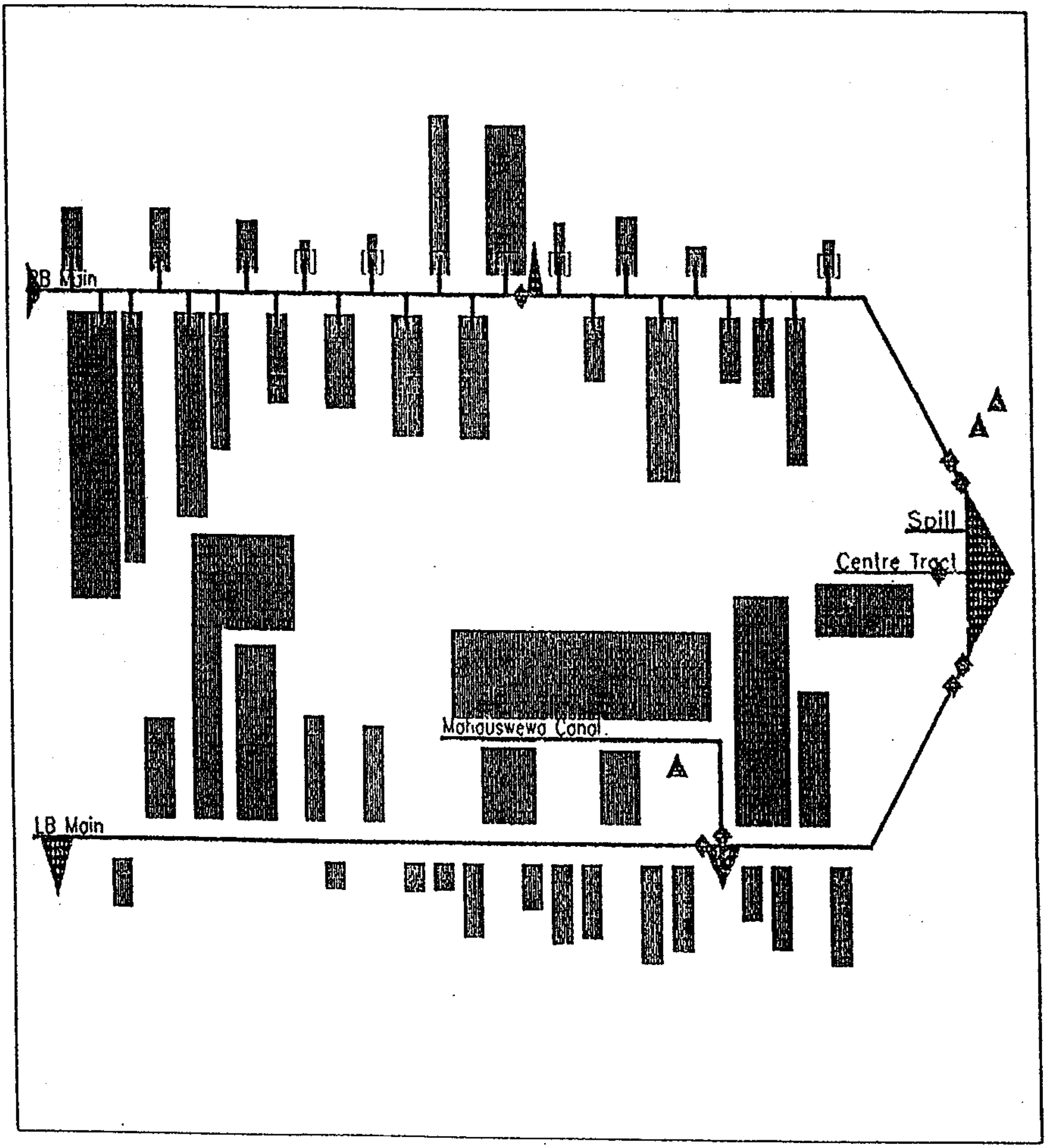


Figure 2 Lay-out of the Inginimitiya Irrigation System



Means of mass communication has been poor. Those who have reported of reading news papers was 18% of the population. Participation in formal social organizations has been very poor.

Eighty seven percent (87%) of the population has been dependent on agriculture to earn an income. The annual income of 74% of the population has been less than Rs. 3600. Due to the inability to cultivate both seasons most people have been unemployed part of the year.

Average size of a paddy holding has been 2.63 acres and that of high land 1.52 acres. In 1980 only 5.9 acres of paddy had been cultivated in the *yala* season and 1719 acres (98% of cultivable) of paddy land had been cultivated in the *maha* season. Crop failures have been frequent due to inadequacy of water. The average paddy yield in 1980 *maha* has been as low as 24.5 bushels per acre.

Cultivation of non paddy crops (vegetables, pulses, chilies, root crops) in home gardens have been widely prevalent. These crops have been grown for commercial purposes, where 91% of the production has been sold.

Chena cultivation has been highly prevalent. The average extent of chena lands have been 3.83 acres. About 71% of the chena product too has been sold.

The above described socio-economic status of the IIS indicates a community under poverty, comparatively illiterate, socially less organized, semi-commercialized, having no experience on large scale irrigated farming prior to commissioning of IIS. With such socio-economic status 10 years back it should not be expected that innovations of any nature to be readily adopted.

1.3.3.3 Management Structure of IIS

The management structure of IIS is based on the concept of farmer participatory management. Each field channel is used as the basis for a three tiered system (field channel/ distributor channel and irrigation system level) of representation by elected farmer leaders. This organization is expected would provide a reciprocal flow of information required for system water management, between farmers and the system management officials and facilitate the implementation of seasonal water management plans.

There are few studies that have examined the strength and weaknesses of above management structure (Athukorale and Athukorale, 1990). A study has been done on one of the crucial decision making institution - the meeting[1] - (Murray-Rust and Moore, 1983) which is part of the above management structure. These studies have shown the inadequacies of the management structure in the flow information and decision making process. The success of adopting CIMSS is crucially dependent on the availability of reliable and timely information. Hence it is necessary to assess the adequacy of the prevailing management structure in providing such information.[2]

1.3.3.4. Water Use and Cropping Practices by Farmers in IIS

The water use information and the cropping pattern of IIS since commissioned is given in table 1. It indicates of poor performance of IIS. Of 14 seasons there has been no cultivation at all in 4 seasons. Surprisingly 3 of the four uncultivated seasons have been *maha* seasons. Farmers reported that there were severe droughts during these periods. However this indicates that those farmers who had been cultivating a *maha* season under minor irrigation systems in the past have been deprived of such cultivation upon commissioning of IIS. Of the 10 seasons that has been cultivated the cropping intensity has ranged between 10% to 80%. In 6 seasons the cropping intensity has been less than the cropping intensity that was planned (see figure 3). In the IIS project feasibility study it has been targeted that:

> " with the commissioning of the project it would guarantee at least 85% cropping intensity in *maha* paddy cultivation and 70% cropping intensity in *yala* cultivation."

The predominant crop that has been cultivated in IIS is paddy (even in *yala*). The next most cultivated crop has been chili, which by having long growth period requires as much water as paddy. Chili cultivation with long growth period had been possible since such land has been fallow in the preceding season allowing early cultivation.

Water sharing arrangements (*bethma*) have been practiced in situations of water scarcity. The experiences with *bethma* based on land sharing has been disappointing, where farmers have not adhered to *bethma* rules (IIMI, 1992a). The currently practiced *bethma* is a form of `sequential cultivation` of cultivating right and left bank command area sequentially over years. This is *bethma* system is locally referred to as pella (sequential) *bethma*.

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[1] *Kanna* meeting is held at the beginning of the season to decide on a seasonal plan. It is attended by farmers and governmental officials who have a role in irrigated agriculture.

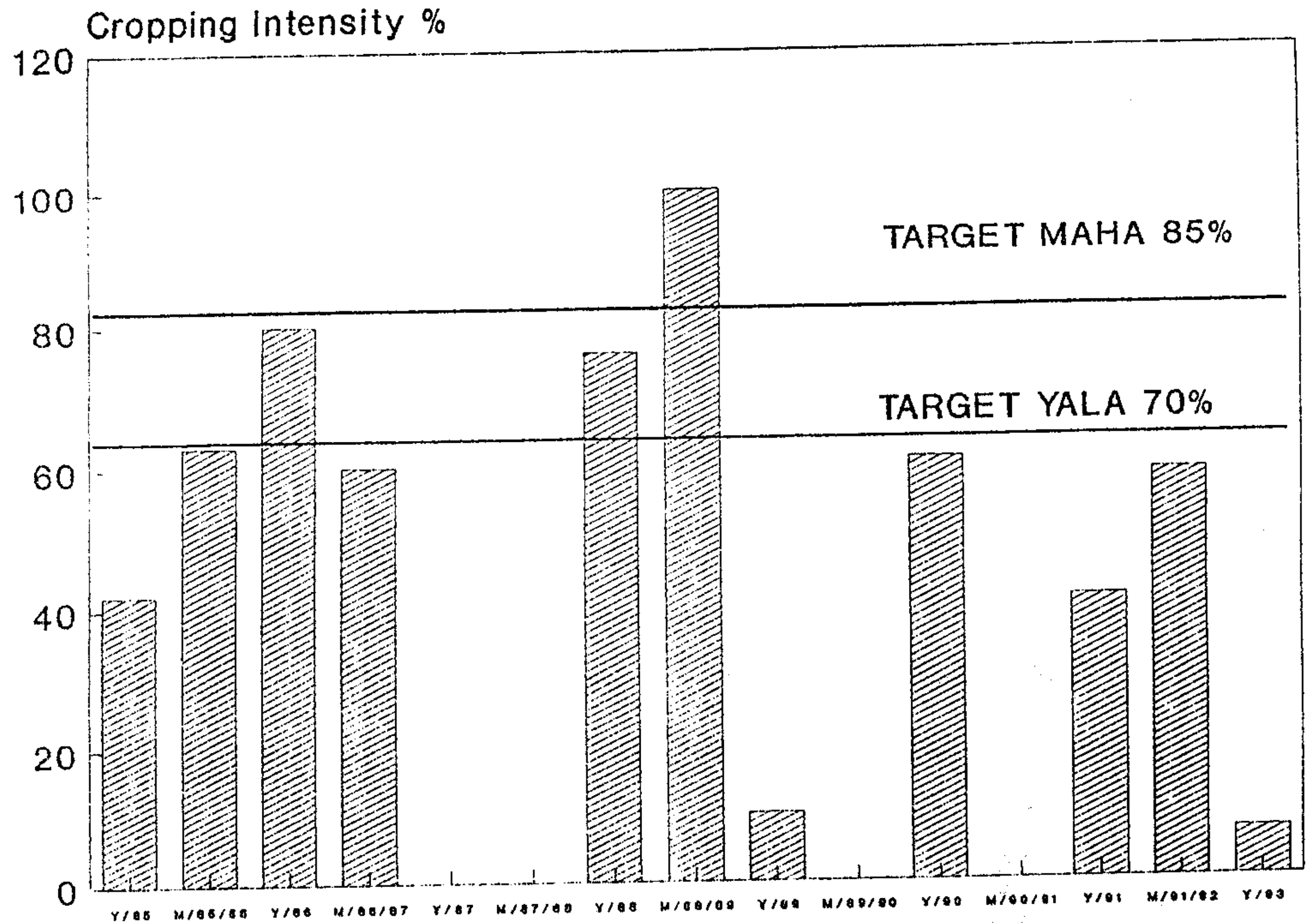
[2] This was examined by IIMI researchers.

Past experiences of water use and agricultural performances indicates the difficulties of managing the IIS. If the water shortages that were experienced in the past are expected to prevail in future, an investigation on a suitable form of *bethma* is imperative to improve performance of IIS. This indicates the potential to use INCA to improve management and thus improve system performance.

Table 1
Cropping Pattern and Water Use in IIS

Season	Area Planted (Acres)				
	Paddy	Chili	Fallow	Water Use (ft.)	Cropping Intensity (%)
Yala 1985	2784	0	3746	6.04	42
Maha 1985/86	4133	0	2397	6.10	63
Yala 1986	5200	0	1330	7.22	80
Maha 1986/87	3890	0	2640	4.71	6
Yala 1987	0	0	6530	-	0
Maha 1987/88	0	0	6530	-	0
Yala 1988	4680	288	1562	5.88	76
Maha 1988/89	6530	0	0	4.93	100
Yala 1989	0	672	5858	5.11	10
Maha 1989/90	0	0	6530	-	0
Yala 1990	3300	700	2530	6.83	61
Maha 1990/91	0	0	6530	-	0
Yala 1991	2585	0	3945	6.19	40
Maha 1991/92	3850	0	2680	-	59
Yala 1993	165	116		-	7

Figure 3 Comparision of Targeted Cropping Intensities with Actually Achieved Cropping Intensities in IIS



Chapter 2

2. Conceptual Framework

This chapter reviews studies that have assessed the adoption of CIMSS and presents a conceptual frame-work for the assessment of INCA.

2.1. Review of Studies on Assessment of CIMSS

Numerous CIMSS has been developed. A review of the appropriateness of some of these CIMSS is given in Kotagama (1992). The appropriateness of CIMSS has been assessed in terms of:

[1] the degree to which CIMSS have been able to use available knowledge on technical and socio-economic aspects of irrigation and

[2] the degree to which these CIMSS have been capable of integrating the technical and socio-economic aspects of irrigation management.

The assessment has been based on comparing available models to a theoretically ideal model of irrigation management in a diversified cropping system. Kotagama (1992) has concluded that realism in modelling technical aspects of irrigation management has been traded off with realism of modelling socio-economic aspects of irrigation management and vice-versa. Available models are specialized models in a single aspect of the irrigation management problem and often does not enable realistic use.

Juriens (1993) has presented a state-of-the-art review on CIMSS. Its mentioned referring to 3 earlier reviews on assessing CIMSS:

> "All three reviews concluded that there are surprisingly small number of irrigation programs that are up to standard, complete and available, quick to learn and easy to use."

All reviews and assessments on appropriateness of CIMSS are either comparisons with a theoretically ideal model or subjective expert opinion on appropriateness. There has not been much pilot testing of CIMSS. One such study had been done by Bird and Zainudeen (1989) at the Hakwatuna oya irrigation system in Sri Lanka to pilot test INCA. In this pilot study Bird and Zainudeen (1989) has only considered physical parameters of water adequacy, equity, variability, water losses etc., in measuring the performance of the irrigation system upon the use of INCA.

There has not been any study (to authors awareness) that has considered quantitative socio-economic performance indicators to study the appropriateness and choice of CIMSS. Hence there is no conceptual guidance available to conduct such studies. Therefore the next section discusses the difficulties and possibilities of using socio-economic performance indicators to study potential for sustained adoption of CIMSS.

2.2 Conceptual Framework for Socio-Economic Assessment of CIMSS

An objective of this study is to assess the potential for sustainable adoption of INCA CIMSS. Economics of information deals with the question of selecting that information system (CIMSS is an information system with a specialized purpose of providing information for improved irrigation system management) from among many systems which will provide largest benefit over time (Eisgruber, 1978). However neither theory nor methodology exist to address adequately the economics of information to objectively choose an appropriate information system (Eisgruber, 1978). This is due to the following factors.

[1] There is no market price for public information (such as produced by CIMSS).

[2] Information is a service thus valuation is much more difficult than of valuing tangible physical goods or technologies.

[3] The impact of information use often can not be clearly measured.

[4] Often public and private value of information could differ. CIMSS provides a public good. The service it provides, ones provided will be publicly available.

CIMSS facilitates the process of collecting and recording data, analyzing that data and changing of beliefs of managers. Thus it would have the following three components.

[1] Collecting and recording data,
[2] Processing data and
[3] Decision making.

The effectiveness of a CIMSS would depend on the effectiveness of all three components simultaneously. A restriction in one component will restrict the effectiveness of the whole CIMSS.

Information from CIMSS must cause a change in the beliefs of managers such that future courses of action that could give higher performance could be selected. Therefore CIMSS could be considered as a technology that creates an output of value of increased performance of the system. Thus assessing the impact of adoption of CIMSS could be viewed as assessing improved performance due to a change in the system management. Hence it is associated with all problems of assessing performance of irrigation systems (Kotagama,1992) and particularly in desegregating improved performance attributable to the use of CIMSS.

In the real world it is seldom that information concerning a set of management actions is obtained from one source such as a CIMSS. Learning is seldom an on-off event. Beliefs are developed through a long process of sorting information from many sources and is effected by previous experiences. Thus it is not possible to restrict the change in belief undergone by the irrigation manager to that associated with obtaining of the information from the CIMSS being assessed.

Theories that provides guidance to develop conceptual frame-work and methodologies to assess the adoption of agricultural technologies which are privately used are well developed (Rogers and Shoemaker, 1971). Studies on aspects of adoption of agricultural technology is abundant in Sri Lanka and elsewhere (see Sivayoganathan, 1982 for references). However most of these studies have addressed adoption of technologies from a static point of view based on cross sectional studies. These studies have not adequately addressed the issue of sustainability of technological adoption. The same applies to assessment of adoption the potential for sustainable of CIMSS.

Developing a conceptual framework to assess the sustainable adoption of CIMSS is novel and challenging. Although there are conceptual approaches that have been proposed in economic theories on information (Eisgruber, 1978) their empirical application requires considerable time and effort for collecting of data and analysis which may not exceed the benefits of such an analysis. Hence this study has taken a simplistic pragmatic approach to assess the potential to sustainably adopt INCA CIMSS.

Sustainable adoption of an technology is assured if a technology is technically sound, financially accessible, socio-economically acceptable. A technology that is technically sound may not be adopted if socio-economically unacceptable. However the concern of this study is confined to examine the potential for sustainable adoption of CIMSS from a socio-economic point of view only. It is assumed that INCA is technically sound and financially accessible to potential users. Thus this study examines the following.

[1] Whether there exists social circumstances in the IIS that could adopt INCA.

[2] Whether the use of INCA could provide economic benefits for sustainable adoption of it.

A CIMSS as mentioned earlier stores and analyses data relevant to the irrigation system thus aids management decision making. It's successful adoption thus requires input of relevant, adequate, reliable, timely data and a management organization to take appropriate decisions and implement those decisions. Provision of irrelevant, inadequate, unreliable, untimely information would provide misleading guidance to management decision making. Therefore the successful adoption of INCA would depend on the availability of sustainable management organizations that could meet above needs of provision of input data and use of output information to improve management.[3]

The economic benefits of the use of INCA would be an improvement in management of the system thus improved performance. It is expected that the use of INCA would improve water use efficiency, water supply reliability and timeliness and equitable water supply.[4] These factors in turn would result to increased agricultural production and farmer income. Hence from an economic point of view the value of the use of the soft-ware can be estimated as the increased net system income (and its distribution).[5]

A limitation of the above analytical approach would be that like many other studies on adoption of technology this study would be based on cross sectional data and would not permit make sound conclusions on the sustainability of the use of the INCA. Assessment of sustainability could be assessed adequately by doing cohort studies or temporal data analysis, on with and without use of CIMSS.

2.3 Objectives of the Socio-Economic Study

Following were the objectives of the socio-economic study.

[1] Primary objective: Measure performance of the irrigation system with and without the use of INCA in IIS and assess the potential for sustained use of INCA CIMSS.

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3 Another component of the project conducted by IIMI researchers have examined this aspect.

4 Physical performance measures of water adequacy, and reliability of supply were to be conducted by IIMI researchers as a component of the project.

5 In this regard it is necessary to establish past performance of IIS in order make allowance for improvements or deterioration or improvement of performance that occurs without the use of INCA.

[2] Secondary objective: Surveying farmer attitudes, skills and knowledge on planning and operational procedures of irrigation system water management in IIS to provide input to INCA and to guide decision making on water management in IIS.

2.4 Method of the Socio-Economic Study

The work schedule that was planned for the socio-economic study is given in appendix table 13. The study was planned to conduct 4 questionnaire based sample surveys.

[1] The first survey was done to document base-line socio-economic status of farmers "without use" of INCA and also to find preference of farmers on water management plan for IIS. It was conducted prior to the use of INCA.

[2] The second survey was done to examine farmer attitudes and knowledge on water management.

[3] The third survey was planned to be conducted whilst INCA was being used during the cultivation season to examine problems during the process of using INCA.

[4] The fourth survey was planned to assess the performance of IIS "with use" of INCA.[6]

The sample surveys were based on a stratified random sample. Stratification was based on areas of farmer organizations which are closely congruent with hydrological boundaries of the water distribution channel net-work. A sample of 60 farmers were interviewed by three graduate research assistants. Participant observation were done to examine farmer behavior in water use during the cultivation season. In addition to the farmer surveys observation made by author and research assistants during field visits were used in the analysis.

The above work schedule though planned was not fully implemented since INCA was neither effectively used for planing nor operation of water management in IIS during project period. Hence the objective of the socio economic study was changed to examine reasons for not adopting the use of INCA from a farmers socio-economic perspectives and to assess the economic performance of IIS in *yala* 1993.

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[6] The third and fourth surveys were not done as planned since INCA was not used either for planning or operation of water management of IIS in *Yala* 1993.

2.5 Organization of the Report

The study reports in chapters 3,4,5 activities that were done on expectation that INCA would be used. Hence chapter 3 documents base line information on socio-economic status of farmers that could be used as a basis to compare the improvements in socio-economic parameters upon use of INCA. Chapter 4 provides an analysis on farmer opinions, attitudes and practices in crop and water management to be used as input to INCA and guide decision making on system water management. Chapter 5 reports the preference of farmers on seasonal water management plan to guide input data to INCA. Since INCA was not used the study objective was changed and chapter 6 instead of reporting the performance of IIS upon use of INCA now reports performance of IIS without use of INCA and attempts to analyze why INCA was not used from farmers socio-economic perspectives.

Chapter 3

3. Baseline Information on Socio-economic Status of Farmers

Prior to use of INCA

This chapter provides a brief description of socio-economic status of farmers prior (i.e. 1992/1993 *maha*) to use of INCA (without use). The socio-economic status of 1993 is compared with the socio-economic status prior to the commissioning of the IIS in 1982.

The purpose of the description of farmers socio-economic status is to document the trend of socio-economic performance of IIS. The performance of IIS with sustained use of the INCA could be compared with the natural long term trend of system's socio-economic performance (in terms of selected economic indicators such as income) to estimate the net improvement in performance due to use of INCA in the long run.

3.1 Socio-Economic Status of Farmers

3.1.1 Demographic Characteristics

3.1.1.1 Family Size

The family size in 1993 in the Inginimitiya Irrigation System is 4.7 individuals per family. The family size had been the same 4.7 in 1982 (Statistics and Planning Division, 1982).

3.1.1.2 Age Distribution

The distribution of the sample according to age categories in 1993 and 1982 are given in table 2. It is found that population in the working age category (15-60 years) has increased overtime.

Table 2
Distribution of Population According to Age Categories

Age Category	Percent persons in total sample	
	1982*	**1993**
Less than 15 years	42.3	27.9
16 years to 60 years	57.7	68.2
More than 61 years	2.0	3.9

* ***Source:*** *Statistics and Planning Division (1982)*

3.1.1.3 Male:Female Ratio

The male:female ratio in 1993 is 1:1.15 whilst it has been 1: 0.9 in 1982.

3.1.1.4 Educational Status

The educational achievements of the sample is given in table 3. Compared to 1982, where 85% had received education up to 8th grade and 1% receiving university education (Statistics and Planning Division, 1982) the educational level of the farmers have improved, by 1993.

Table 3
Educational Achievements of Sample Above 5 Years

Educational Level	% of Persons
No schooling	4.6
1-3 years	14.5
4-8 years	47.7
9-ordinary level	24.1
Ordinary level to Advanced Level	6.9
University	2.1

Further 15.7% of the farmers have received informal training on agriculture related aspects. Of the 15.7% who had received informal training 36.8% have received training on water management, 35.8% on home gardening and 25.3% on animal husbandry.

The high literacy level of farmers indicate generally the possibility of higher participation in water management activities. They could also be expected to effectively participate in measuring and recording data required as input to INCA.

3.1.1.5 Employment Pattern

In considering employment pattern of individuals above 18 years (table 4) a trend of moving away from farming is found. About 10.2% of the population is employed in non-farming activities.

Table 4
Employment Pattern

Employment Type	% Persons
Farming	77.7
Teaching	1.7
Security forces	3.4
Other public sector employment (irrigation, postal service)	1.1
Vehicle driving	1.7
Other private employments	2.3
Unemployed	9.5

3.1.2 Income

In 1982, 74% of the families had derived a monthly income of less than Rs. 300, 21% of families Rs. 300 to 800 and 5% of families more than Rs. 800. When the 1992 values[7] equivalent to these income levels are considered 2% of families are earning under Rs 898 and (equivalent to Rs.300 in 1982) 37% of families earn Rs.898 - 2394 (equivalent to RS.300-800 in 1982) and 61% of families earn more than Rs.2394. This income includes grants provided by the government, such as the *Janasaviya* grants.

3.1.3 Land Tenure

3.1.3.1 Land Holding Size

The average land holding size of different land types in 1993 is given in table 5. It is apparent that although the average extent of *chena* has reduced since 1985 there is yet a substantial extent of *chena* cultivation around the IIS. The involvement in *chena* need to be considered in planning of water management of IIS.

Table 5
Land Holding Size

Land Type	Average Extent Acres
High land	1.04
Low land	3.01*
Chena	2.04

*** Note :** *The sample consisted of one respondent owning 20 Acres of low land The average size falls 2.76 Acres when this respondent is not considered.*

7 By converting Rs. 300 and Rs. 800 to current values (1992) using consumer price index.

3.1.3.2 Nature of Land Tenure

Nature of land tenure is given in table 6. A significant extent of low land is owned jointly.

Table 6
Nature of Land Tenure

Type of Tenure	% Land Over Total in each Land Type		
	Land Type		
	Low Land	High Land	*Chena*
Singly owned (LDO)	88.9	92.8	0.0
Jointly owned	11.1	7.2	0.0
Encroached	0.0	0.01	100.0

Chapter 4

4. Farmer Opinions, Attitudes and Practices in Crop and Water Management

This chapter provides an analysis on farmer opinions, attitudes and practices on water management to provide guidance to decision making on system management with use of INCA.

4.1 Preferred Crops and Criteria Considered to Decide on Crop to Cultivate

It is essential to know preference of farmers crops to be cultivated for pre seasonal planning of system water management. Preference of farmers on crops depend on many factors such as technical aspects of soil suitability, water availability, occurrence of pest and diseases, economic aspects of profit margins, cash requirements to purchase inputs, labor requirements and social aspects of family and community preferences. On this presumption farmer preference on crops (particularly non-paddy crops) was inquired. In addition the criteria that are considered in deciding on crop to be cultivated was inquired.

Farmers were asked whether they had cultivated non-paddy crops in the irrigable land in the previous year. It was found that water was issued only to left bank to cultivate non-paddy crops in the previous year. Of those farmers of the left bank 93% had cultivated non-paddy crops. The information on non-paddy crops that had been cultivated are given in table 7.

Table 7
Non-Paddy Crops that had been Cultivated

Crop	% Reporting
Chili	60
Gherkin	15
Onion	8
Pulses	8
Vegetables	8

The most cultivated non-paddy crop has been chili. Recently there has been an increase in the cultivation of high cash earning crops as gherkins. Gherkin is a crop that has been recently introduced to Sri Lanka (perhaps 1986)[8].

Eighty five percent cent (85%) of the farmers have reported that they consult other farmers in deciding on the crop and variety to be cultivated. Of those who do not consult other farmers in deciding of the crop to be cultivated 5% had their own water source and 10% had kept their own seeds. It is seen that farmers collectively agree on the crops to be cultivated.

Farmers (86.7%) are willing to cultivate non-paddy crops in situation of water scarcity. The priority of preference on non-paddy crops is ranked[9] in the descending order of priority as follows.

[1] Chilies
[2] Pulses
[3] Onion
[4] Gherkin and
[5] Vegetables

The main factor that is considered by farmers in selecting crops is given in table 8. Thus it is reasonable to consider profit maximization as the criterion that farmers consider to decide on a cropping pattern.

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8 Agronomic information particularly on aspects related water requirement may not be found locally.

9 The ranking was obtained by giving a weight of 5 for the most preferred and 4 for the second most preferred, and so on for 5 crops. These weights were then averaged for each crop. The averages were considered for ranking.

Table 8
Main Factor Considered in Deciding on Crop to Cultivate

Factors Considered	% Farmer Reporting
Profit margin	88.3
Possibility to use water efficiently	6.7
Previous experience in growing the crop	1.7
What neighbors cultivated	1.7
Convenience in cultivation	1.7

4.2. Land Preparation

Timely land preparation, with minimal use of stored water (ie. by use of rain water) has been encouraged for efficient use of water in reservoir. In IIS only 7% of the farmers commence preparatory tillage with the expectation of rains prior to water issues from the reservoir. Twenty four percent (24%) of farmers commence preparatory tillage after rains but before issues of water and 69% of farmers commence land preparation after water issues from the reservoir. The reason given for commencing land preparation after water issue from the reservoir is to avoid risks (61%) of water being not supplies for the whole season and shortage of tractors and buffalos to prepare land (8%).

Seventy five percent (75%) of farmers reported that they have been able in the past to complete land preparation along with others in the track. The reasons for the delay of land preparation as reported by 25% of the farmers are given in the table 9.

Table 9
Reasons for Delay in Land Preparation

Reason	% Farmers Reporting
Lack of water at required time	53
Lack of sufficient quantity of water	24
Lack of sufficient labor	6
Lack of cash to hire tractor or buffaloes	19

The average time taken for land preparation for paddy and non-paddy crops are 25 and 11 days respectively. According to farmer opinion paddy and non-paddy crops require 3 supplies and 1 supply of water respectively for land preparation. Seventy nine percent (79%) of farmers mentioned that more water is required for land preparation when land is fallowed in the previous season.

Fifty seven percent (57%) of farmers begin *chena* cultivation before commencing land preparation in irrigated land. This need to be seriously considered in planning water scheduling in IIS since *chena* cultivation is a dominant activity.

4.3. Planting

The ability to complete planting along with others in a tract is important to make the best use of scheduled water supplies. Seventy two (72%) percent of the farmers have reported the possibility to complete planting together with others in the tract. Among the 28% of farmers who gets delayed in planting 13.8% have reported the lack of water availability at planting as the reason for delay in planting, 8% as lack of sufficient quantity of water, 6% as inability to find seeds at the required time.

On the average farmers have reported of needing 26 days and 14 days for planting of paddy and non-paddy crops respectively.

4.4. Fertilizer Use

Optimal water availability at fertilizer application is technically required for optimal fertilizer use.

Ninety three percent (93%) of farmers and 80% of farmers have reported of the need of having water in the field at fertilizer application for paddy and non-paddy crops respectively.

Twenty seven percent (27%) of the farmers have reported the lack of water at fertilizer application as a problem they have faced in the past.

4.5. Weed Control

Manual and mechanical weeding generally requires more water in the field than chemical weeding. Among the sample farmers 82% do chemical weeding, whilst 12% do both chemical and manual weeding. Only 7% of the farmers do manual weeding alone.

Forty two percent (42%) of the farmers reported of maintaining high water levels in paddy fields to control weeds.

4.6. Pest and Disease Control

Ninety seven percent (97%) of the farmers have reported of pest and disease occurrence in the past. Of these 97% farmers 11.7% feels that water inadequacy as a cause of pest and disease problems.

4.7. Labor Use

More than 83% of the farmers do their cultivation practices by using only family labor. Ninety percent of the respondents reported that he/she personally attended the water management at the farm. Sixty three percent (63%) of the farmers stay in the field till the whole field is irrigated.

4.8 Water Management

4.8.1 On-farm Water Management

Fifty eight (58%) percent of the farmers have reported of receiving adequate water in the past. According to the 42% of farmers who reported inadequacy of water the severity of water shortage according to stage of crop growth is indicated in table 10.

Table 10
Severity of Water Shortage According to Crop Growth Stage

Crop Growth Stage	% of Farmers Reporting
Land preparation	31.7
Seedling stage	7.3
Vegetative stage	17.1
Ripening stage	43.9

According to the ranking[10] by farmers on causes for water shortage following is the descending order of importance on causes for water shortages

(1) Low water level in the reservoir
(2) Damaged control structures
(3) Defects in channels
(4) Wasteful use of water by farmers and
(5) Illegal water tapping

According to farmers water scarcity is due lack of water at the reservoir and water scarcity was felt most at the late stages of crop growth.

Sixty five (65%) percent of the farmers reported that they received water in the time required.

The criterion on which farmers decide to stop irrigating their fields is given in table 11. It is apparent that farmers decide to stop irrigation in consultation with other farmers.

Table 11
The Criteria on Which Farmers Decide to Stop Irrigating a Field

Criteria	% Farmers Reporting
Irrigate the field as long as water is issued	8.3
Share (stop) in consultation with other farmers	58.3
When water reaches a certain depth above soil for paddy (3")	28.3
Irrigate till all high spots in spots in the field are covered	5.0

Eighty two (82%) percent of the farmers reported that in situations of water scarcity they left part of the crops un irrigated whilst irrigating the other part. This can be generally interpreted as the majority of farmers irrigate crop close to the technically optimal water requirement, when water is available.

[10] In the ranking a weight of 5 was given to the most important and a weight of 4 was given to the second most important. Thus only 5-1 weights were given to each reason and weights were then totaled and the ranking was done according to total weights.

Ninety six percent (96%) of the farmers reported that if there was a shortage of water they would give priority to irrigate some crops over the others. Of the above percentage 93% reported that they would first irrigate the high income generating crops and 3% reported that they would first irrigate the crops that did not receive water in earlier application.

4.8.2 Water Management at the Field Channel

In sharing water at the field channel level, tail end farmers receive water first (93% farmers reporting) but in few channels all farmers (7% farmers reporting) receive water simultaneously. Seventy seven percent (77%) of the farmers responded that water sharing arrangements at the field channel level as fair.

4.8.3 Water Management at the Distributor Channel

The method of water sharing within a distributor channel according to farmer reporting is keeping some field channels open whilst others are closed (58.3%). In most cases (41.7%) the field channels at the tail end of distributor channels are kept opened first, in fewer cases (16.7%) the field channels at the head end of distributor channels are opened first. According to 41% of farmers all field channels are kept open simultaneously. Seventy five percent (75%) of the farmers consider that water sharing arrangements at the distributor channel level as fair.

4.8.4. Water Management at the Main System

The water rotation adopted at the main system was considered as fair by 85% of the farmers.

Ninety two (92%) percent of the farmers agreed to adopt a change in water rotations if it increased system income. However, 88% of these farmers responded that they would not adopt such a change if their individual income dropped.

The frequency of occurrence of illicit activities in water use in the system as responded by the farmers is given in table 12.

Table 12
Frequency of Occurrence of Illicit Activities

Activity	% Farmers Reporting		
	Often	Sometimes	Never
1. Unauthorized opening of gates	18	33	49
2. Making illegal inlets to field	12	33	56
3. Obstructing channels	20	22	46
4. Threading other farmers to get extra water	11	28	61
5. Threatening officials to get extra water	2	13	86
6. Interference through politicians to get extra water	2	17	82

The prevailing condition of the channel system as perceived by the farmers are given in table 13. Majority of the farmers consider the channel system in fair to good condition.

Table 13
Condition of the Channel System as Perceived by Farmers

	% farmers reported		
	Highly Damaged	Fair Condition	Good Condition
1. Main channel	22.2	46.8	31.0
2. Distributor channel	25.0	54.2	21.0
3. Field channel	29.4	41.4	30.0

4.8.5 *Bethma* Water Sharing

Eighty four percent (84%) of farmers of farmers preferred to adopt a *bethma* water sharing in situations of water shortages. Table 14 gives the farmers (of the 84% preferring to adopt *bethma*) preference on different types of *bethma*.

Table 14
Preference of the Farmers on the Type of *Bethma*

Bethma Type	% Farmers Reporting
(1) Intermittent cultivation of areas between seasons.	
i. Left bank and Right bank	67
ii. Upper and lower part of command area	2
iii. Distributor channel command areas	0
iv. Field channel command areas	0
(2) Share cultivation of areas	
i. Upper and lower part of command area	5
ii. Distributor channel command area	10
iii. Field channel command area	0
(3) Cultivation of part of own farm	0

Farmers prefer intermittent cultivation of left and right bank in consequent seasons (*pella bethma*). This is mostly due to the convenience and reduced risk to farmers. This also allows to cultivate paddy which is highly preferred by farmers in IIS.

The next preferred *bethma* method is share cultivation of parts of the command area. This method has the difficulties of high transaction cost in organizing farmers to share land.

The reasons for not preferring *bethma* by 16% of the farmers is due to unacceptable land sharing arrangement (8%) and the misuse of the land by those sharers who do not own the land (8%)

4.9 Farmer Organizations

The sustained use of computer based management software requires strong farmer organizations to provide information required by the software and also to implement management decisions.

Ninety three percent (93%) of the farmers know the distributor channel level farmer organization leader, whilst only 58% of the farmers know the field channel level farmer organization leader.

Farmers assessment on the successfulness of farmer organizations on various activities is given in table 15. Majority of the farmer consider farmer organizations as successful in relation to facilitating water management activities.

Table 15
Farmer Assessment on Farmer Organizations

Activity	% Farmers Reporting		
	Extremely Successful	Moderately Successful	Un-Successful
1. Regulation/sharing of water	49.15	35.59	15
2. Resolving irrigation conflicts	31.00	51.72	17.28
3. Liaising farmers with officers	44.80	32.75	22.43
4. Planning seasonal irrigation activities	32.20	44.00	23.00
5. Implementing seasonal irrigation activities	40.30	33.33	26.30
6. Supplying of inputs other than water	-	3.50	96.49

Eighty percent (80%) of the farmers believe that farmer organization cannot function without governmental support.

4.10 Liaison with Government Officers

According to 54% of the farmers the government officer most met is the institutional organizer, second most (25% farmers reports) met is work supervisors and third most (22%) met is the technical assistants of the irrigation department officers. Meeting of officers from other agricultural related departments/institutions was not mentioned. The most preferred (62.5% farmers reported) officer to resolve irrigation problems was the institutional organizer.

4.11 Information Sources

Seventy five percent (75%) of the farmers reported of reading newspapers. Of those reading news papers 35% read news papers daily, 33% read weekly and 6% occasionally. About 50% of the farmers read newspapers at shops. This indicates that irrigation related information could be effectively communicated to farmers by displaying such information at shops.

At present farmers receive information on water issues mostly (80% of farmers reporting) at the *kanna* meeting, 14% from officers and 6% from notices.

Chapter 5

5. Reference of Farmers on Water Management Plan for *Yala* 1993

The feasibility of INCA in improving system management depends on the relevance, accuracy and timeliness of data that is used as input. If data that is not agreeable to farmers are used as input then output information will be non-agreeable to farmers. Hence to assess the potential for sustained adoption of INCA it is necessary to test the relevance and accuracy of input data.

The input data for seasonal management planning is obtained through farmer organizations, by a sequence of meetings between system management officials and farmer leaders. The input data for the seasonal plan is finalized at the *kanna* meeting on collective consensus between farmers and management officials.

A special workshop (referred to as workshop hereafter) with the participation of farmer organization leaders and irrigation management officers was organized by the project to decide on a seasonal plan for *yala* 1993. It was examined whether the seasonal plan as decided at the workshop and subsequently at the *kanna* meeting was acceptable to farmers. It is based on the scientific premise of proper representation of an population by a random sample.

The questions in the interview schedule were based on the water management plan that was decided at the workshop. This plan was as follows.

Given that the left bank has priority for water use in *yala* 1993 (since right bank received water during *maha* 1992/1993) and that the available water is insufficient for the cultivation of whole of IIS to adopt following strategies.

[1] To supply water to the left bank only;
[2] To cultivate non-paddy crops;
[3] To provide strict rotations of 2 days of supply and 4-6 days of closure of the main sluice.

In the event that left bank is not cultivated in *yala* 1993 to adopt following strategies.

[1] To provide water for paddy cultivation for the left bank for *maha* 1993/1994.

[2] To allow the right bank to cultivate non-paddy crops with provision of irrigation water at the latter part of *maha* 1993/1994 season if required.

The questionnaire was designed to examine preference of farmers on the above seasonal management plan. A sample of 60 farmers were interviewed based on a stratified sampling procedure. Stratification was done on the basis of farmer organization jurisdiction that was closely congruent with hydrological boundaries of the water supply channel net-work.

5.1 Preferences of Left Bank Farmers on Seasonal Water Management Plan

Among the farmers of the left bank preference was almost equally divided between foregoing *yala* 1993 cultivation of non-paddy crops for the possibility of cultivating paddy on the entire left bank command area in the next *maha* 1993/1994. Fifty three percent of the farmers were not willing to forego *yala* cultivation, whilst the balance 47% preferred to forego *yala* 1993 cultivation and cultivate paddy in full command area of left bank in *maha* 1993/1994.

The reasons to prefer the cultivation of *yala*, according to farmers who reported preference was that they required some form of cultivation to sustain life (17%) and the balance 36% believed that cultivation of non-paddy crops would be profitable during *yala* 1993.

The most preferred crop for cultivation as expressed by those who preferred to cultivate *yala* were as follows: Chilies 43%, paddy 23%, gherkin 13%, onion 10%, Pumpkin 7% vegetables 5%. It is found that farmers prefer the cultivation of high cash crops.

The preferred *bethma* system, within the left bank command area, is the cultivation of the upper half of the distributor channels (78% of the farmers reporting). The other *bethma* suggestion as reported by 22% of the farmers was to share cultivate the upper and lower parts of the left bank command area.

All the farmers who preferred to cultivate paddy in the left bank opted to cultivate non-paddy crops if they would be given priority of water supply to cultivate paddy next *maha* 1993/1994.

It was found that most farmers prefer to begin land preparation middle of March and complete by mid April. Mid april coincides with sinhala and tamil new year when farm work is not done. Early land preparation is possible since these land were not cultivated in the previous *maha* 1992/1993 season.

As related to above farmers prefer first issue of water for land preparation in mid march to end of March. Farmers apparently prefers to prepare land with use of water in the reservoir. This is because higher quantities of water is required to plough land that had been fallowed.

The preferred interval between two water supplies is 5 to 6 days. The preferred period of a single supply was not directly mentioned. As indicated rightly by 63% of the farmers it should be decided depending on the extent cultivated.

5.2 Preferences of Right Bank Farmers on Seasonal Water Management Plan

Of the right bank farmers 58% were willing to forego next *maha* 1993/1994 cultivation to allow for left bank to cultivate paddy, if left bank would not be able to cultivate *yala* 1993. This indicates that farmers have a favorable attitude to sharing of water fairly.

Of the 42% who did not agree to forego *maha* 1993/1994 cultivation, the reasons given for their preference was that 50% preferred a water sharing arrangement of distributing water to both banks and 50% responded that they are not willing to forego cultivation of paddy in the *maha* season.

Among the farmers who were not willing to forego *maha* 1993/1994 cultivation 25% were willing to accept the option of cultivating non-paddy crops whilst left bank cultivates paddy in *maha* 1993/1994.

5.3 Summary on Preference of Farmers

Farmers in the left bank are indifferent between cultivating *yala* 1993 with non-paddy crops and foregoing *yala* 1993 cultivation for paddy cultivation in *maha* 1993/1994. Majority of farmers in the right bank are in agreement to the option of foregoing *maha* 1993/1994 cultivation to allow the left bank farmers to cultivate paddy. It is apparent that farmers prefer the option of forgoing *yala* cultivation contrary to the seasonal water management plan proposed at the workshop. Thus preferring cultivation of part (left and right bank) of the command area in alternate *maha* seasons (*pella bethma*). It is preferred by farmers since they could cultivate paddy with assured supply of water. Administering this seasonal plan is also convenient. Hence in a given season neither would the farmers feel a water scarcity nor would the irrigation officials feel an administrative difficult in the management of water.

Farmers have a strong preference to cultivate paddy. Among non-paddy crops farmers prefer to cultivate cash crops such as chili and more recently gherkins. Farmers do not prefer cultivation of most other non-paddy crops (pulses, pumpkin, cucumber etc.) in irrigated land since these are cultivable in *chena*.

The implication of preference of farmers for *pella bethma* with paddy cultivation is that the utility of using INCA may not be appreciated by neither the farmers nor the irrigation officials.

If the farmer preferred form of water sharing (*pella bethma*) of foregoing the cultivation of a season to cultivate part of the command area under assured water supplies in the subsequent season is allowed, INCA may not be adopted. Its adoption will largely depend on convincing farmers on the possibilities of alternate forms of *bethma* and cropping that would benefit farmers than *pella bethma*.

Chapter 6

6. Management of the Inginimitiya Irrigation System in *Yala* 1993 and Farmers' Response

6.1 *Yala* 1993 *Kanna* Meeting Decisions

At the *kanna* meeting held on the 29th of April 1993 (presided by a member of parliament representing Inginimitiya area) following were decided.

[1] To cultivate about 50% of the command area.
[2] To share water by share cultivating land of selected field channels. Two farmers to equally share a farm plot of 2.5 acres.
[3] To cultivate only non-paddy crops.
[4] Not to supply water for land preparation.
[5] First supply of water to be on 20th may 1993 and the last supply of water to be on 25th August 1993.

6.2 Congruence of Actual Cultivation in *Yala* 1993 with *Kanna* Meeting Decisions

This decision taken at the *kanna* meeting was contrary to preference of farmers;

[1] as expressed at the workshop held with the participation of farmers and irrigations officials prior to the commencement of the *yala* season (IIMI, 1993) and

[2] as found through socio economic surveys (see chapter 5).

Perhaps due to the haste in which the seasonal water management plan was decided due to probable influence by a politician, the irrigation management officials were not able to use INCA to aid planning of water management for *yala* 1993. There onwards the INCA was not used to aid operational decision making of seasonal water management too. Thus the primary objective of the project of pilot testing of INCA was not possible.

The Project Manager (who was appointed to IIS at the beginning of the *yala* 1993) was optimistic of successful implementation of the *bethma* system that was agreed at the *kanna* meeting. However by 22 May 1993 it was observed that more than perhaps 90% of the farmers had not cleaned their fields. Resentment was building among farmers on how the seasonal meeting was conducted, (particularly the very short notice that was given on the date of the *kanna* meeting) and the decisions that were taken. Farmers in H6 village did not cultivate. According to the chairman of the farmer organization of that area, to protest against the nature of how the *kanna* meeting was conducted. According to him only 170 farmers attended out of 2393 farmers and this far below the required quorum of 3/5 to take legally valid decisions. As expressed by a farmer leader representing the left bank farmers were dissatisfied of not implementing the seasonal plan the was decided at the workshop.

6.2.1 Observations made at the beginning of the Season

Some farmers disliked on principle the *bethma* system that was proposed at the *kanna* meeting for the following specific reasons.

[1] The farmers in the left bank were particularly unhappy since they were not given priority in water supply despite having foregone cultivation in the previous 1992/1993 *maha* season. The *bethma* system that was decided to be implemented at the *kanna* meeting considered fairness in terms of distributing water equally among farmers at a given point in time. This was contrary to the norm of fairness in sharing water at IIS. The norm of fairness in sharing water at IIS has a temporal dimension, where water is shared over seasons (*pella bethma*).

[2] The destruction of bunds and land level with the cultivation of non-paddy crops. When share cultivated the immigrant farmer (the farmer who share cultivates another farmer's land) tend not cooperate in reconstructing the bands and re-levelling of the field at the end of the season. Hence the land owning farmer has to bear additional costs on reconstructing bands and re-levelling land in the subsequent season. This problem would not arise in the case of cultivating paddy under *pella bethma*.

[3] Some wealthy farmers objected to the *bethma* system since it prevented them from cultivating large extent of land as they have been cultivating in the past and possible under *pella bethma*

[4] Poor farmers who lease-out land did not prefer the *bethma* system since they were thwarted from renting out land that was not supplied with water, and not permitted to be cultivated.

[5] Cattle owners who are generally the wealthy people of the area objected to the *bethma* system since free grazing of cattle was hindered by the proposed *bethma* system of cultivating land spread all over the command area.

The extent that was cultivated in *yala* 1993 was only 452 acres. This is 7% of the total command area of IIS as opposed to the 50% of the command area that was decided to be cultivated at the *kanna* meeting. This is the lowest cropping intensity during a *yala* season since the commissioning of IIS (see figure 3).

The poor performance of the season was mainly due to the inappropriateness of the *bethma* system as viewed by the farmers. According to the participant observations made during the *yala* 1993 following were further reasons for non adoption of the *bethma* system as was observed at the beginning of the season.

[1] Farmers complained of favoritism by farmer organization leaders in selecting land to be allowed for cultivation. Farmers complained of ignoring their opinion on the selection of suitable land for cultivation. Thus farmers made their own arrangements of land sharing with neighbors rather than that was suggested by management officials.

[2] Although land was divided along the water inlet to the field to provide equal access to water and similar soils and land characteristics some farmers complained of receiving the infertile, less productive areas of the land and land owners taking the better parts of the land for cultivation. Such conflicts led to abandoning of cultivation.

[3] The delayed water issues discouraged farmers to begin cultivation due to the belief that late cultivation would lead to crop diseases. Farmers preferred to receive water by mid March as found through socio-economic surveys (see section 3.2.). The tail end farmers particularly did not cultivate since it was expected that it would take at least 2 weeks to a month for them to receive water from the first date of water issues to the head end farmers. It was observed by the first week of July pulses crops were infested with yellow mosaic virus. Whether this was due to the delay in cultivation or otherwise is not technically known but farmers firmly believe that it was due to delayed cultivation.

[4] Most farmers had already begun cultivation of *chena* by the time *kanna* meeting was held and did not wish to forego what was already done and shift to cultivation in irrigable land.

[5] Post planting care (water management and weeding and harvesting) required by non-paddy crops is more and staggered than what is required by paddy. Thus farmers having residence far away from farms did not prefer to cultivate. Instead they preferred to cultivate *chena* where they could be temporarily reside whilst cultivating to care and protect crops.

[6] Non adherence of some farmers to the proposed *bethma* system.

(i) Though paddy cultivation was not allowed by *kanna* meeting decisions 36% of the area cultivated was cultivated with paddy.[11]

(ii) Though the channels that were not to be cultivated and not receive water was sealed with concrete often these were broken and water was taken illegally. Thirteen field channels of the right bank that was sealed were frequently broken despite being complained to the police. In some cases paddy was cultivated amidst non-paddy cultivation thus the paddy cultivations were able to obtain water when water was supplied for non-paddy cultivations. Often paddy was cultivated in the head ends of channels (example D7, where 50 acres was cultivated) and the use of water for paddy lead to shortages of water to the tail enders who cultivated non-paddy crops.

(iii) Some farmers had cultivated more than extent decided to be cultivated. This was done by not sharing land with other farmers.

6.2.2 Observations made during the Seasons

The following weaknesses of the *bethma* system were observed during the cultivation season.

[1] Some farmers had deceived farmer organization leaders and management officials in saying that their field were saline thus uncultivable and opted to share cultivate others land and later had cultivated their own land too under rainfed conditions and illicit tapping of irrigation water.

[2] Farmers were unable to protect crops from cattle damage as crops were cultivated in non contiguous patches leading to high cost of fencing.

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[11] The anger against those cultivating paddy was so high that a farmer organization representative suggested at a project committee meeting that paddy cultivations should be destroyed. The arguments between farmers who cultivated paddy and nd those who cultivated non-paddy lead to uneasiness between the two groups.

[3] High water wastage was observed where in some channels very small extent were cultivated but water had to be sent to these channels too. For example in the left bank D2 channel water had to be taken 1.5 miles to irrigate a mere 1.5 acres. In the D5 and D6 channels only about 2 acres was cultivated, yet water had to be supplied. The timing of water release of opening sluice on Fridays had also lead to water misuse and waste, since management officials were often not in the field to supervise water sharing during the weekends. Farmers who had illegally cultivated paddy were also therefore able to obtain water.

In addition to above specific reasons for non-adoption of the *bethma* system the following factors were also found to be contributory factors for not cultivating a small extent with low potential profit under *bethma*.

[1] Recipients of *Janasaviya* grants were not interested in the cultivation of low profit generating non-paddy crops.

6.3. Economic Performance of IIS in *Yala* 1993

The performance of IIS assessed is assessed by comparing the planned extent, cropping pattern and net system income with the actual *yala* 1993 achievements.

6.3.1. Comparison of Planned vs Actual *Yala* 1993 Extent Cultivated

Figure 4 compares the planned extent (3342 acres) with the actual extent cultivated (532 acres) in *yala* 1993. It is observed that only 16% of the planned extent had been cultivated in *yala* 1993.

6.3.2. Comparison of Planned vs Actual *Yala* 1993 Crop Patterns

Figure 5 compares the planned cropping pattern (that included a mix of cowpea, greengram, blackgram, soyabean, groundnut, gherkin and vegetable) with the actual *yala* 1993 cropping pattern. It is observed that paddy and chili that were excluded from plan has been was dominantly cultivated in *yala* 1993.

6.3.3. Comparison of Estimated of Net system Income of the Plan vs *Yala* 1993 Net System Income

The net system income that could have been obtained from implementing the plan was estimated by simulation. The FAO CROPWAT simulation program was used to estimate the potential yield and observed prices were used to value the yield. The *yala* 1993 net system income was estimated based on a sample survey.

Figure 6 compares the estimated net system income of the plan with the actual net system income of *yala* 1993. It is observed that the actual net system income is only $% of the potential net system income had the plan been implemented.

In considering above three performance indicators it could be concluded that the performance of IIS in *yala* 1993 has been very poor.

Figure 4 Comparision Between Planned Extent
Vs Actual Yala 1993 Extent Cultivated

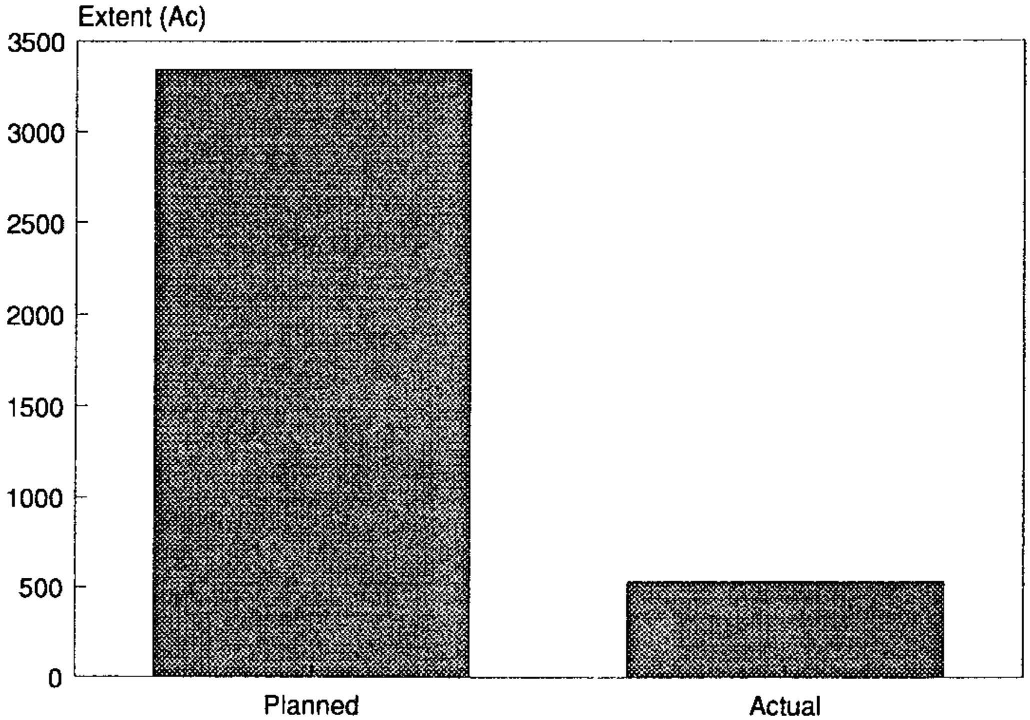


Figure 5 Comparision Between Planned Vs
Actual Yala 1993 Crop Pattern

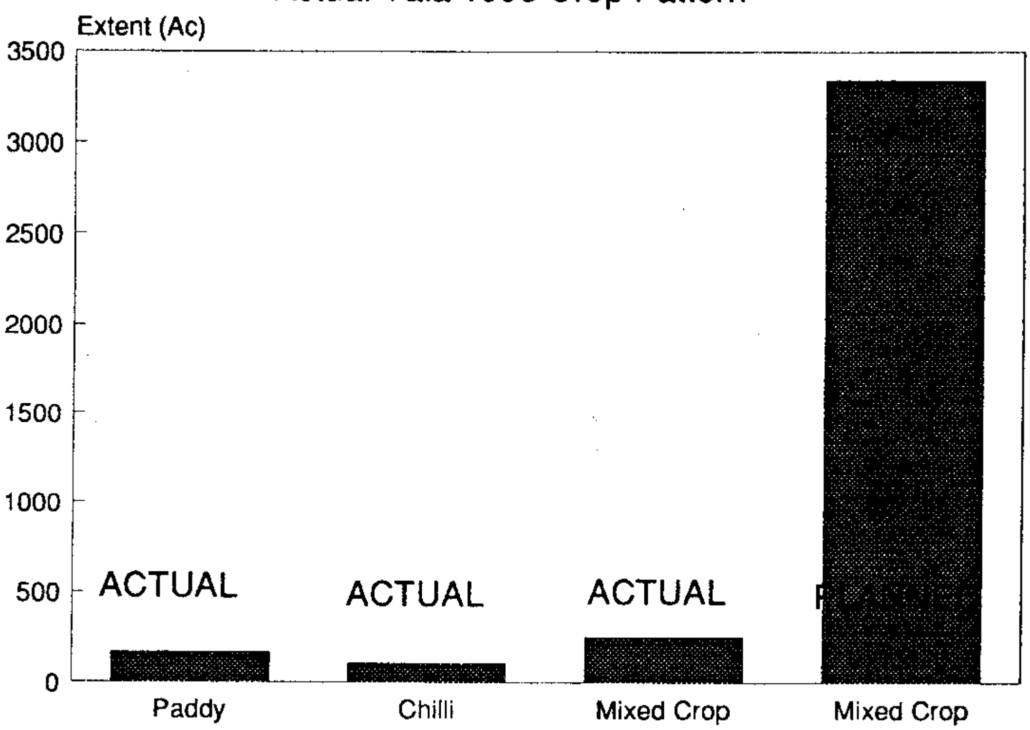
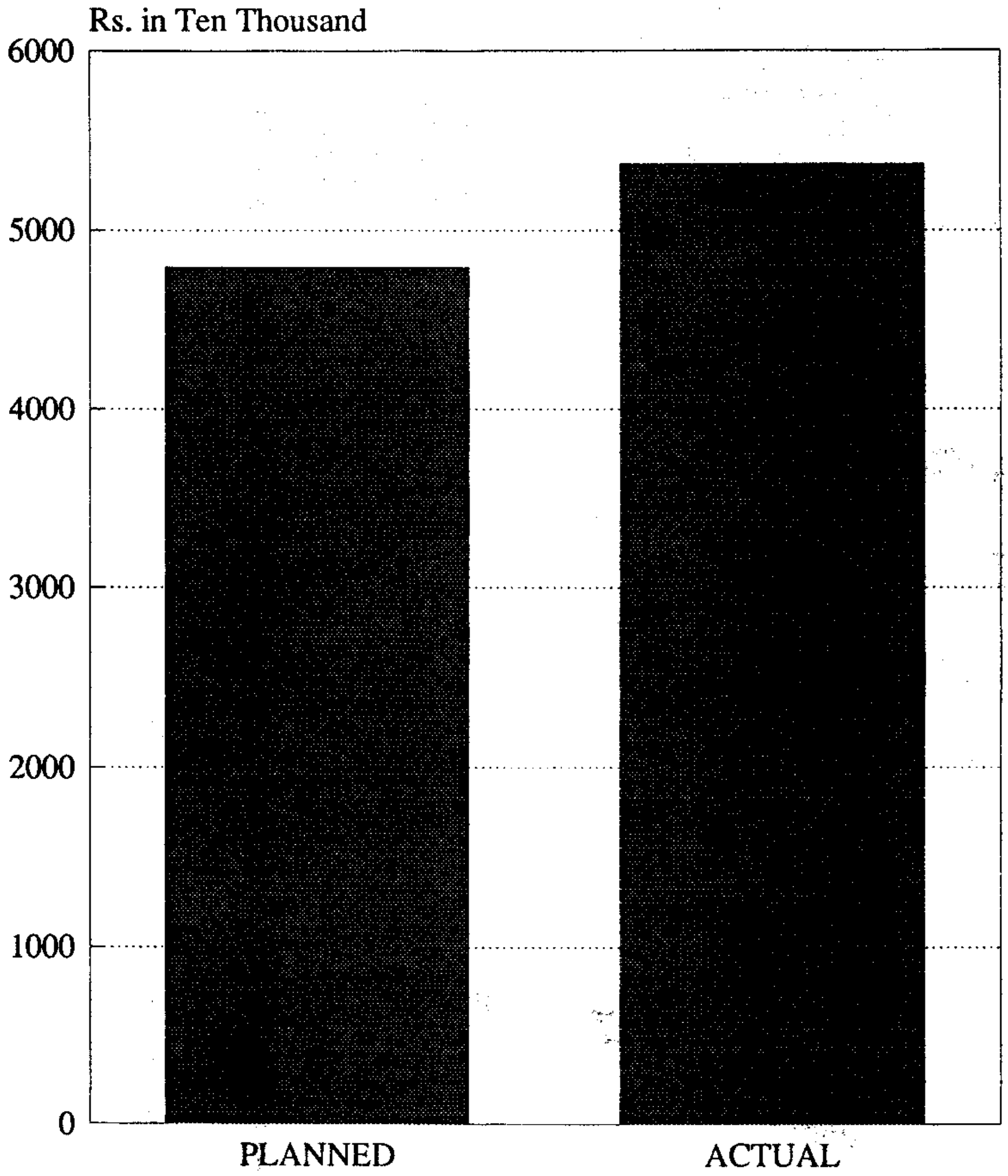


FIGURE 6. COMPARISION OF NET SYSTEM INOCME FROM THE PLAN VS ACTUALY OBTAINED NET SYSTEM INCOME IN YALA 1993 IN IIS



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APPENDIX

SCHEDULE OF PROJECT ACTIVITY - TIME

ACTIVITY	TIME														
	1992			1993											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1. Reconnaissance Survey and design of research method	x														
2. Preparation of Questionnaire, pre-testing and selection of sample of farmers.		x													
3. Farmer Survey 1-B			x												
4. Analysis of Farmer Survey 1-B and Report				x	*										
5. Preparation of Questionnaire and pre-testing for Farmer Survey 1-E						x									
6. Farmer Survey 1-E						x	x								
7. Analysis of Farmer Survey 1-E and report writing							x	*							
8. Preparation of Questionnaire and pre-testing for Farmer Survey 2-B								x							
9. Farmer Survey 2-B								x							
10. Analysis and report writing of Farmer Survey 2-B									x	*					
11. Preparation of Questionnaire pre-testing for Farmer Survey 2-E											x				
12. Farmer Survey 2-E												x			
13. Analysis and report writing of Farmer Survey 2-E												x	*		
14. Overall Report on Project														*	

1-B Survey 1 - Beginning of Season
1-E Survey 2 - End of Season
2-B Survey 2 - Beginning of Season
2-E Survey 2 - End of Season

* Reports to IIMI

ANNEX E

IRRIGATION MANAGEMENT IMPROVEMENT PROJECT

Performance Assessment Study
Inginimitiya Irrigation System

Lalith Dassenaike

Performance Assessment Study
Inginimitiya Irrigation System

Lalith Dassenaike

1. INTRODUCTION

There are many studies on the performance of irrigation systems. However, there are few studies systematically documenting the use of performance assessment methodologies and indicators currently used by managers in systems, and the outcomes of their use.

The study was undertaken as a component of the Irrigation Management Improvement Project (IMIP), carried out jointly between the International Irrigation Management Institute (IIMI), Hydraulics Research Wallingford, and the Irrigation Department of Sri Lanka at Inginimitiya Irrigation System, funded by the British ODA. The broad objective of the IMIP study was to attempt to improve irrigation management through the introduction of a decision support computer software. Since it was necessary to study the effectiveness of the existing management framework of the system, in order to introduce such a decision support tool, the field study for IMIP provided a good opportunity for doing the case study.

The working hypothesis of this study is that systems with a simple performance assessment program integrated into a systematic management process will exhibit a higher level of performance than those lacking such a process. Inginimitiya Irrigation System in Sri Lanka, a system jointly managed by a government agency and farmers, was selected as one of the three systems for the study.[1]

The study documents the extent to which a systematic performance assessment process actually takes place, how it is done, how the information is used, and what gaps exist. The research focuses on the management process (planning, implementation, monitoring, and evaluation), and both output and impact indicators, if any, used by the system managers at Inginimitiya. The study also looks into the potential for system performance improvement and the system managers' suggestions for the same.

Data collection methodologies consisted of structured and informal interviews of agency staff, personnel of other departments, and farmers; and analysis of agency records, reports and other appropriate secondary sources.

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[1] The other two are Pattharaiya Irrigation System in Nepal and Nayom-Bayto Rivers Irrigation System in the Philippines.

1.1 Background of the System

The Inginimitiya Irrigation System is located in the Northwestern Province of Sri Lanka, about 175 km from Colombo, in the dry zone of the country (Figure 1). The feasibility study for the project was conducted by the Japan International Cooperation Agency (JICA) in 1977. The loan agreement was signed between the Government of Sri Lanka and the Overseas Economic Cooperation Fund (OECF) of Japan in 1978.

The construction of the Inginimitiya dam and irrigation canal system was started in 1981 and was substantially completed in 1985, at which point the project entered its operational stage. Commanding an area of 6,530 acres (2,643 ha), the system aims at double cropping of paddy and other field crops. The objectives of the project are to increase agricultural production and incomes, and enhance the living standard of farm settlers.

The executing agency for the project was the Irrigation Department (ID), Ministry of Lands and Land Development. The Land Commissioner's Department was responsible for the selection of settlers and for the provision of infrastructural facilities. The Survey Department dealt with all survey works including the acquisition of the land. The Department of Agriculture has provided agriculture extension services. The Irrigation Department (ID), through the Chief Resident Engineer's (CRE) Office, is responsible for the management of the main canal and reservoir. (In the past, the ID was responsible for operating and maintaining the entire system, with the exception of cleaning of field canals which was done by the farmers). Currently, the ID is in the process of handing over responsibilities for operation and maintenance of secondary canals to farmer organizations. However, the ID is still responsible for the maintenance of structures at the distributary and field level. The Irrigation Management Division (IMD) appoints a project manager under the INMAS program, who has overall responsibility for project operation and coordination. (The IMD was established in 1984). The Government Agent Puttalam (District Secretary) has the responsibility of coordinating the project activities among the related government agencies.

Operation and maintenance of the irrigation facilities is the responsibility of the Irrigation Engineer of the CRE's office. The current staffing structure consist of 1 irrigation engineer (IE), 4 technical assistants (TA), 4 work supervisors (WS), and 3-5 Jalapalakas (Irrigators) for each bank depending on the need (Figure 2). The work supervisors are responsible for operation of the gates along the main canal. There are several distributary canal leaders selected from the respective farmer organizations for operating the field canal gates.

Crop cultivation in the system is generally carried out through the following three farming systems: 1) cultivation of paddy and other field crops in the irrigable land, 2) cultivation of upland crops in the homestead, and 3) traditional chena (slash and burn) cultivation on the abundant surrounding land. The irrigated land is usually used for paddy cultivation during the maha season (September to March) and yala season (April to August). Due to the water shortage, cultivation of other field crops (OFCs) such as chillies, green gram, cowpea and red onion, has been recommended and is encouraged by the IMD and the Department of Agriculture especially during the yala season.

According to the results of a socio-economic survey conducted by the Provincial Land Commissioner's Office in 1990, the total population in the gross area of the system is approximately 10,700 persons consisting of 2,600 families (SAPS report 1993). The average family size is estimated to be 4.1 persons. Forty eight percent (48%) of the total population is less than 18 years old and only 3% are above 61 years. Data from the Irrigation Department show that the number of farm families who cultivate the irrigable area is 2,092, of which 1,098 or 52% are settled in the right bank, and 994 or 48% are in the left bank. The total population of these families is estimated to be 8,640 persons, comprising 4,850 persons in the right bank and 3,790 persons in the left bank.

Under the settlement program, land allotment for each settler has been made on the basis of 1.0 ha paddy lands and 0.2 ha for their homestead. Accordingly, all farmers should be owner farmers. However, it is reported in the survey that there are about 400 encroachment families and 100 landless farmer families in the system area. Although there is no documented evidence of renting or leasing of the lands, the general opinion among the IMD staff is that approximately 40% of the farmers lease out their lands to businessmen from the area. Since leasing out land is illegal, it may not be possible to obtain accurate information regarding this from surveys. About 11% of the farmers are employed in non-farming activities and 10% are unemployed (Kotagama 1993).

2. PERFORMANCE OF THE SYSTEM

2.1 Cropping Pattern

After the commissioning of the project, the first water issue was in yala 1985, which commenced in April 1985. Since then, upto the current 1993 yala season 17 seasons have elapsed. Of these 17 seasons, 5 seasons had no cultivation due to inadequate water levels in the reservoir (Table 1). An OFC (Other Field Crop) crop (Chilies) was cultivated only in 5 seasons, while paddy was cultivated the rest of the seasons.

2.2 Cropping Intensity

Cultivation of the full extent of the command area of 6,530 acres (2,643 ha) was possible only once in maha of 1988/89 (Table 1). Cropping intensity was greater than 75% only in 4 seasons. For the first 15 seasons (excluding 92/93 maha and 93 yala), the average cultivated area was 2,576 acres (1,043 ha), while the average cropping intensity was 79% which is less than 50% of the targeted performance figure of 165% cropping intensity in the feasibility report (Table 3, Figure 4).

2.3 Water Duty

The average amount of irrigation water used during the 1985-1992 period was 5.8 Ac.ft/Ac/season (1.77 meters) or 11.6 Ac.ft/Ac/annum (3.54 meters) (SAPS). In the feasibility report the overall duty was estimated at 4.26 Ac.ft/Ac/season (1.30 meters) or 8.52 Ac.ft/Ac/annum (2.6 meters). Therefore, the water use (actual duty) has been 1.4 times greater than the estimated amount. In the last two seasons, the duty has been very high, especially the 93 yala season where the duty was 9.69 Ac.ft/Ac/Annum, the highest figure since the system was commissioned in 1985 (Table 2, Figure 3).

2.4 Yield and Production

According to a farm economic survey conducted by the Japanese SAPS team (Special Assistance For Project Sustainability) in March 1993, the current performance levels of some of the leading indicators are far below the expected levels set in the feasibility report. For example, the yield of chillies at present is only about 15% of the target while for paddy it is 89% (Table 4). In the case of production of paddy and chillies, the figures are 46% and 37% respectively. Similarly, the current cropping intensity for paddy is nearly half (50%) that of the target and for OFCs it is only 21%.

The feasibility report documents that on a more direct level, the project-related increase of agricultural production in the project area would reach 13,000 tons of paddy in year two. However, based on the total area cultivated for year two (86 yala and 86/87 maha)- which is 3,679 ha, and given the average yield for the system (3.32 ton/ha), the total production for year two was approximately 12,214 tons, or 94% of the target. However, in terms of production, it was an exceptional year as this performance was never sustained in the following years with an average cropping intensity of only 79%.

2.5 Economic Return

According to the feasibility report, the project's economic rate of return was estimated at about 17%. However, Franks and Harding (1987) pointed out certain methodological errors in the computation and re-computed the economic internal rate of return. Based on this new calculation, the rate of return of the project had fallen to 11%.

A new rate of return was calculated based on the performance of the system. This calculation took into consideration direct benefits and costs incurred in the last 8 years of operations. For costs, cultivation, O&M and project costs were considered, while the main benefits were the farmer income from paddy cultivation and savings on foreign exchange which was considered a benefit to the national economy. The calculation resulted in a benefit-cost ratio of approximately 0.7, and an approximate 4% internal rate of return for the project (Table 13). Based on national irrigation guidelines these figures fall well below requirements. According to guidelines, for an irrigation project to be economically feasible, the benefit-cost ratio should be greater than unity, and the Internal Rate of Return should not be less than 15% (Ponrajah 1988).

2.6 Water Use

According to Franks and Harding (1987), water use during the early seasons-soon after commissioning of the project-was higher than forecast for the system at full development. During the first season of operation, water use was about twice the expected amount in relation to the total seasonal requirement. As the development of the project progressed, both technical and institutional factors combined to reduce water use but even by the end of the third season, it was still about one third more than its forecast value at full development.

An important step in their analysis was the definition of a measure of performance known as the "performance ratio", which is defined as the ratio between the seasonal duty at full development and seasonal duty during commissioning (Franks & Harding 1987). Based on this definition, when commissioning of a project has been completed and it is operating normally at full development, the performance ratio approximates 1.0. The amount by which it differs from 1.0 is an indicator of the extent to which water use is greater than at full development, while the rate at which it approaches 1.0 is an indicator of the speed with which full development can be achieved.

This same measure (Franks & Harding) was carried out for the remainder of the seasons in order to assess the performance of the system since its commissioning in 1985 (Table 5). The approximate design duty figures calculated for maha and yala seasons are 3.14 and 5.38 Ac.ft/Ac respectively. (The feasibility report did not provide duty figures for the two individual seasons. Hence, based on Irrigation Department water duty guidelines of 4 and 6 Ac.ft/Ac for maha and yala respectively for paddy cultivation, the above approximate figures were calculated). Over time, the performance ratio has improved somewhat compared to the initial seasons. For instance, the highest performance ratio obtained for a maha season has been .93 for 91/92 maha, and for a yala season .85 for 91 yala. However, this performance has not been consistent, with the ratio falling below that of the initial figures for two seasons, and further, five of the fifteen seasons had zero cultivation. Other factors such as reservoir level, rainfall, and cropping intensity could affect the overall duty. Hence, one cannot safely make a generalized conclusion as to the performance trend over the years of the system with regard to the overall water duty. But generally, the trend has been positive. However, the ratios for the last two seasons (92/93 maha and 93 yala) were significantly lower with .54 and .56 respectively.

2.7 Operation and Maintenance

Staff and equipment requirements for the system for O&M work have fallen short of the required figures of the feasibility report (Table 12). The CRE's office at Inginimitiya has usually received less than requested in terms of annual budgets for O&M. For example, the CRE's office received the sum of Rs. 1.2 million for O&M for 1990 when the requested amount was Rs. 1.44 million (Table 12). Since then, the budget allocation has been rapidly decreasing, and in 1992, the allocated amount was Rs. 0.5 million whilst the requested amount was Rs. 1.43 million.

According to the project feasibility report, experience with existing irrigation schemes in the dry zone of Sri Lanka show that poor maintenance of irrigation systems, careless water management and inadequate agricultural extension and supporting services are the prime constraints limiting agricultural production in the schemes. However, this project was expected to be a prototype for ameliorating most of these limiting factors in order to bring this and other schemes to their full potential. The project was supposed to provide year-round irrigation benefits to 2,550 ha for production of paddy and other subsidiary food crops by both the domiciled farmers and the newly settled farmers. The current area cultivated is 2,643 ha. Project implementation would be phased over 5 years and the full project benefits would be achieved 5 years after project implementation in the newly developed land. The output expected for paddy in the 6th year was 45 bushels per acre (2,274 kg/ha).

According to Dimantha (1987), the objectives of the Inginimitiya Project as stated in the feasibility report, are to meet the shortfall of moisture supply for crops on the 2650 ha. of irrigable land and also for the project to be an example of a well managed and well maintained irrigation project. The project envisages demonstrating high standards of water management.

3. FORMAL MANAGEMENT PROCESSES AND PERFORMANCE ASSESSMENT MECHANISMS

3.1 Joint Management System

Current policy of the Government of Sri Lanka is to turn over responsibilities for operation and maintenance of secondary canals to farmer organizations. The objective is to facilitate the closer integration of the water delivery function of the Irrigation Department with the goals and capabilities of water users through the Project Manager System.

Under this Project Manager System, the Irrigation Department retains full responsibility for operation and maintenance of reservoirs, diversion structures and the main canal system. In essence, the department takes full responsibility for managing the water supply function with respect to the main canal. A Project Management Committee, including representatives of farmer organizations, irrigation and agricultural agencies is the forum for planning overall system operational policies. As an Irrigation Management Division (IMD) System, Inginimitiya possesses a special program of institutional strengthening using the services of a Project Manager, an Institutional Development Officer (IDO), and six Institutional Officers (IO). The objective of this program is to integrate the overall system management and to strengthen farmer organizations. The Project Manager, is supposed to facilitate direct linkages between the farmer and the Irrigation Department, and is the Chairman of the Project Management Committee. Of the many functions expected of him, one duty which is important in the context of this paper is that of "maintenance of irrigation system at optimum level of performance".

In general, progressively decreasing budgetary allocations for O&M of irrigation schemes in Sri Lanka over the years, made the Government formulate and implement a policy to ensure the O&M costs are shared by the farmers and the Government. It is anticipated that within a few years the DCOs (Distributary Canal Organizations) will take full O&M responsibilities for both field canals and distributary canals. The Project Manager and his staff are expected to ensure they have the technical and organizational capacity to undertake these new roles.

To achieve an effective and smooth transition of O&M activities from the Government to the farmers, and to encourage active farmer participation in the management of the irrigation system, farmer organizations have been established. Each field canal is used as the basis for a three-tiered system of representation. Field canal groups choose a representative to sit on the Distributary Canal Organization (DCO), and each DCO provides a representative to the Project Management Committee. This committee also has representatives of irrigation and agricultural agencies but farmers are expected to be in the majority. Through this program, the DCOs are expected to play an important role in actively monitoring agricultural and water conditions, and providing feedback on the same to the Irrigation Department during a cultivating season. Further, the Organizations are expected to take on a major share of responsibility in the operation and maintenance of their respective distributary and field canals, which in turn would enhance their capacity to make effective and knowledgeable inputs into the management process.

The Project Management Committee meets monthly. One of its most important roles is to hold early discussions with farmer representatives about possible cropping patterns so that these can be discussed among the general membership before the formal seasonal meeting, which is the "kanna" or cultivation meeting. It is now a normal and required practice that all issues pertaining to cultivation activities be addressed prior to the seasonal meeting through this process of consultation and discussion, so that the final decisions can be taken at the kanna meeting.

In Sri Lanka, the cultivation meeting plays an important role in irrigation practice. Prior to every irrigation season, the cultivation meeting is held to decide the cultivation calendar or the cropping calendar, which includes the date of first water issue, crop varieties to be cultivated, last date of sowing or transplanting, rotational water issue, and last date of water issue. This cultivation meeting is governed by the Irrigation Ordinance. The Government Agent (GA) of the area chairs the meeting with attendance by other appropriate Government officials and all farmers of the scheme.

Successful implementation requires an effective dialogue between different agencies and water users in the planning process. With emphasis on crop diversification and the change in cropping patterns, operational strategies have to be changed in order to maximize system objectives in times of both water abundance and water scarcity. Therefore, pre-season planning constitutes an important phase in the overall management process, where issues such as water allocation, irrigation scheduling, and cropping calendars are addressed accordingly. Follow up activities such as monitoring actual performance during the season and making necessary adjustments in response to changes in water supply and demand conditions are also important aspects.

3.2 System Design and Operation

The Inginimitiya System was designed by the Irrigation Department based on the following design criteria (IMIP Inception Report):

* all field canals are designed to operate with a discharge of 1.0 cusec (28.3 l/sec), limiting the total command area of a field canal to 18 ha (40 acres), on the basis of supplying approximately 75 mm (3 inches) of water per week;

* if the total area of a field canal is less than 16 ha, the discharge remains constant but the number of days of irrigation per week is reduced in proportion to the command area;

* the designs for all field canals and their structures are identical, with each field canal commanded by a sliding head gate and a 6-inch (150mm) diameter culvert;

* distributary (secondary) canals are sized to meet maximum demand from all field canals simultaneously, plus a small allowance to meet losses along the distributary canal;

* the main canals are provided with sufficient cross-regulators that water surface elevation along the entire length of the canal can bept at or close to design elevations irrespective of total discharge entering the canal.

According to the inception report, this type of design allows for a relatively simple set of operational rules to be developed. It is anticipated that a flow of 1.0 cusec (28.3 l/sec) in a field canal will be shared by adjacent pairs of farmers for 12 hours each, a delivery rate of approximately 75mm per week. (According to the IMIP Inception Report it is 12 hours. According to Ponrajah the rotation is 12 hours of day light. Present operation principles practiced at Inginimitiya is 8 hours during a 24 hour-day/night period). Field canals are adjusted to meet the required flow, and closed when all farmers have had their turn for the week. Distributary gates will be operated only when there is a change in discharge due to the rotational pattern among field canals along a single distributary. In practice, large distributary canals will have continuous flow, as will the main canal. However, during land preparation, there is a full flow in all of the distributary as well as all of the field canals.

As for the main canal operations, discharges are kept more or less constant except when there is sufficient rainfall to justify closing the system down. Because of the presence of large numbers of cross-regulators, it is possible in theory to meet the full demand of the system with discharges way below design discharge.

The design calls for complete control over every offtake along the main canal to ensure that discharges are at target level. Although the design guidelines discourage field canals offtaking directly from the main canal, Inginimitiya is not unusual in having a high proportion of these direct offtakes because the topography forces it.

4. MANAGEMENT CYCLE AND PERFORMANCE ASSESSMENT AS PRACTICED

4.1 Management Process

4.1.1 Planning

Pre-seasonal planning is carried out through pre-kanna meetings. These meetings are held a few weeks before land preparation, leading to the cultivation meeting where the final decisions are taken for all issues concerning cultivation for the upcoming season. In planning for the cultivation season, issues concerning the cropping calendar, such as date of first water issue, crop varieties to be cultivated, last date of sowing or transplanting, rotational water issue, and last date of water issue are all discussed by the Project Management Committee. At the kanna meeting, the same issues are discussed by all the farmers before making final decisions.

At the kanna meetings, the most important item on the agenda is the cropping calendar. Date of first and last water issues, dates of sowing and harvesting and crop varieties are addressed at length. Sometimes, dates for cleaning of canals are also included in the agenda. Most often, the date of first water issue and crop variety are actually achieved without change. However, dates of planting activities, harvesting and last water issue are all extended and not carried out according to planning decisions (Table 9). Fines and penalties to be imposed on farmers who do not adhere to these decisions and for those who resort to illegal tapping of water, are commonly spelt out in great detail at each meeting.

Although the above is what should ideally take place, in practice what actually happens is a procedure which is more adhoc in nature. Dates of planting activities, harvesting and last water issue are all extended and not carried out according to planning decisions (Table 9). The decisions are vague and no proper responsibility is delegated to individuals to carry out such action when such issues arise during the season. No one knows the proper legal procedure in order to take necessary action.

For example, the IMD provided the farmer leaders with a possible scenario for OFC cultivation in yala 93, for 25% of the command area. This illustration consisted of area to be cultivated, crop types, yields, prices and revenues (Table 8). This was done at a PMC meeting for farmer leaders, during a planning session before the kanna meeting.

4.1.2 Setting Objectives

There is no clear and explicit objective in operating the system. Different staff members assume different objectives. The mentioned objectives are also vague and general, such as "water management", "managing the available water such that all the farmers receive adequate water for paddy", and "maximizing crop harvest" and so on. The Irrigation Management Division believes in a broad objective specified for all irrigation schemes in general, increasing the overall productivity per acre and per unit of water. The IMD used a very crude method for calculating the output at the end of yala 93 season, which was initiated by the new project manager. (There is no evidence of such outputs being calculated in the past). Based on the maximum and minimum harvest obtained for each tract (done through a random survey of the farmers), they take an average figure which is then multiplied by the actual area cultivated to obtain an average output figure for the respective tract. The actual area cultivated was obtained during the season from a cropping information survey done by the IMD (Table 7). This information was for the ID for purposes of water delivery schedule preparation and water allocation.

It is evident that after commissioning of the scheme, the main objective of the ID Inginimitiya in managing the system has changed in its focus, mainly due to the severe water shortage experienced in the last few years. The rainfall experienced for the catchment area is significantly lower than forecasted in the feasibility report. For example, in the last seven years, the average rainfall was 75% less than the expected figure in each of the nine months out of the twelve. It exceeded the forecasted figure only in three of the months (Table 11). Further, the mean annual rainfall was 79% less than what was expected (Table 3). At the inception of the project during the time of commissioning, the objective was to maximize the income of the farmer through maximizing yields. But now, with the shortage of water, and in line with Government policy, the objective remains more or less the same, maximizing farmer income, but through the active promotion of OFC cultivation. The reasoning behind this change is that one could obtain the same amount of income from either 1 ha of paddy or 0.1 ha of chili, although the amount of water used is much less in the latter case. Based on this, the managers are trying hard to promote paddy cultivation only during the maha and chili cultivation during yala. Further, due to the scarcity of water, the current objectives are restricted to cultivation of only one bank of the system per season.

4.1.3 Setting Operational Targets

The targets-in theory-invariably take the form of rotational schedules for water delivery. The rotational schedule is based on the design of the system, and was developed by a former TA according to irrigation guidelines. The same standard rotational schedule is drawn up each season without any variation or relation to possible change in objectives. The targets are not linked to the objectives and serve more as subjective guidelines born out of experience in trying to implement a rotation.

According to system design specifications, the optimal water delivery schedule is an 8 hour rotation among the field canals. Based on this, the target is to issue water to 3 lots (fields) in a 24 hour period for every season when paddy is being cultivated. (For OFCs there is no definite target). This rotation among the field canals is prepared by the ID and given to DCOs for implementation, while the ID controls the opening and closing of the distributary canal offtakes from the main canal.

The only quantitative component of the target is the discharge to be released at the main sluice which is in cusecs (l/sec), for the duration of the rotation. For example, a target of 60 cusecs (1,698 l/sec) to be released from Thursday to Sunday for the right bank during the maha 92/93 season. This discharge is adjusted depending on the need, rain fall, time taken for the flow to reach the tail-end, and past experience.

4.2 Implementation

The only definite plan available to the staff for implementation is the water rotation schedule. This is drawn up by the engineers and given to the technical assistants (TAs) for implementation.

At the start of the cultivation period, water is issued for land preparation. During this period water is issued along the main canal (right or left bank) in such a way that all fields receive water simultaneously. Depending on the rainfall, the discharge is reduced or completely shut off from the main sluice. There is no rotation at this time. In implementing this water distribution, the TAs operate the main sluice. There are two TAs employed for the right bank and one for the left bank (Figure 1).

Only about 7% of the farmers commence land preparation with expectation of rain prior to water issues (Kotagama 1993). Approximately 24% of farmers start this activity after the rains before the water issues, and 69% will do land preparation only after the water issues. It is interesting to note that the main reason given by the farmers for this is to avoid the risk of water not being supplied for the entire season.

After the land preparation period is over, the rotational schedule is put into operation. The ID employs Jalapalakas (Irrigators) who are casual laborers, to implement the rotation of the DC offtakes, off the main canal. The number of Jalapalakas employed depends on the need, generally 3-5 for each bank. They are responsible for opening and closing the DC offtakes as well as FC offtakes from the main canal. The operation of these offtake gates is done in a very ad-hoc manner, i.e., if there are 3 field canals to be issued water on a given day off a particular DC, then the Jalapalaka will open the respective DC gate 3/4 of the full capacity. There are no calibrated measuring structures on these gates to monitor the flow quantitatively. The ID staff controls the main canal flow from the main sluice at the head with a constant flow through the main canal. Sometimes the cross-regulators located along the main canal are used to control this flow. Before the joint-management system came into operation, the agency staff managed the rotation within the field canals. But currently, the ID is in the process of implementing a policy of "handing over" DC's for operation and maintenance to DCO's.

The respective DCOs are expected to implement the rotational schedule. The FC leaders of the respective DCO area operate these gates. The 8 hour rotation is should be implemented as follows: the field canals are designed to take a maximum of 1 cusec. of flow at a given time. From a field canal, each field is fed for 8 hours per day, so in one day 3 fields can be fed off a field canal. Hence, for a given field canal, at a given time only one field should be receiving water. The system is designed to handle not more than 21 fields for a field canal. Thus, once a particular field receives water for the 8 hour period, it will receive water again only after 7 days. Based on the soil conditions and the FC leaders' experience, the gates will be operated in such a way so that certain fields will receive water for a period less than 8 hours while others receive for a longer period.

To illustrate this further, in theory (according to the schedule), the rotation is supposed to operate as follows: (A sample of a rotational schedule is given in Table 6). The areas given for the DCs and FCs are in acres. The number of lots are the number of fields for belonging to the respective field canal. The last 7 rows represent 7 days of the week. For example the schedule reads as follows: FC14 (last column of the table) offtakes from DC 4 and has 9 fields consisting of 22.5 acres. (FC6 directly offtakes from the main canal and hence is shaded to note the difference). On days 5, 6, and 7, 9 fields (FC14) receive water, which basically relates to one field receiving water for approximately 8 hours.

However, there is no evidence that the formal rotation is strictly adhered to. In the absence of any monitoring, the irrigators basically open and close gates as and when they feel like. For example, on many occasions it was observed that certain D canal offtake gates at the head-end of the main canal were opened when they should have been closed according to the schedule, although water had not reached the tail-end in any significant quantity.

Besides this water delivery schedule, the only other plan that is somewhat adhered to are certain dates of the cropping calendar. In both maha and yala seasons, while the date of the first water issue was strictly adhered to as planned, the date of the last issue was extended considerably. Execution of the cropping calendar is carried out by the ID in collaboration with the IMD and the DCO's. The cropping calendar consists of dates for the following activities; dates of first and last water issues, dates for sowing and harvesting, dates for cleaning of canals, and type of crop to be grown. Planning for this and decisions regards these dates are made by the Project Management Committee at the pre-kanna meeting and then the final decision is taken by all the farmers at the kanna meeting. .

4.3 Monitoring

There is no systematic monitoring of water issues, and as a result there is very little control over the water being delivered. In the absence of any gauges at offtakes, and the poor working condition of the gates at certain places, a very crude method is adopted to monitor water issues. The TAs and the Work Supervisors' job is merely to see if the gates are opened or closed,and if the water is flowing or not flowing. The only precise quantifiable flow measurement that can be taken is at the two right and left bank partial flumes-at the heads of the main canals-where the structures are calibrated. Even at certain locations where there are gauges fixed and structures calibrated, there is no target flow to monitor for.

The communication path is so weak and ineffective that even when problems such as broken gates or damaged structures are discovered, it takes two to three days before the ID staff receives the information and action is taken to rectify the problem. The process can be expedited if at least some monitoring were undertaken.

The absence of a proper mechanism for monitoring and lack of control lead to a lot of damage and destruction to gates, structures and weirs for illegal tapping of water. This type of damage is more prevalent towards the tail-end of the system, where the field canals are in extremely poor condition and there is a large variation between the field canal capacities. This condition only aggravates the problem of equity of water distribution between the head-end and tail-end farmers.

Currently, only rainfall, reservoir level, and water flow from the main sluice data are collected on a daily basis. However, this data is not analyzed to obtain meaningful information that can be then used by the managers in a performance oriented management framework. No data are collected on water flow measurements, in spite of having gauges installed at certain locations and rating curves prepared for these control points. A monthly report is sent by ID to the ID headquarters in Colombo, which consists of rainfall, water issues, reservoir level, total consumption and water duty data. However, there is no feed back from or evaluation by ID headquarters based on these monthly reports.

Similarly, there are periodic Monitoring and Evaluation (ME) reports sent by IMD to IMD headquarters in Colombo. For a season there are four such reports which are prepared: ME1 - a cropping plan for the season done at FC level, ME2 - a similar plan at DC level, ME3 - a plan at project level at the start of the season, and ME4 - project Level report at end of the season. Here again, there is no feed back or evaluation by the IMD headquarters.

4.4 Evaluation

There is no provision in the management process for any kind of systematic evaluation of the performance of the system, either during or after a season. During the implementation of the water rotation, though there are many problems concerning certain fields receiving water, there is no mechanism for addressing these issues and rectifying them. The same problems at the same locations persist season after season with only minimal attention given to solving them.

Sometimes, depending on the seriousness of the problem, certain issues are discussed at length at the Project Management Committee level and subsequently attended to thereafter, e.g., repairing a broken gate. However, it takes two to three days at the minimum before the repair done. At every kanna meeting, the same issues come up repeatedly, and vague decisions are taken by the staff, but nothing gets done to correct the problems. For example, decisions are taken and documented in detail regarding prosecuting farmers who break the law, but nothing happens when complaints are made. In the last yala season, a decision was taken that no one will be allowed to grow paddy and farmers who break this rule will not be issued water and will be prosecuted. However, by the end of the season, 30% (the highest percentage for all crops) of the total area cultivated for the season was paddy and these farmers were able to get away without being prosecuted.

4.5 Output Indicators

The only performance output indicator which is systematically used is water duty. In general, this is an indicator used across all systems in the country and is required by the Irrigation Department. However, the nature of the indicator is such that it can be calculated only at the end of a season. No indicators are used to monitor performance during the season.

Water issue, which is calculated from data at the end of a season, is determined by dividing the total amount of water issued by the total acreage cultivated for the season. As a benchmark, the Department specifications for this indicator is a range between 4.5 (1.37 meters) and 5.5 (1.68 meters) acre-feet per acre as being a satisfactory level of performance under paddy cultivation. It is not possible to use this indicator during the season to assess operational performance of the system.

In a crude manner, the ID staff and farmers use "adequacy" as an output indicator during the season. For example, farmers always focus on the adequacy of water for their fields in assessing the performance of the system. In doing so, all their complaints or compliments - as the case may be - always revolve around this issue of adequacy. Based on this, it is interesting to note that the agency staff in turn uses this feedback mechanism as a crude indicator of performance. For example, the number of complaints made by the farmers at a particular time, and or the frequency of such complaints to the agency office during a given period of time, indicates how well the system is performing in terms of staff managing the water delivery function. The staff do not keep any records of these complaints. Generally, farmers first complain to either the WS or the TA. Only in the case of a more serious complain will he complain to the IE.

In order for the IMD to evaluate how well the farmer organizations have been performing, one common indicator used is the amount of funds that the organization has been successful in collecting over the past years. Certain DCOs have significant account balances and are thus active and performing well, while others are still struggling with various problems. A recent random survey of a few DCOs indicated that these funds-which are collected as membership fees-range from Rs. 4,000 to 19,000. The IMD does not update this information although this is supposed to be done monthly, and no records are available. They will conduct a survey for an outside source if necessary to obtain such information. For example, such periodic random surveys were conducted for our benefit during the IMIP project.

The farmers have a set of simple indicators whereby they assess the performance of the farmer organizations. The two most important indicators are the amount of money available in the organization fund and the unity among the farmers. They believe that if the organization has enough funds then they can get most of the maintenance and cleaning activities accomplished without much burden. Unity between the members is very important for organizational activities to be successful. This in turn helps to improve the fund, and therefore the ability to work together is a pre-requisite for improving the performance of the organization.

4.6 Impact Indicators

As far as assessing the impact is concerned, there is no evidence of any systematic indicators being used. However, there is some concern along the lines of overall agricultural production for the area, socio-economic well being of the average farmer, and the environment, related to salinity problems and its impact on the crops.

In trying to identify these indicators (both output and impact), the classification of Bos, Murray-Rust, Merrey et al. is utilized as follows (Table 10):

4.6.1 Water Delivery Performance

According to the authors, some of the indicators mentioned under this category-which come under sub-groups such as conveyance, maintenance, utility of water supplied (adequacy and reliability), and equity-are Delivery Performance Ratio, Water Delivery Performance, Relative Water Supply, Modified Interquartile Ratio etc. The only water delivery performance indicator used by the system managers is Water Duty. With regard to adequacy and reliability, sometimes the managers and agency staff use a very crude measure namely, the feed back from the farmers.

4.6.2 Agricultural Performance

Here, the indicators mentioned are Irrigated Area Performance, Cropping Intensity Performance, Production and Yield Performance etc. Although, at times cropping intensity and yield are referenced to by the managers, these are never used as performance indicators.

4.6.3 Non-Agricultural (Socio-Economic) Performance

Under this section, areas such as economic viability, physical environmental sustainability, and social viability are taken into consideration. Based on this, a few of the indicators referenced are Total Financial Viability, Fee Collection Performance, Water Based Profitability, Economic Rate of Return, Sustainability of Irrigated Area, Irrigation Employment Generation, Relative Poverty etc. The managers of the system do have access to data such as income, wage, and other basic agricultural and economic data collected by government departments, and hence these data can be utilized as valuable sources of information to assess socio-economic impacts and trends such as employment, wages and poverty levels. But, the data are not used meaningfully to assess any kind of performance or trends. A crude measure of farmer satisfaction-based on farmer organization fund balances and farmer incomes-are looked into in a very ad hoc manner at times.

4.6.4 Strategic Management

According to the authors, strategic management deals with three basic conditions namely, the adoption of a suitable framework that permits performance assessment, the adoption of a practical set of indicators that are used within the assessment framework, and the creation of the necessary institutional conditions that will enable or require managers to be responsive to performance. The system fails completely in meeting the first and the third requirements, while to some extent, although in an ad hoc manner, utilizes a few indicators for assessing performance in meeting the second requirement. What is really lacking is any incentive to improve performance or any performance based reward mechanisms. Performance accountability is rare and commitment is virtually non-existent.

5. Diagnostic Analysis

The performance of the system is at a very low level. There is no systematic management process, and the management agency has no systematic methodology for assessing performance. The overall performance of the system both in terms of agricultural output and water delivery is far below its potential.

The following factors have been identified as the main causes for the low level of performance and also may explain the deviation between the initial objectives and the actual results.

5.1 System Design

The system design and the accompanying assumptions about operations were not consistent with the overall objectives. The canal design was not uniform; although the 1 cusec. principle was supposed to be used, certain field canals have more water flowing while others have less. This together with the 8 hour rotational schedule require a certain level of control in management of water deliveries. However, the water control structures are inadequate and of poor standard. Discharge measurement capacity was never installed and gauges that are present were never calibrated. These gauges were only installed and subsequently calibrated under specific project requirements, rather than to meet monitoring tasks of the ID. And so now, although the calibration of these gauges are available no measurements are taken. Hence, there is no systematic development of quantified operational targets, water levels and discharges are not monitored, and if monitored they are not accurate. This in turn leads to water delivery schedules which are ad-hoc and unpredictable.

5.2 Institutional and Organizational Arrangements

5.2.1 Staffing

Staffing is a major problem. Although the presence of many control structures calls for thorough monitoring in order to control the water delivery, this is not possible given the number of staff employed. With current staffing of 1 irrigation engineer, 3 technical assistants and 4-5 irrigators per bank it is impossible to closely monitor discharges as specified in the targets. Further, many gates are not in proper working condition or are completely broken, while others are missing altogether. Lack of funds for fuel to operate vehicles, and funds for repairs and maintenance further worsens the situation.

5.2.2 Inter-Agency Collaboration

There is very little communication between the two main agencies managing the system, the ID and IMD. The IMD is a relatively new agency set up within the Ministry to help develop and strengthen the farmer organizations. But the two organizations do not seem to be able to work together effectively. For instance, they do not share common objectives. Communication is extremely weak and each party tends to blame the other for weak levels of performance. No one is willing to take responsibility. The coordination mechanisms are so ineffective at times, that even a simple task such as communicating the date of a project management committee meeting between the agency staff and the farmers seems to be an extremely difficult assignment. Hence, such meetings are never held on scheduled dates and get postponed for weeks or are never held. For example, the PMC meeting for both March and April 1993 got postponed at least on two occasions due to lack of attendance which resulted from miscommunication of the dates. As a result there was no forum and a proper meeting never took place until May. Minimum preparation is done before hand for such meetings unless there is significant pressure from the farmers to solve certain issues.

The management process lacks coherence. The objectives specified in the planning documents are poorly understood by the staff. But these are also vague and not specific. Hence, the staff never work according to a specified plan. When the objectives are not clear, everything else in the planning process collapses thereafter.

All the above deficiencies in the management process have resulted in a low level of trust between the farmers and the agency staff. The farmers have little confidence in the managers. A good example is the decisions taken at the beginning of the yala 93 season at the kanna meeting. First, the decision was to do nothing and wait for rain, after which paddy would be cultivated provided there was sufficient rainfall to fill the reservoir. This decision was taken in spite of some managers and farmers wanting to cultivate at least OFCs if not paddy. Subsequently, after a few weeks, due to much protest, the decision was reversed and it was decided to grow OFCs. However, the first issues of water were significantly delayed and many farmers lost interest in any form of cultivation. They did not know whom to believe, and were not sure that water would be issued at all. Hence, they were waiting to see the water actually flowing in the canals before doing land preparation. On the other hand, the ID staff had no plans and were waiting until the farmers started land preparation to develop a rotation, as they were not sure that the farmers will cultivate OFCs. Finally, all this resulted in less than 20% of the planned area cultivated and a lot of water being wasted.

5.2.3. Political Interference

At times there is a lot of political pressure and interference from the politicians, which has a negative impact on the performance of the system. For instance, politicians exert pressure in getting certain construction work completed according to their deadlines which results in water management being neglected. Also, closer to election time, there is pressure for cultivation meetings to be held on the dates specified by the politicians rather than the management committee, purely for political purposes. For example, the first kanna meeting for yala 93 was held on March 4th. Generally, the PMC decides on a suitable date for the meeting beforehand, and hence one of the items on the agenda for discussion at the February PMC meeting (as it is the general practice), was finalizing a suitable date for the kanna meeting in March. But to the surprise of all PMC members, there was an order from the GA's office to hold the meeting on March 4th, and hence the PMC had no say in the matter. The kanna meeting was presided by the Minister, and it was obvious that he dominated the entire meeting, and influenced many of the decisions. Further, his presence pressured most of the members into making hasty decisions. However, the agency staff, together with all the farmers were so dissatisfied and angry about this, that the PMC was forced to have a second kanna meeting in April.

5.2.4 Lack of Interest and Motivation

A major constraint to good performance is the lack of interest and motivation in getting the system to perform well. Across the board, from the manager to the casual laborer, there is no interest and effort devoted to improving the performance. One of the major reasons for this is the high priority given to construction work compared to water management, and all the financial incentives that go along with it. Allocation of funds by the Government for O & M and water management is very little compared to that for construction. Further, incentives provided for construction work such as holiday pay, vehicle usage and travel claims and construction allowances are not available for staff engaged in water management work. With tight deadlines to be met due to pressure from government officials to finish certain construction work, there is also a big demand for construction labor. Hence, the management is forced to utilize labor for construction at the expense of system operations and water management.

Lack of monetary incentives for water management may not be the most important reason for this low motivation and interest. Motivation could mean different things to different individuals. According to some managers, social pressures such as urban migration for more lucrative jobs and schooling of children may be more pressing problems that result in the low performance of individuals. Apparently, it is extremely hard find a dedicated TA or work supervisor who is well trained in water management, devoted and genuinely interested in the work.

Not only the agency staff, but certain farmers also exhibit similar patterns of disinterested behavior. Only one bank per season is being cultivated presently, so the rest of the farmers are forced to find other means of employment. For the most part, farmers are absent from their fields for long periods of time. Due to water shortage and lack of proper cultivation activities, even during the cultivation seasons these farmers keep away and continue doing other jobs. They are better off elsewhere than cultivating under these adverse conditions. This has a negative impact on the entire scheme especially for farmers of the adjoining fields.

Also, in the absence of easy access to capital, machinery etc. and the inability to secure loans and financial guarantors for cultivation, the average farmer tends to lease out his land to business people for whom these inputs are not a problem. However, these outsiders cultivate only for one season; hence their main objective is to reap the maximum from this land during this short period. They often resort to illegal tapping of water, theft and destruction. Thus, there is no sense of ownership of the land among the farmers.

6. SUGGESTIONS BY AGENCY STAFF FOR IMPROVING PERFORMANCE

During the course of our interviews, one of the objectives was to discuss with the system managers and other staff, their suggestions for improving the performance of the system. Different staff had different ideas and suggestions. However, for purposes of this study, only the important and most common suggestions are synthesized in the following section.

6.1 Priority for Water Management

Many of the managers were of the opinion that construction is given too much of a priority over water management. This they felt is nothing new to Inginimitiya, as many other systems in the country are also faced with this problem. Some of them were of the opinion that there should be a balance between the construction and water management work. Staff should not be employed for construction work at the expense of system operations. The Department should make every effort to bridge the gaps-of financial and human resources-between water management and construction.

The staff felt that incentives for effective water management duties would help improve the situation a great deal. This should not be too difficult to implement because already there exist numerous incentives for construction work. Along with this, there should also be a system for evaluating individual performance for effective water management.

Successful staff should be appropriately rewarded to encourage motivation and interest.

The overall system should be appraised in terms of the working condition of the structures. Periodic assessment is necessary and responsibility for maintenance of these structures should be shared by both the agency staff and the farmers. Such inspection should be done well in advance before planning decisions are taken such as water delivery targets etc.

6.2 Re-organizing of Farmers

In terms of the strength of farmer organizations, certain IMD staff members felt that the design of the DCOs in relation to the design of the scheme was not correct. On many distributaries, the number of farmers is too small for a DCO. Currently, the structure is such that a DCO has approximately 45 farmers. This is too small a number for active organizational work, the main reason being that it is not possible to collect adequate funds within the organizations for operation and maintenance activities. Further, too many of these small DCOs result in breaking up the responsibility of managing the secondary canals.

6.3 Funds for O & M

According to a few system managers, rehabilitation is a necessary but not a sufficient condition for improving the performance of the system. There comes a time when a major rehabilitation program is necessary, and no doubt the performance of the system will improve thereafter. However, this is only short term. But it was suggested that apart from rehabilitation, what is necessary is a steady cash flow from separate investments, such that maintenance and rehabilitation activities then can be carried out on a continuous basis. This however, they felt is a policy issue for the donors and the government of Sri Lanka to consider and act accordingly.

7. CONCLUSIONS AND RECOMMENDATIONS

Resulting from the above mentioned suggestions and our own observations and analysis of the system, the following conclusions are drawn and appropriate recommendations are presented in the following section.

Construction work is given priority over operation and maintenance activities, and therefore water management is neglected. The department provides positive incentives for construction work which makes it even worse.

The management cycle is ineffective and extremely weak. There is no performance assessment process or systematic use of performance assessment indicators. Water duty, cropping intensity and to some extent tracking adherence to cropping calendar dates are the only indicators which are currently in practice. Apart from this, farmer satisfaction, farmer complaints, farmer incomes, and farmer organizational funds are used in an ad hoc manner to assess performance. However, these are not monitored on a regular basis, or used in a systematic way for performance evaluation.

A major constraint to good performance is the lack of interest and motivation in getting the system to perform well. The system lacks a systematic process for evaluating individual performance, as well as incentives for good performance in system management.

The following are recommendations for improving the performance of the system:

* An effective management cycle consisting of a set of basic but necessary tasks in planning, implementation, monitoring and evaluation have to be enforced. When addressing such components of the management cycle, initially, the existing management cycle will be improved as much as possible before introducing any new ideas. For example, during the planning stage at PMC meetings, the existing objectives and targets have to be clearly defined and well coordinated. All staff-system managers, field staff, IMD staff-together with farmer leaders must be in agreement with these set of targets. Gradually, these targets will be strengthened by incorporating a set of standards such as an acceptable range with minimum and maximum levels, which will then facilitate the implementation of a monitoring program and subsequently the evaluation process of the set targets. Field staff together with farmers will perform the monitoring. In implementing the monitoring task, who, what, when and where questions will have to be clearly specified, responsibilities assigned and accounted for. Monitoring will consist of improving and strengthening the data collection tasks. The data to be collected will go beyond the standard rainfall, reservoir level, and discharge measurements at partial flumes to include discharge at lower levels of the system, water level at selected locations of the system, actual cultivated area and progress of land preparation. Periodic evaluation (i.e. at monthly PMC meetings) of these targets and decisions to be implemented will have to be carried out. For example, during the evaluation process, a basic analysis of comparing the actual measurements against the targets will transform the data collected into meaningful information, which can then be used by the managers for assessing and improving the performance of the system.

* Decision making at PMC meetings have to be more specific. Each persons responsibilities and time deadlines have to be clearly defined and understood by all participants. For example, the procedure for prosecuting farmers on account of theft and illegal tapping of water has to be clearly delineanated among the staff and farmers. Although, many vague decisions are taken on the subject at every meeting, no one really knows what to do when they are confronted with such a situation.

* Communication paths have to be improved a great deal. Especially in a jointly managed system, intra-agency as well as inter-agency communication is essential. Further, the communication between the agency staff and the farmers is also important. For example, dates of PMC meetings have to be communicated to the farmers well in advance along with agendas, thereby providing adequate time for preparation before the meetings. The attendance at these meetings should be made compulsory for all participants. The dialogue between the farmers and the agency staff has to be ongoing right throughout the season, and not only during times of meetings. This is very important in order to improve already strained relationships and low level of trust between the two parties. The managers need to develop an effective mechanism whereby two-way and not mere top-down communication channels are facilitated. For example, the field staff will be responsible for communicating the delivery schedules to all the farmers on a timely basis, while the farmer leaders will be responsible for providing a continuous feed back from their respective farmer organizations in response to such delivery schedules. Managers also need to develop a system whereby remedial action to farmer complaints can be expedited without undue delay.

* All staff should be evaluated in the light of their performance related to water management activities. Their contribution to this area and appropriate impact on the system performance has to be given due recognition either in terms of monetary renumeration and/or career promotions. Development of such reward mechanisms and incentive packages, the objective being to induce motivation and interest, is the responsibility of senior department officials, and hence it is a more policy related issue. However, the system managers have an important role to play at present in actively lobbying for it, as many of them see a definite need for such a program.

Figure 1. Inginimitiya Irrigation System: Location and Layout
(Source: SAPS Report 1993)

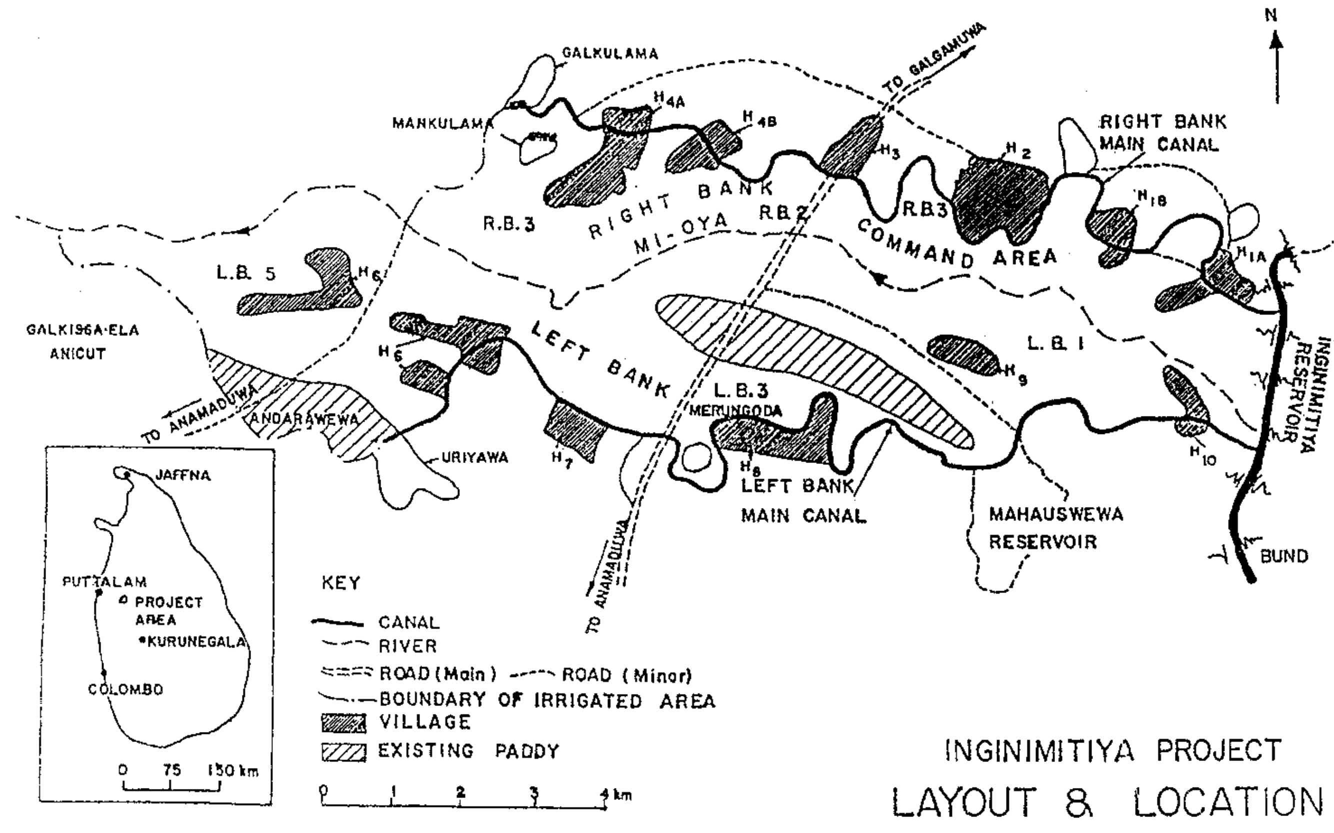

Figure 2. Organizational Chart - Inginimitiya Irrigation System

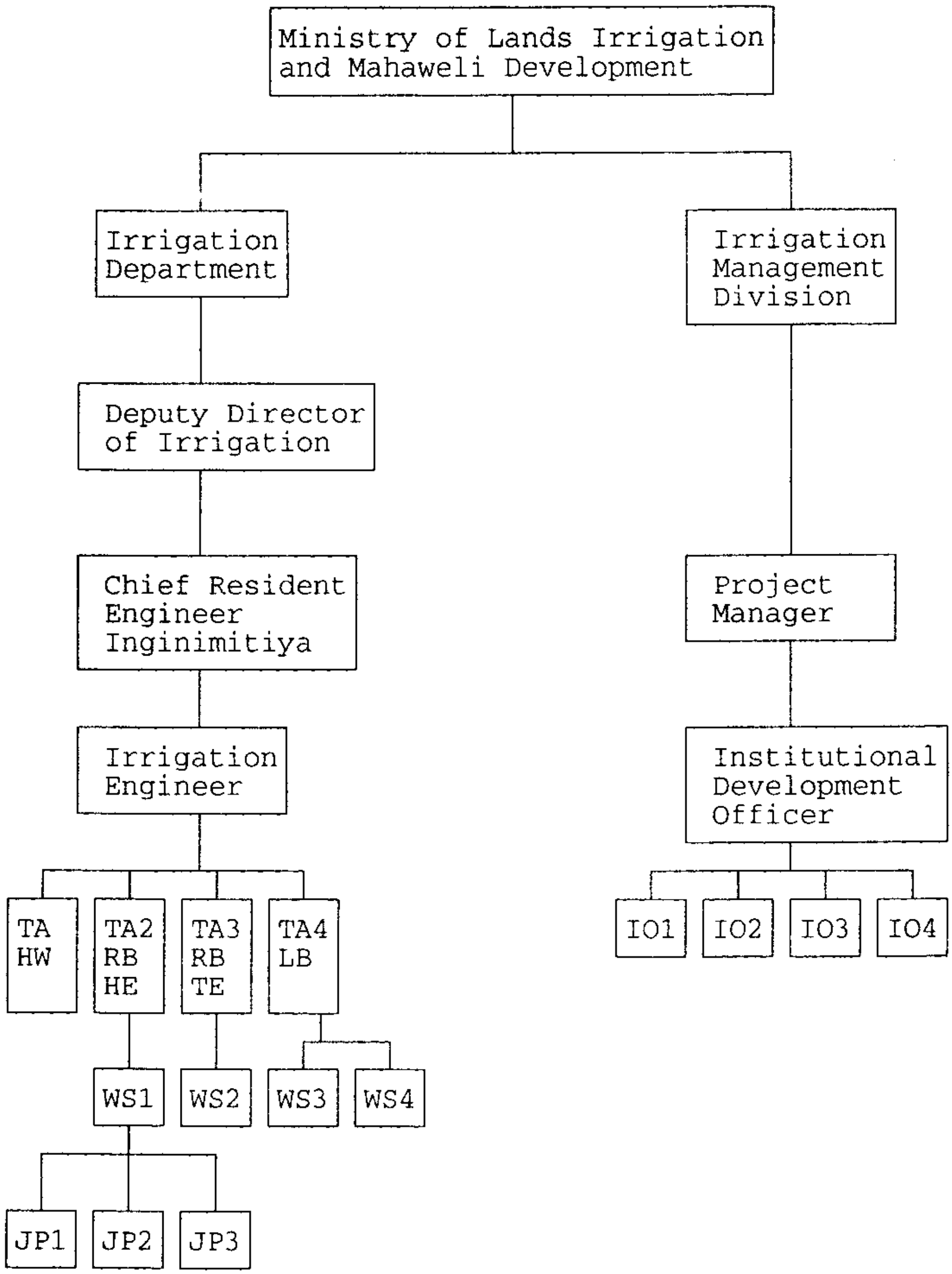

Figure 3. Water Duty and Rainfall - Inginimitiya Irrigation System 1985 to 1993 (Source: SAPS Report 1993 and ID)

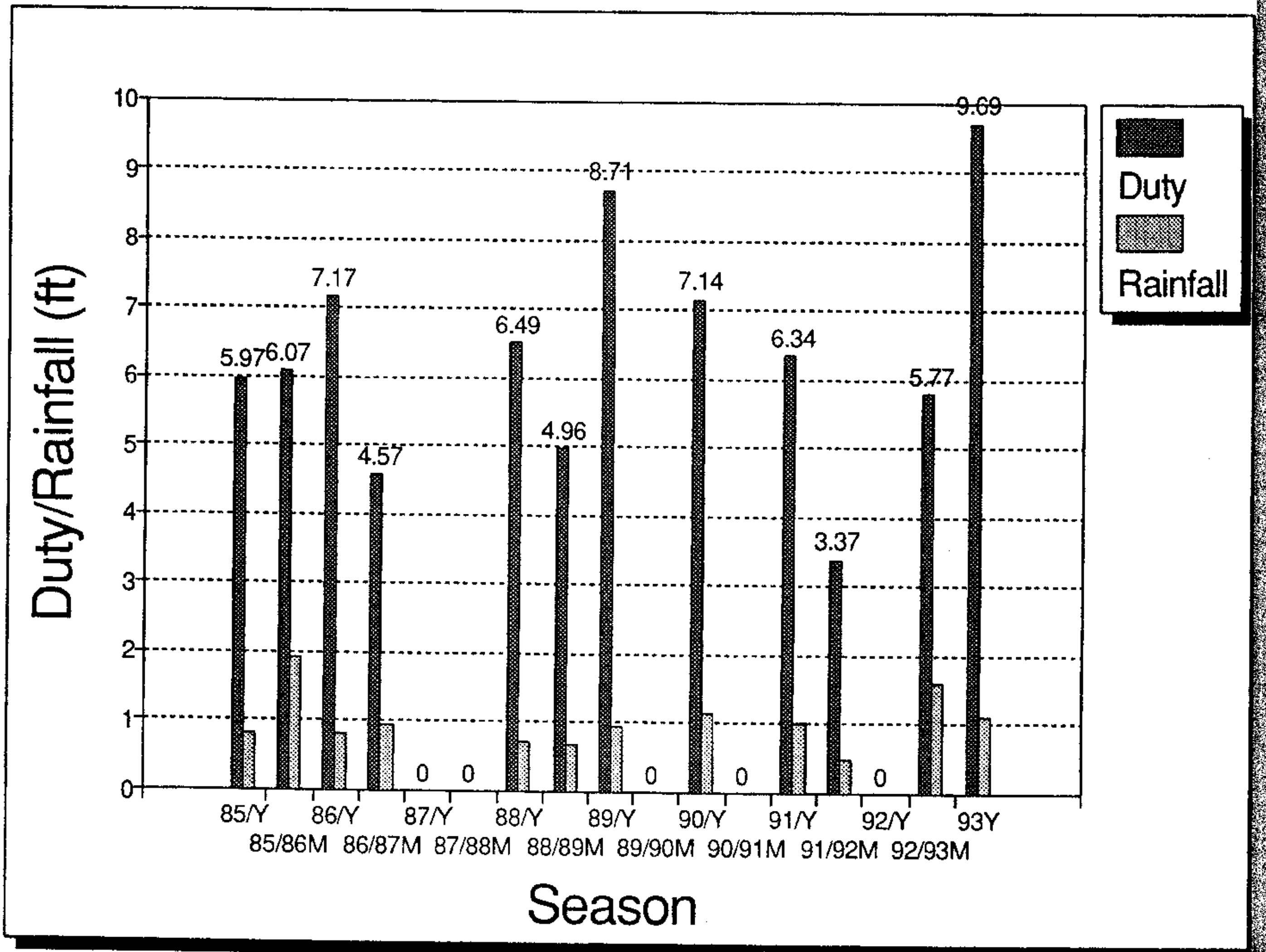

Figure 4. Total Cultivated Acreage and Cropping Intensity - Inginimitiya Irrigation System 1985 to 1993
(Source: SAPS Report 1993 and IMD)

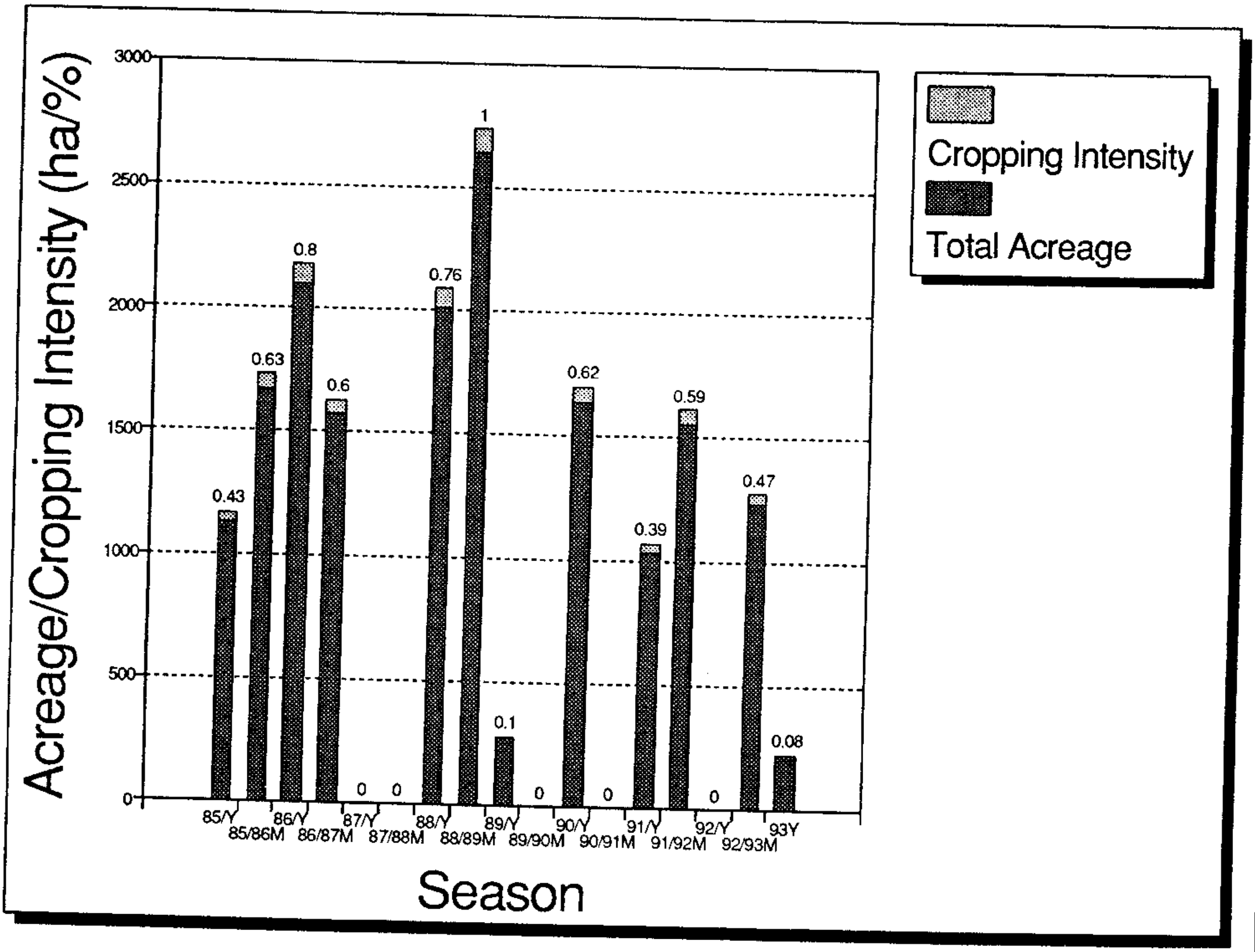

Table 1
Cultivation Acreage from 1985 to 1993, Inginimitiya Project

Cultivation Season	Paddy (ha)	Chillies (ha)	OFC (ha)	Total (ha)	Cropping Intensity (%)
85 yala	1,127	0	0	1,127	43
85/86 maha	1,673	0	0	1,673	63
86 yala	2,104	0	0	2,104	80
86/87 maha	1,574	0	0	1,574	60
87 yala	0	0	0	0	0
87/88 maha	0	0	0	0	0
88 yala	1,894	117	0	2,011	76
88/89 maha	2,643	0	0	2,643	100
89 yala	0	272	3	275	10
89/90 maha	0	0	0	0	0
90 yala	1,336	283	20	1,639	62
90/91 maha	0	0	0	0	0
91 yala	1,033	0	0	1,033	39
91/92 maha	1,558	0	0	1,558	59
92 yala	0	0	0	0	0
92/93 maha	1,233	-	-	1,233	47
93 yala	67	49	106	221	8

(Source: SAPS Report 1993 and IMD)

Table 2
Water Consumption and Duty from 1985 to 1993, Inginimitiya Project

Cultivation Season	Consumption of Water (Ac.Ft)(MCM)	Total Rainfall (Inches)(mm)	Overall Duty (Ac.Ft/Ac)(meters)
85 yala	16,627 (21)	9.56 (243)	5.97 (1.82)
85/86 maha	25,088 (31)	23.24 (590)	6.07 (1.85)
86 yala	37,306 (46)	9.84 (250)	7.17 (2.14)
86/87 maha	17,772 (22)	11.4 (290)	4.57 (1.39)
87 yala	0		0.00
87/88 maha	0		0.00
88 yala	30,394 (37)	8.78 (223)	6.49 (1.98)
88/89 maha	32,394 (40)	8.11 (206)	4.96 (1.51)
89 yala	5,850 (7)	11.28 (287)	8.71 (2.65)
89/90 maha	0		0.00
90 yala	28,930 (36)	13.71 (348)	7.14 (2.18)
90/91 maha	0		0.00
91 yala	16,186 (20)	12.36 (314)	6.34 (1.93)
91/92 maha	12,981 (16)	5.76 (146)	3.37 (1.03)
92 yala	0		0.00
92/93 maha	16,465 (20)	19.2 (480)	5.77 (1.76)
93 yala	5,814 (7)	13.52 (338)	9.69 (2.95)

(Source: SAPS Report 1993 and ID)

Table 3
Performance Data - Planned (Feasibility Study) Versus Actual

Description	Unit	Plan (F/S)	Actual
1.Meteorology Rainfall at mahauswewa	mm/annum	1,380	1,089
2.Land Use Total area	Ac(ha)	6,300(2550)	6,530(2643)
3.Settlement No. of Families		2,520	2,200
4.Cropping Pattern maha-Paddy Yala-Paddy Yala-Chillies Total Cropping Intensity	 Ac(ha) Ac(ha) Ac(ha) Ac(ha) %	 5,356(2168) 4,160(1684) 88(36) 10,396(4208) 165	 2,855(1156) 2,075(840) 197(80) 5,132(2077) 79
5.Production Paddy Chillies	 bu(ton) cwt(ton)	 761,280(15870) 1,320(67)	 323,933(6612) 3,078(156)
6.Unit Yield Paddy Chillies	 bu/Ac(ton/ha) cwt/Ac(ton/ha)	 80(4.03) 15(1.88)	 65.8(3.32) 14.8(1.86)
7.Water Delivery Overall Duty	Ac.ft/Ac	8.52	11.57
8.Water Balance Inflow Irrigation Issue	 Ac.ft Ac.ft	 94,052 53,695	 44,834 29,557

(Source: SAPS Report 1993)

Table 4
Current Performance Level

Crop	Unit	Target (FS)	Current	Target=100
1. Yield				
Paddy	(kg/ha)	4,000	3,540	89
Chillies	(kg/ha)	1.880	284	15
2. Production				
Paddy	(ton)	15,408	7,045	46
Chillies	(ton)	68	25	37
3. Cropping Intensity				
Paddy	%	151	75	50
OFC	%	14	3	21

(Source: SAPS Report 1993)

Table 5
Performance Ratios

Season	Design Duty Ac.ft/Ac(meters)	Actual Issue Ac.ft/Ac(meters)	Performance Ratio
85/86 maha	3.14 (0.96)	6.07 (1.85)	.52
86 yala	5.38 (1.64)	7.17 (2.19)	.75
86/87 maha	3.14 (0.96)	4.57 (1.39)	.69
87 yala	5.38 (1.64)	0.00	.00
87/88 maha	3.14 (0.96)	0.00	.00
88 yala	5.38 (1.64)	6.49 (1.98)	.83
88/89 maha	3.14 (0.96)	4.96 (1.81)	.63
89 yala	5.38 (1.64)	8.71 (2.65)	.61
89/90 maha	3.14 (0.96)	0.00	.00
90 yala	5.38 (1.64)	7.14 (2.18)	.75
90/91 maha	3.14 (0.96)	0.00	.00
91 yala	5.38 (1.64)	6.34 (1.93)	.85
91/92 maha	3.14 (0.96)	3.37 (1.03)	.93
92 yala	5.38 (1.64)	0.00	.00
92/93 maha	3.14 (0.96)	5.77 (1.76)	.54
93 yala	5.38 (1.64)	9.69 (2.95)	.56

Table 6
Example of a Rotational Schedule (maha 92/93 Unit One, Tract 01)

D.C.		2				3		4	
Area		120.0				65.0		70.0	
F.C.	6	7	8	9	10	11	12	13	14
Area	12.5	27.5	20.0	32.5	40.0	37.5	37.5	27.5	22.5
No. Lots	5	11	18	13	16	15	15	11	9
1	_	_	x	x	x	x	x	_	_
2	_	_	x	x	x	x	x	_	_
3	_	_	x	x	x	x	x	_	_
4	_	x	_	x	x	x	x	_	_
5	_	x	_	x	x	x	_	x	x
6	x	x	_	_	_	_	_	x	x
7	x	x	_	_	_	_	_	x	x

(Source: ID Inginimitiya)

Table 7
Cropping Information of OFC Cultivation for yala 1993

Crop Type	LB(acreage)	RB(acreage)	Total	Percentage
Paddy	36.5	128.5	165	30%
Chili	55.75	63.75	119.5	22%
Cowpea	46.5	14.5	61	11%
Pumpkin	25.75	26	51.75	9%
Gherkin	4.75	23	27.75	5%
Vegetables	7.25	19.5	26.75	5%
Others*	75.75	18.75	94.5	17%
Total	252.25	294	546.25	100% (18%)**

* Other crops cultivated are green gram, black gram, soybean, ground nut and corn.
** The total acreage of 546.25 acres is 18% of the total planned acreage of 3,000 acres.
(Source: Survey done by IMD Inginimitiya-during the season)

Table 8
Targeted and Actual Yield and Income for yala 1993
(for 25% of the Command Area)

OFC	Trgt Area acrs	Actl Area acrs	Trgt Yield kg/ac	Actl Yield kg/ac	Trgt Price Rs/kg	Actl Price Rs/kg	Trgt Rvnue (mil)	Actl Rvnue (mil)
Chili	100	110	500	600	100	80	5	5.3
Cwpea	50	56	400	800	20	16	.4	.72
Grgrm	150	20	400	570	20	20	1.2	.23
Blgrm	1500	-	400	-	30	-	18	-
Sbean	50	13.25	600	200	20	18	.6	.48
Grnut	-	30	-	1000	-	16	-	.48
Corn	-	.75	-	2500	-	6	-	.01
Ghrkn	-	29.75	-	420	-	21	-	2.6
Vgtbls	-	100.5	-	17300	-	-	-	7.9
Total	1850	360.25	2300	23390	-	-	25.2	17.72

(Source: ME4 Report from IMD Inginimitiya-end of the season)

Table 9

Targets Versus Actual Achievement of Planning Decisions Taken at Kanna Meetings for maha 92/93 and yala 93

Target Decision	Actual Achievement
Maha 92/93 kanna meeting (1/10/92)	
1. Land preparation to be completed before 25th October.	1.Only 5-10% of farmers had completed.
2.All planting activities to be completed before 15th Nov.	2.Activities completed end of December.
3.First water issue 25th Oct.	3.Issued on 25th October.
4.Last water issue 15th Feb.	4.For a small group of farmers extended until 11th March.
5.Crop type 3 month variety	5.3 month variety.
6.Last date for harvesting sometime during March.	6.Lasted upto April.
Yala 93 kanna meeting (29/4/93)	
1.Half the total area to be cultivated (LB & RB), 1.25 acres for each farmer (approx: 3,000 acres).	1.Total area cultivated is 546 acres (LB-252, RB-294).Only 18% of the estimated area.
2.Selection of D canals for cultivation by IE & PM. Dividing and allocation of land the responsibility of the respective DCO leader.	2.Selection of D canals successfully completed. Many farmers dissatisfied with allocation of land.
3.Only OFCs to be cultivated. Paddy cultivation strictly prohibited.	3.165 acres of paddy cultivated (30% of total area)
4.Allocation of land to farmers to be completed by 10th May.	4.Only partially completed.
5.Cleaning of canals to be completed by 15th May.	5.Only 10% of farmers had completed cleaning.
6.Land preparation between 10th & 20th May.	6.Only a small Percentage of farmers completed.
7.First water issue 20th May.	7.Issued on 20th May.

8.Last water issue 25th August	8.Extended for certain tail-end farmers beyond 25th August
9.Rotational schedule-once in 4 days for each field during first two weeks, and once in 7 days thereafter.	9.Main canal-three days a week (Thursday to Sunday).For D canals issued on request.
10.Harvesting to be completed by 10th September.	10.Only partially completed.
11.No land to be allocated for farmers who started paddy cultivation before 29/4/93. No water to be issued for paddy.	11.Decision carried out accordingly.
12.For farmers who started paddy cultivation after 29/4/93-land to be allocated only if paddy cultivation is given up.	12.ID has no control of preventing paddy cultivators from illegally tapping water.

Table 10
Performance Indicators in Use, Classified According to the Classification of Bos et al.

Classification	Indicator Used (User)
1.Water Delivery Performance	1. - water duty (ID) - feedback from farmers(ID) - farmer complaints (ID & IMD) - actual deliveries/ rotational schedule (crude measure) (ID)
2.Agricultural Performance	2. - cropping intensity (ID) - yield (ID & IMD) - cropping calendar (first & last water issue, sowing & harvesting dates, land preparation dates) (ID)
3.Non-Agricultural Performance	3. - farmer satisfaction (IMD) - organization funds of DCOs (IMD) - farmer incomes (IMD)
4. Used by farmers	4. - DCO fund balances - unity among farmers

Table 11
Rainfall at Inginimitiya-Expected versus Actual

Month	Expected Rainfall (Feasibility Report) (mm)	Actual Rainfall (7 yrs average) (mm)	Target = 100 (%)
January	57	61	107
February	45	18	40
March	88	51	58
April	220	104	47
May	119	65	55
June	41	47	114
July	39	29	74
August	31	23	74
September	55	59	107
October	254	172	68
November	255	150	59
December	178	64	36

(Source: SAPS Report 1993)

Table 12
Operation and Maintenance- Target Versus Actual Achievements

Requirement	Target (Feasibility Report)	Actual
1. Staff Requirement		
Engineer	1	1
Technical Assistant	2	4
Store Keeper	1	1
Clerk	1	4
Maintenance Overseer	10	3
Maintenance Labor	26	8
Driver	6	1
2.Equipment Requirement		
5-ton truck	1	1(3-ton)
Tractor	5	1
4-wheel drive car	1	-
Motor cycle	2	-
Bicycle	32	privately owned
Jeep	-	3
3.Budget Requirement	As requested by CRE's office	
1987	Rs. 1.3 million	-
1988	.84	.84
1989	.85	.85
1990	1.44	1.2
1991	1.12	-
1992	1.43	0.5

(Source: SAPS Report 1993 and ID)

Table 13
Benefit-Cost Ratio Analysis

Year	Discount Factor at 16%	Cost (Rs. mil)	NPV of Cost[1] (Rs.ml)	Farmer Benefit[2] (Rs.ml)	Forex Benefit[3] (Rs.ml)	Total Benefit (Rs.ml)	NPV of Benefit (Rs.ml)
85/86	0.862	38.7	33.4	43.0	23.8	66.7	57.5
86/87	0.743	16.1	12.0	20.1	14.6	34.7	25.8
87/88	0.641	19.4	12.4	29.2	28.1	57.3	36.7
88/89	0.552	27.1	15.0	44.9	54.7	99.6	55.0
89/90	0.476	13.7	6.5	28.7	28.6	57.3	27.3
90/91	0.410	10.6	4.3	22.2	25.7	47.9	19.7
91/92	0.354	16.0	5.7	38.3	39.0	77.4	27.4
92/93	0.305	19.1	5.8	60.8	55.6	116.4	35.5
	Project Cost	340.0					
	Total		435.1				285.0
	Benefit/ Cost Ratio	0.65					

1 - cultivation and O&M costs
2 - farmer income from paddy cultivation
3 - foreign exchange savings

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ANNEX F

IRRIGATION MANAGEMENT IMPROVEMENT PROJECT

Performace Improvement Capacity Audit: A Simple Methodology for Identifying Potential Interventions to Improve Irrigation Performance

D. Hammond Murray-Rust, Douglas J. Merrey, Carlos Garces-Restrepo, R. Sakthivadivel and Wasantha Kumara

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Performance Improvement Capacity Audit: A Simple Methodology for Identifying Potential Interventions to Improve Irrigation Performance

D. Hammond Murray-Rust, Douglas J. Merrey, Carlos Garces-Restrepo, R. Sakthivadivel and Wasantha Kumara

ABSTRACT

This paper describes a simple methodology to assess the capacity of a system to improve performance. It guides an evaluator by providing five basic sets of questions that attempt to determine potential strengths and weaknesses in current physical, managerial and institutional conditions that may favor or hinder performance improvements. The approach is intended to be sufficiently generic that it can enable evaluators to compare performance improvement capacity in different systems, as well as assessing changes in capacity to improve before and after interventions, and to overcome much of the subjectivity inherent in rapid appraisals. The methodology does not describe actual levels of performance, but focusses on the inherent capacity of the system to improve performance from existing levels to a level closer to those anticipated in the overall system objectives.

The five sets of questions cover the following areas, asking in each case whether the system can expect to meet currently stated objectives: system design; system operation and maintenance, data collection, information management, and institutional rewards, incentives and willpower to improve performance. For each set of questions a simple score can be earned, facilitating inter-system comparison.

The results suggest that the methodology is able to distinguish clearly between different capacity levels in systems with quite different objectives and in different agro-ecological zones. Using experiences from five systems in Sri Lanka, India and Pakistan a ranking of their capacity to meet objectives is given, and for two of the systems a comparison of capacity before and after interventions is also provided.

The scores awarded to each system can then be used to guide evaluators towards proposing an appropriate set of interventions, and identifying likely time frames for achieving success. The results from this survey suggest that some interventions were doomed to failure because of an incomplete understanding of the constraints and potentials that existed before intervention.

Performance Improvement Capacity Audit: A Simple Methodology for Identifying Potential Interventions to Improve Irrigation Performance

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1. Purpose of the Paper

The initial evaluation of the performance of an irrigation system tends to be highly subjective. Frequently based on some form of reconnaissance survey, the individual observer comes to an opinion as to whether the system is performing "well" or "badly"; in many instances this initial set of impressions may guide the observer towards recommendation of one or more interventions that form the basis for development of a project.

This approach is clearly fraught with all the dangers associated with subjective assessments. The overall judgement is highly dependent on the experience and observational capacities of the individual observers, each of whom brings their own biases and interests into the process. Further, there is a strong likelihood that the assessment is based on only the physical evidence of performance: condition of canals, condition of crops, head-tail variations, and so forth. It is difficult to quickly obtain similar levels of understanding of the less tangible aspects of management or institutional capacity even though these are increasingly recognized as important elements in the success or failure of individual systems (Merrey *et al.* 1993).

The purpose of this paper is therefore to propose a straightforward and simple approach that guides observers towards a common set of questions, and come to some judgement as to the potential of a system to respond positively to efforts to improve performance and the likelihood that managers will be able to achieve higher performance into the future.

Based on their experiences in a number of different systems, the authors believe that the proposed methodology does help to identify whether a system has the potential to respond to an improvement program in the short run, and to guide the evaluators towards a specific set of interventions that match the observations of currently weak areas.

Before discussion of the methodology adopted, it is useful to make a distinction between different aspects of performance assessment. At one level there is the **actual performance** of a system, measured through a set of indicators that either describe actual levels of performance or, more useful in comparative studies, a set of ratios that compare actual values to specified targets. This type of approach is addressed by Merrey *et al.* (1993) in their parallel presentation to this Internal Program Review.

A second type of assessment addresses the **potential performance** that can be expected from a system. The potential is hard to define: it is affected by conditions specific to an individual system, as well as the external physical, social, economic, institutional and political environment in which it is managed. Despite these uncertainties, potential performance is conceptually important in helping managers know what they may aim for in future interactions of the management cycle.

This paper addresses a third element of performance, namely the **capacity to improve performance** above existing levels. This approach is similar to the TOWS approach (Threats, Opportunities, Weaknesses and Strengths) used in assessing whether a particular project or course of action is more or less likely to succeed (Weihrich, 1982).

The importance of capacity cannot be underestimated: IIMI stresses the whole aspect of capacity building, and yet we rarely try to identify those elements that foster or hinder long term, sustainable capacity building. A system that performs poorly may have a high potential to improve performance, but a low capacity to actually do so; a system that performs well may have less potential for overall performance, but may have the capacity to make those improvements. In attempting to evaluate the capacity for improvement, this paper therefore addresses five basic sets of questions that can help reduce subjectivity inherent in rapid performance assessment, and guide observers into a consistent set of comparisons among different systems.

The set of questions that forms the heart of the methodology is intended to be sufficiently generic to apply in almost all circumstances. The questions address what we suggest are the five main conditions that characterize a well-managed enterprise:

- ☞ Appropriate Design to Meet System Objectives
- ☞ Appropriate Operations and Maintenance to Fulfill Targets
- ☞ Adequate Data Collection to Facilitate Monitoring
- ☞ An Effective Process of Evaluation and Feedback
- ☞ An Institutional Setting that Rewards Good Performance

The methodology described does not rely on measurement programs as the first stage, but guides the user by answering some relatively straightforward questions towards identification of possible constraints to performance improvements. This approach is called the **performance improvement capacity audit**, and is intended to be valid for a wide range of different irrigation systems.

Once this basic set of questions has been answered, the nature of the approach required to improve performance is expected to be clearer; this will then assist in the design and implementation of subsequent intervention activities.

It should be clear that the performance improvement capacity audit is no more than an initial diagnostic tool. By itself it will not lead to a full understanding of all the complexities underlying the performance of an irrigation system nor is it a substitute for research, or more in-depth analysis and diagnosis. The audit should be accompanied by an assessment of the present performance of a system and an estimate of its potential performance vis-a-vis its objectives. Finally, this tool takes as given the wider institutional, policy and physical environment within which irrigation systems exist. But the wide variation in the results of the initial application of the audit even within small countries suggests it is useful for designing system-level interventions to fit the needs of specific systems.

This approach is still in its infancy. It is based on a limited set of irrigation systems, and it is still open to question as to whether the five basic conditions used are valid determinants of performance, whether they are sufficient to cover most of the primary constraints, and whether they really work in practice. We hope the paper will lead to the voluntary testing of this methodology in a wider range of systems based on the experiences of colleagues in different countries.

2. Typical Types of Constraints to Performance

The approach adopted in this paper makes one basic assumption:

> **the objectives of the system are clearly known so that it is possible to make specific observations about whether the objectives are being met.**

Without this assumption, the exercise will rapidly revert to a more typical assessment of performance that is either totally subjective (performance is viewed as good or poor based on experience from other systems), or is based on a set of objectives imposed by the outside observer that may or may not be valid for the system under review.

The initial step is therefore to determine what the primary objectives are in the minds of the managers that the program wishes to assist.

2.1 Five Basic Elements Affecting Performance Improvement Capacity

The performance assessment framework proposed by Murray-Rust and Snellen (1993) is characterized by a set of conditions that appear to be prerequisites of a well managed enterprise. These include identifying objectives, setting operational targets for performance indicators, implementing an operational plan including monitoring and controlling the system during implementation to ensure the plan is resulting in satisfying the targets, and a longer term process of evaluation and feedback that determines whether the overall system objectives are being met. This final step includes elements of strategic management that examine the institutional and organization factors favoring or inhibiting the attainment of high levels of performance. Each of these conditions are discrete elements, and each can probably always be improved to some extent independently of the condition of the other elements. However, only when they are linked together in an overall performance-oriented framework are conditions favorable for fulfillment of the potential to attain optimal performance.

To assist in the process of rapid assessment of the capacity to improve performance, five basic sets of questions are proposed.

☞ 1 **system design**: is the physical infrastructure capable of being managed to meet the overall system objectives?

The purpose of this question is to guide the evaluator towards an understanding of whether, all other things being equal, the system design and construction enable objectives to be met. By looking at such aspects as conveyance capacities of canals, installation of measurement devices, expected water availability, assessment of proposed cropping patterns, and estimates of crop water demand made at the time of system design, it should be possible to determine whether the system design constrains the capacity to meet current objectives.

☞ 2 **system operation**: are the planning, operational and maintenance inputs resulting in a water delivery pattern that supports fulfillment of the overall objectives?

Many systems have developed operational rules that are not necessarily consistent with the initial objectives. Questions here should focus on the type of water delivery targets, cropping targets, and output targets that are in place, how water is requested or delivered (timing, volume, water rights, indenting, etc), and what additional rules or regulations exist for periods of shortfall or excess water availability. Determination of the type of standing orders given to field staff may reveal a great deal concerning the actual operation of the system, particularly in the difficult task of distinguishing between formal and actual rules.

☞ 3 **data collection**: is sufficient information being collected to determine if targets and objectives are being met?

Questions in this group focus specifically on whether there is sufficient information actually collected and available to enable managers to effectively monitor and control operations. The location or density of measurement points and the type of data collected (water level, discharge, rainfall, area irrigated, etc.) reveal whether they can monitor the degree to which targets are actually met.

☛ 4 **management framework**: are available data used as part of a systematic process of control for operational performance and evaluation for assessment of outcomes and impacts?

The follow-on to the set of questions on data collection is related to the capacity of the management of the system to utilize available information both in the process of assessing short term performance and making appropriate adjustments to current targets, and in the longer term periodic activity of evaluating past performance, altering seasonal targets and even modifying system objectives.

An underlying assumption here is that performance and management are intimately associated. A more detailed discussion of this association is provided in Merrey *et al* (1993), a paper that directly complements this one.

☛ 5 **rewards, incentives and willpower**: is there sufficient motivation to improve performance of the organizations and individuals involved in system management?

The final observations relate to the willingness of the agency to be flexible and supportive both in operational practices and staff management to encourage its staff to obtain higher levels of performance. This may include determination of various incentive packages, the way in which promotions are determined, the response of the agency to individual initiative and innovation, and whether there have been changes from previous conditions.

Based on the answers obtained in each of these five areas, it is possible to award a score that allows the potential for performance improvement earned by each system to be assessed and compared. A high score indicates that there is good capacity to achieve higher performance. A lower score indicates the presence of several constraints to improvement of performance.

In this paper, scores of 0, 1 or 2 can be earned in each of the five areas to allow a simple comparative value to be calculated: more complex scoring systems could be used, but there is then the possibility of the procedure losing some of its deliberate simplicity. Simplicity is far more important than precision, even though this admits an element of subjectivity into the analysis.

2.2 Application of the Performance Improvement Capacity Audit

Having numerical scores for each of the five areas included in the performance potential audit makes it possible to be more definitive about opportunities for intervention. Three immediate uses of the audit are apparent.

a. The **total score** will indicate the relative ease or difficulty of improving performance. A high score means that most of the conditions are in place to enable the system to reach a high or optimal performance: it does not mean that the system is necessarily performing well, but that few additional interventions are needed to achieve a high potential for performance. A system that earns a low total has several constraints, and will require more time and attention than one that scores well in the initial evaluation. It does not mean that the system is beyond hope or salvation, but it does mean that improvements will be harder to achieve.

b. The **combination of high and low values** is also important. Low scores in certain areas may guide the intervention program towards a particular orientation, by determining whether more or less stress needs to be placed on physical improvements, management interventions or institutional changes. The purpose here is to enable the evaluator to systematically identify appropriate interventions rather than merely propose interventions for a particular system just because they were successful somewhere else: such success may only occur when there is particular combination of high and low values.

c. The **change in scores** following an intervention makes it possible to determine whether the improvements that have been achieved are more or less likely to be sustained. There is some evidence that IIMI presence in a system invokes the Hawthorne Effect: our presence makes people work harder, performance improves, but when we withdraw performance returns to previous levels. Using the audit approach makes it possible to see whether the intervention really addressed a structural weakness, or merely achieved a short term success.

If the approach is successful it may lead potential projects away from adopting a particular innovation merely because it is in vogue, and towards adopting an intervention or combination of interventions that best address the identified constraints. Many agencies, including IIMI, are guilty of promoting a particular innovation to improving performance: it was successful elsewhere, or it is within the expertise of particular staff members. However, this approach is weakened if it does not account for the particular combination of system strengths and weaknesses.

3. Examples of the Use of the Audit

The validity of using the audit as an approach to identify opportunities for improving performance has been tested initially by applying it retrospectively to a number of systems in which IIMI has been working in Sri Lanka, Pakistan and India. Further validation is required on other systems to confirm its usefulness.

Table 1
Performance Improvement Capacity Audit in Five Selected Systems

	Gal Oya (1981)	Gal Oya (1993)	Mahi Kadana (1993)	Kirindi Oya (1989)	Kirindi Oya (1993)	Inginimitiya (1993)	Chashma Right Bank (1993)
Design	1	2	2	1	1.5	1	1
Operations	1	2	1	1	1.5	1	0
Data Collection	1	2	1	1	2	1	0
Management Framework	0	1	1	0	2	0	0
Willpower	0	1	1	1	1	0	0
Total	3	8	6	4	8	3	1

Notes:
0 Low Capacity for Performance Improvement
1 Moderate Capacity for Performance Improvement
2 High Capacity for Performance Improvement

IIMI's activities in Kirindi Oya started in 1986. At that time willpower was assessed at "0," and the overall score at "3."

More detailed descriptions of the conditions faced in each of the systems are provided in the appendices to this report, including the rationale for the score earned in each category of the audit. Table 1 provides a summary of the scores for easy reference.

A summary of the situation in each case study is provided, followed by an assessment of what the audit can tell us about what remedial action is needed, and what the potential for performance improvement actually is.

3.1 The Gal Oya System, Sri Lanka

Gal Oya in its 1993 state represents a system that has few constraints to performance improvement as far as the water delivery system is concerned. The design is compatible with system objectives, the operations match the objectives, there is a good data collection program, and there is strong willpower at the individual but not necessarily institutional level to continue to perform well. However, there is still a weak management framework. If a better system were in place for evaluating the results of each season and feeding these into the plans for next season, then it would be possible to feel confident that the system would be resilient in terms of staffing changes, and would be well equipped to cope with unpredictable changes in the external environment such as drought or excess rainfall.

This favorable audit contrasts with Gal Oya in 1981. At that stage the system design was only partially capable of meeting system objectives because the main canal was severely deteriorated, data collection was primarily at the reservoir and main canal level, there was no effective management framework that used data to improve performance, and certainly at system level there was little motivation to improve performance. The reasons why this average situation was transformed into a success are discussed below.

3.2 The Mahi Kadana System, Gujarat, India

Mahi Kadana represents a slightly less favorable situation than Gal Oya in 1993. There are no serious constraints in respect of the system design (probably only the lack of suitable measurement structures at the critical handover points between irrigation work supervisors). The operations, while adequate at main canal level, are less optimal at secondary level; the data collection programs are moderate; there is a management framework but it is out of date and not fully effective; and the willpower remains a little unsure both at management and field level.

3.3 The Kirindi Oya System, Sri Lanka

The Kirindi Oya system in 1989 represented a situation in which there was a multiplicity of problems: there were important design, operational, and institutional constraints, and a complete lack of a management framework. As IIMI was designing an intervention phase, the Department was attempting to overcome some of the design constraints; IIMI's interventions focused on operations, institutional strengthening and establishment of a management framework. By 1993, these interventions showed considerable progress and the constraints were less serious as a result, performance of the system was improving.

3.4 The Inginimitiya System, Sri Lanka

Inginimitiya is significantly lower in total score. The design has some deficiencies, particularly in meeting land preparation requirements. Operations are only moderate, characterized by inequity and uncertainty; there is data collection only at the reservoir/system level but not below that; there is no use of that information in any effective management manner and little evidence of response to past failures in achieving effective management. There is little evidence of any serious effort to improve performance, either at field, system or agency levels.

3.5 The Chashma Right Bank System, Pakistan

Chashma Right Bank falls at the bottom of the ranking, and shows very limited capacity to improvement of performance. There are serious design constraints at both secondary and tertiary level that make it virtually impossible to meet system objectives; it is not possible to envisage much progress towards meeting system objectives until these design shortcomings are met. The operational mode adopted by both agencies involved in main system management shows no serious effort to meet the project objectives, and neither agency collects sufficient information to permit much improvement. The lack of any significant data collection below the main canal is matched by the lack of any management framework: development of a data collection program would probably be ineffective because no system exists to process and evaluate those data. There is also little willpower evident at system or agency level that can start to turn things around in the near future.

4. Assessing IIMI's Experiences in Light of the Audit Results: Some Hypotheses for Further Testing

Application of the audit in this way allows us to evaluate some of the reasons for the relative success or lack of it in each of the five systems where IIMI has either directly intervened, or observed interventions of its partners[1]. Although the sample is small, the range of degree of success suggests some degree of causal relationship that requires further verification.

This verification can be best accomplished by suggesting a set of simple hypotheses that can be easily tested:

a. **If there is a low overall score in the audit, then the probability of a single intervention being successful is very low: improvement will likely require a mix of two or more interventions.**

At Inginimitiya a single intervention was chosen: the introduction of a sophisticated decision support computer model that would make it simpler for managers to better match water deliveries to crop demand[2]. In reality the intervention failed because there was no motivation to organize staff to collect necessary information on field level conditions, and no interest at system level in using the model to help make better informed decisions to be presented at the joint agency-farmer planning meetings.

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[1]. IIMI itself did not intervene in Gal Oya, but several IIMI staff including two of the authors of this paper were heavily involved; the experience of this project has had a strong influence on much of IIMI's other work.

[2]. In fact, this was an intervention in search of a system: the Irrigation Department proposed Inginimitiya as an appropriate system when consulted on its interest in testing of the computer model.

At Chashma Right Bank the current project is designed primarily to improve operations and strengthening monitoring, with the expectation that additional recommendations will be made that address some of the design problems. However, there is little emphasis given to either the establishment of a systematic management framework or to amelioration of the admittedly extremely complex institutional constraints. The very weak package of incentives, rewards and willpower makes the adoption of the more technical aspects unlikely, indicating that until these issues are addressed the fulfillment of the current objective set will be an extremely long and hard process.

Despite the low score, it is possible to envisage improvements in performance if the agency pays more attention to the problems of willpower, data collection, and operations, without having to consider changing the overall project objectives.

b. **A low overall score also suggests that the time required to improve performance will be significant, making a long term commitment necessary to bringing about change**

Gal Oya in 1980 was an unsatisfactory but not irretrievable system. Although the first few years of a donor-funded project were not encouraging, by 1990 the system was working well, and has continued to do so since then. However, it took the entire 10 years, with a series of sequential interventions to achieve the current level of performance: rehabilitation of water delivery infrastructure, organization of farmers, establishment of mechanisms for effective communication between agency and farmers, introduction of new operational plans, and upgrading of data collection programs to ensure that plans and targets were accomplished. In addition to the long period of time required, a substantial investment of about $20.0 million was made.

The current low score at Inginimitiya indicates that short term inputs will have little or no impact on the capacity of the system to improve performance. The conditions at Inginimitiya are similar to those of Gal Oya in 1981, and to those of Kirindi Oya in 1986. This suggests that a fairly lengthy program of systematic interventions is likely to be required to increase the capacity of the system to higher levels.

c. **A very low score may require a major rethinking of project objectives and the way it is to be implemented**

At Chashma where the overall score is very low the mix of interventions is even more complex than in Gal Oya, involving a change from supply-based water deliveries to deliveries that respond to the extent possible to field-level demand. Assessment of the progress of this change over the eight years of the project suggests there are so many deficiencies that a major reassessment of the project objectives would be fruitful (in reality this has happened by default, with the system now operating as a supply-based system with a high water allocation). This suggests that the problem must be tackled in stages, starting with the institutional dimension that sets the scene for other possible interventions. Change will be slow and expectations modest for each stage of intervention.

One aspect peculiar to Chashma Right Bank when compared to the other systems in this sample is that it represents the first effort in Pakistan to more closely match water supplies and crop demand. This means that there has to be significant institutional learning to understand project objectives and capacities before technical and managerial capacities can be upgraded.

In Kirindi Oya, the project objectives had evolved during the construction phase, as outside consultants recognized that some previous assumptions were wrong. However, it was not until after the system had been operating for several years that the Department itself along with farmers began focusing its attention on the objectives of the system, and how these could be achieved. Progress has been made but far more time will be required to achieve a satisfactory level of performance.

d. **A high overall score indicates that an appropriate single purpose intervention has a high potential for improving performance**

At Mahi Kadana there are few design constraints and there is currently sufficient interest in improving performance; therefore a single purpose intervention has been proposed. In this instance, the intervention involves the introduction of an upgraded management information system that permits managers to utilize existing information more effectively. It is hoped that as the utility of the MIS in helping managers to make more informed decisions is recognized, existing weaknesses in system operation, data collection, and the overall management framework will automatically be overcome.

Similarly, in Gal Oya, a further potentially useful intervention is in strengthening the management framework that assists managers in trying to fine tune existing procedures to make them more efficient.

e. **Attempting to improve a low score in one area of concern while allowing others to remain at zero is unlikely to result in significant performance improvements**

If the audit indicates a serious constraint in one or more areas, and only moderate constraints in others, the potential to improve performance will be very limited if the intervention package does not address the more compelling constraints as well as the less serious ones. Inginimitiya and Chashma Right Bank are examples of interventions that were too limited in scope; Gal Oya and Kirindi Oya are examples of more comprehensive interventions to address several constraints. The latter are more difficult to manage, but have a higher likelihood of success in the long run.

5. Conclusions

The audit of capacity to improve performance is a tool to analyze the potential of a system to respond to particular kinds of management interventions, and to identify the most appropriate types of interventions and their sequencing. The audit does not, by itself, identify the actual or potential performance of the system. This is a separate, but also important, analysis that still needs to be undertaken. The authors conclude that the audit approach offers a number of significant opportunities. Each of these is briefly discussed below.

A set of questions like those described in this paper reduces, but does not eliminate, the common problem of subjectivity in rapid appraisals. If colleagues have a similar set of questions, then it makes it easier to make comparisons about the utility of alternative approaches.

The audit helps in confirming whether the most promising intervention is going to be comparatively simple, with a relatively short gestation period, or whether it will involve a mix of interventions spread over a longer time period.

It may also help in identifying what the mix of interventions should be, and in what order they should be sequenced, to provide a basis for sustainable improvements in performance into the future.

In a retrospective mode, IIMI may be able to gain a greater insight into why some projects have been more successful, why others had only short term impact, while others were comparatively unsuccessful. This learning process provides an opportunity to design better projects in the future that have a higher likelihood to achieving tangible benefits within the proposed project time frame.

Finally, the audit approach offers the prospect of being able to assess whether there have been structural improvements in the capacity to improve performance rather than the short term performance gains that may quickly be lost after the conclusion of the intervention period. This may represent a significant improvement in IIMI's task of improving and strengthening the capacity of agencies to manage their systems better. At the same time, it should be noted that there may be a significant time lag between the strengthening of capacity to improve performance and actual improvements in performance achieved.

The validity of these conclusions can be tested using IIMI's and others' past and current experiences in different types of systems in different countries. If we are willing to invest some time and effort into this retrospective review, it may be possible to refine the questions, add some that may have been neglected, and use this as a common approach to assessing both potential to improve performance in different projects, and analyzing the causes of our successes and failures.

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APPENDIX A
GAL OYA LEFT BANK SYSTEM, 1981

D. Hammond Murray-Rust and Douglas J. Merrey

A.1 System Overview and Objectives

The Gal Oya Left Bank System was constructed between 1952 and 1960 as the first stage of the Gal Oya Irrigation Scheme. The overall irrigated area of Gal Oya was designed to be approximately 48,000 ha, divided into the Left Bank (18,000 ha), Right Bank (10,000 ha), and River Division (20,000 ha). The River Division consists primarily of land irrigated through diversion weirs along the Gal Oya valley and some smaller parallel rivers, as well as using reservoirs constructed several hundred years ago.

Traditionally the entire system has been under rice, with the exception of some 4,000 ha on the Right Bank producing sugarcane to supply the local sugar mill. Although periodic efforts have been made to try to diversify away from rice, these have not been successful: the lower third of the entire area has heavy soils and high water tables, and efforts to pump water for irrigating non-rice crops in higher areas proved completely uneconomic.

The overall objectives for the Left Bank have, therefore, focussed on rice production. It is assumed that the entire system will be irrigated during the wet season (October - March) using a combination of rainfall and irrigation deliveries: some 75% of all annual rainfall (1500 mm out of 2000 mm) falls in the last three months of the year. Dry season cultivation (March or April to August) is dependent on the storage in the Senanayake Samudra Reservoir following the completion of the wet season crop. A period of intense planning takes place in February and March to determine what can be irrigated in the forthcoming dry season, making allowance for a small reserve to provide domestic water supply to many areas because there are few other reliable sources of water towards the end of the dry season when there may not be significant rain for three months.

Almost all rice is broadcast. This requires that land be thoroughly prepared prior to sowing, and it is normal to allow three or four weeks of water issues for land preparation prior to a predetermined sowing date. However, farmers are encouraged whenever possible to use rainfall for land preparation in the wet season.

Equity is an important consideration. Land throughout the Left Bank was allocated to settlers in either 1.2 or 1.6 ha blocks, and all farmers have an equal right to receive water from the system, except when there is insufficient water in storage and some farmers have to temporarily forego their right for a season.

A.2 Performance Potential Audit: 1981 Conditions

Summary of Audit:

Issue # 1:	**Design Considerations:**	**Score = 1**
Issue # 2:	**Operational Considerations:**	**Score = 1**
Issue # 3:	**Information Considerations:**	**Score = 1**
Issue # 4:	**Management Considerations:**	**Score = 0**
Issue # 5:	**Institutional Considerations:**	**Score = 0**
	Total:	**Score = 3**

By 1981, following 20 years of irrigation, the Gal Oya Left Bank was badly in need of rehabilitation. This had been identified during the late 1970s as an important project because the entire Gal Oya Irrigation System accounted for about 20% of the large scale irrigated area of the country. The following evaluation of the system is based on conditions that were experienced immediately prior to the commencement of the USAID-funded Gal Oya Water Management Project that included physical, organizational and operational components.

☛ 1 **System Design**: is the physical infrastructure capable of being managed to meet the overall system objectives?

The system design was based on the assumption that water supplies in main and secondary canals would be continuous; any rotations, if required at all, would be at tertiary level, and normally within the tertiary block. There is no evidence of any rotational schedule being included in the original design. The continuous supply pattern meant that the water level in canals at each offtake would be controlled by the total volume being issued rather than through use of cross-regulation structures in the main canal: in the entire 120 km of main and branch canals there were only 6 cross-regulators, all of which were located close to the head of larger secondary canals.

The major design problem encountered at the main/branch canal level relates to the difficulties in operating the system when water in the reservoir was insufficient to permit the entire Left Bank system to be irrigated. Under these conditions the only alternatives were to operate canals at about half of their designed discharge (resulting in inappropriate water levels at gates and control structures), to implement rotational irrigation at very high levels in the system (an inefficient use of water), or to severely restrict the irrigated area. The sparse density of control structures, combined with a lack of any discharge measuring devices below the main reservoir, meant that precise water control under water short conditions was impossible.

Given that the total capacity of the reservoir is 979 million m^3, maximum storage represents a total water supply potential of almost exactly 2000 mm of irrigated water throughout the command area. This figure represents the normal design allocation of the Irrigation Department for a dry season crop, and theoretically leaves no margin for error if the reservoir is not full.

Both the lack of adequate cross-regulation capacity, and the lack of capacity to implement alternative water delivery patterns when water is in short supply are sufficient to reduce the system design earn to "1."

☛ 2 **System Operation**: are the planning, operational and maintenance inputs resulting in a water delivery pattern that supports fulfillment of the overall objectives?

The overall operational pattern that had developed by 1980 only partially supported the overall objectives for Gal Oya Left Bank. In the wet season there were some efforts to respond to rainfall, thereby conserving water in storage for the forthcoming dry season, but these were not as systematic as they could be. Nevertheless, the majority of the system could be irrigated (about 2,000 ha in tail end areas had become unirrigable) and there is no evidence of any serious water induced crop failure.

Dry season management was much more problematic. In all dry seasons from 1973, rotational irrigation had been adopted as the standard operating practice, involving rotational units of approximately 5,000 ha. The stated plan was that water deliveries would be for five days, with a further five days without water. The actual implementation of these plans was not rigorous, nor was there any process by which information was made available to farmers concerning changes to the nominal schedule so that water supplies were not predictable.

To further complicate matters, there was a tendency in very dry years to authorize more land for cultivation than could be immediately justified by available water supplies. The next result was that in drier years, such as 1981, water deliveries were not only more unpredictable than normal, but also inadequate in some locations and crop yields in marginal areas declined significantly. The standardization of the allocation process in dry years serious affected equity, one of the overall objectives for the system, because whenever water was scarce the same group of farmers (inevitably in tail end areas) were not included in the seasonal allocation plan.

Maintenance had been inadequate to keep the system in good operational condition. Many sections of the main/branch canal system had suffered serious erosion problems and head-discharge relationships were completely different from design expectations; most gates to secondary and tertiary canals were broken or missing; there were no functioning measuring devices; and most water level gauges had become illegible. Although operational plans did not include systematic allocation of water by volume, any initial capacity to control and monitor flows had been lost.

Gate keepers and technical assistants had few standing orders, relying on daily instructions from the engineer's office before making adjustments.

For those farmers in the advantaged head end areas, however, the system appears to have met their needs quite well, and for this reason an overall score of "1" is earned for operational considerations.

☛ 3 **Data Collection:** is sufficient information being collected to determine if targets and objectives are being met?

In 1981 there was a basic data collection program. Water levels and gate settings were recorded daily at 25 locations in the main and branch canal system, but the only discharge measurement made was at the reservoir. Daily rainfall was recorded in three locations. These data were delivered manually, and had a lag of one day: the messengers would wait in the office until the daily instructions were issued. Only the instructions to the reservoir operator could be transmitted by telephone. The data collected were dutifully recorded in the office ledgers, and were normally within a day or two of being up to date.

No information was available of water conditions in secondary or tertiary canals, in drains, or water status on farmers fields.

Data on area irrigated were poor. The only records related to the designed areas of each canal, and ignored increases that were known to have occurred thorough "illegal" expansion of command areas of secondary and tertiary canals. What area data did exist related to the official area authorized for cultivation at pre-seasonal meetings, and not to the area actually irrigated. Yield and other agricultural data were not available to Irrigation Department staff on any systematic basis, and were collected by administrative rather than hydrologic areas.

The overall assessment is that the data collection program was functioning, albeit at a comparatively low intensity. The data that were available were generally accurate, and could be used in a program of calibration of existing structures. For this reason, a score of "1" is awarded for the conditions that prevailed in 1981 relating to Data Collection.

☛ 4 **Management Framework:** are available data used as part of a systematic process of control for operational performance and evaluation for assessment of outcomes and impacts?

The weakest aspect of Gal Oya Left Bank in 1981 appears to have been a lack of a systematic use of available data for changing operations, maintenance and management. Almost all knowledge of actual conditions, ranging from probable inflows into the reservoir to rainfall, water deliveries, area irrigated, etc. were anecdotal: although an adequate basic information set existed, this was not used to determine whether operations were meeting objectives, and whether changes in operations, planning or other activities could be attempted.

Like many weakly managed systems, much of the actual decision-making was delegated to lower level staff with longer experience in the area than the professional engineers who transferred in and out with some regularity. However, lower level staff had no authority to make changes to existing practices, and under normal conditions the system ran more by rote than by management.

There was no systematic process of consultation and communication between farmers and the Department for planning, operations, monitoring or evaluation. Farmers often pressed their cases with higher level officials and politicians, leading sometimes to *ad hoc* decisions in response to these pressures, whether they were legitimate problems or not.

Further, when crises occurred, the normal reaction was one of confusion. Decisions on how much water to release and where to send it become more *ad hoc*, and more subject to political interference. The result was even more erratic performance than under normal conditions.

Under these conditions it is not possible to say the system was really being managed in any systematic way, and does not earn any points.

☛ 5 **Rewards, Incentives and Willpower:** is there sufficient motivation to improve performance of the organizations and individuals involved in system management?

The overall institutional setting in Sri Lanka generally did not reward high performance: promotion was primarily by seniority, there were no financial rewards for doing a better or worse job, and apparently very little concern from superiors as to the actual performance achieved. This lack of support from the central office, lack of systematic assessment of staff performance, and lack of incentives for achieving better performance had a serious impact on local officials' approach to their jobs.

While there is some evidence that individuals, particularly at field level, did try to manage water as well as they could given the overall uncertainties of water delivery at system level, response to crises was *ad hoc*. Individuals spent more time in the field in these difficult periods, and worked longer hours to make the best of a not very good job, but in no way could this process be seen as other than fire-fighting.

Reports from that period characterized the relationships between Department officials and farmers as a state of "warfare." Farmers in many parts of the system were extremely dissatisfied with irrigation services; the pre-season cultivation meetings were observed frequently to break down into shouting matches. In some cases there were language gaps, with the engineers not fluent in the farmers' language, leading to their using English in some meetings -- which was not understood by most farmers. On the farmers' side, there was very little cooperation for irrigation management, and no organizations through which farmers could either express their views or address problems themselves.

No score is earned in this category.

Sources: Murray-Rust 1983; Uphoff 1992; Merrey & Murray-Rust 1989; authors' personal experiences

APPENDIX B
GAL OYA LEFT BANK SYSTEM, 1993

D. Hammond Murray-Rust, Wasantha Kumara and Douglas J. Merrey

B.1 System Objectives

Following rehabilitation there have been a number of changes in the system objectives compared to the situation in 1981. Although there have been few changes in terms of agricultural expectations - the system remains rice-based apart from the continued cultivation of sugarcane on the Right Bank - there have been significant changes in respect to design, operations, organizations and institutional incentives.

Operationally, the objective of the physical component of rehabilitation was to re-establish conditions suitable for continuous irrigation in the main and branch canals, and in the larger secondary canals. Groups of smaller secondary canals and most tertiary canals would have a regular rotation that specified the number of days per week that water would be supplied. To facilitate this during periods of lower flow, a number of additional cross-regulators were constructed in main and branch canals and larger secondaries, while badly eroded sections of the main and branch canal system were patched up and protected with rip-rap to prevent subsequent re-erosion. The cross-sections of most secondary and tertiary canals were restored by desilting and bank strengthening. Secondary and tertiary canal headgates were repaired or replaced, regular measuring sections were installed in main canals, and broad-crested weirs constructed at the head of larger secondary canals.

Organizationally, farmer groups were created that have a four-level hierarchy: field canal (tertiary) groups that deal with internal aspects of water allocation, distribution, and maintenance; secondary level canal groups that federate all constituent tertiary groups into a single organization, again primarily with a focus on O&M; five area committees, which play a major role in planning for each season and as a forum for monthly meetings to discuss problems and find solutions; and farmer representation on the seasonal District Agricultural Coordination Committee that oversees all agricultural activities in the district. The specific objective in establishing these organizations is to involve farmers as equal partners in the entire process of planning, implementation and evaluation. The Gal Oya Left Bank farmer organization program was a pioneering effort that has been replicated in large measure in other large-scale Sri Lankan irrigation systems.

The third objective was to systematize operations through computerization and increased monitoring of day to day conditions, building on the various surveys and inventories that were included in the rehabilitation activity. The data base established on overall system conditions during rehabilitation was quite accurate, and remains largely valid to the present time.

The first two activities (physical rehabilitation and organization) were conducted largely simultaneously, while operational changes came once the rehabilitation was completed. This sequencing was almost certainly the correct one, although it must be admitted that it may have been serendipitous: farmer organization on the scale that ultimately occurred was only an add-on to the initial project, and the physical work was undertaken initially to restore 1952 design conditions without any understanding or analysis of the changes in the system that had occurred since that time. Further, the actual design assumptions that were made during rehabilitation were done largely independently of the operational wing of the Irrigation Department, missing out on using experienced operational staff in the design process.

B.2 Performance Improvement Capacity Audit: 1993 Conditions

Summary of Audit:

Issue # 1:	Design Considerations:	Score = 2
Issue # 2:	Operational Considerations:	Score = 2
Issue # 3:	Information Considerations:	Score = 2
Issue # 4:	Management Considerations:	Score = 1
Issue # 5:	Institutional Considerations:	Score = 1
	Total:	Score = 8

The opportunity to revisit the system several years after rehabilitation provides a test of the actual impact of rehabilitation activities on improving the potential of the system to reach high levels of performance. The focus of these visits has been to specifically examine whether the relatively weak conditions identified in 1980-1983 had been addressed and overcome, or whether the impact of rehabilitation, judged very successful in 1986[1], had started to decline once again.

☛ 1 **system design**: is the physical infrastructure capable of being managed to meet the overall system objectives?

In 1993 the system is still in good physical condition, and there appear to be no constraints imposed by the re-design on the achievement of operational objectives. It is possible to irrigate the entire command area of the system, a condition not feasible before the rehabilitation. The cross-regulators added during rehabilitation appear to provide adequate head conditions when discharges are less than full supply, the repaired gates are still generally functioning as intended, secondary canal measuring devices are still operational, and gauges are still in good condition.

There has been no noticeable deterioration of the main/branch canal system, and there is little evidence of significant erosion in secondary canals in sections that were repaired using compacted soil.

Given these favorable physical conditions, it appears that the rehabilitation did indeed restore the full capacity of the water conveyance system to meet system level objectives; a score of "2" is therefore earned.

☛ 2 **system operation**: are the planning, operational and maintenance inputs resulting in a water delivery pattern that supports fulfillment of the overall objectives?

The operational plan developed subsequent to the completion of the physical works appears to be implemented with little apparent disruption. The plan calls for a distinct effort to conserve water in storage during the wet season, taking every opportunity to reduce discharges or stop releasing water during periods of significant rainfall. There is evidence that this has been successfully accomplished because wet season releases are far less than before.

A second innovation was the rescheduling of water issues for land preparation for the dry season. Traditionally this was not started before mid-April (following the Sinhala and Tamil New Year festival). By agreement with farmers, three weeks of water issues made at maximum canal capacity are allocated

1 The Gal Oya Water Management Project Evaluation Report indicated an Internal Rate of Return of between 19% and 40% depending on different assumptions. Whatever the actual IRR, the project was adjudged to be highly successful.

for land preparation, and a fixed date for the final release of the season is scheduled for mid- to late-July. In recent years this schedule has been strictly adhered to, and no requests for extension of water issues from farmers have been received.

During normal issues the continuous flow pattern appears to have stabilized, and intended water levels at all gauged locations are known to field staff and farmers alike. There appear to be no uncertainties over water deliveries, making it one of the most predictable operational plans encountered.

Equity has been largely restored. For the past few years all farmers in the command area have obtained two crops of rice per year, including those farmers in areas previously out of command due to canal deterioration. This equity has been accomplished with smaller overall water releases than before rehabilitation, and has been accomplished even when water availability in the reservoir was at levels similar to earlier times when only two thirds of the system were successfully irrigated.

In all regards the operations appear to provide adequate and predictable water supplies to all areas, to the point where there are no longer any farmer complaints reaching the Irrigation Department offices, and no political interference in system operation. Any difficulties that arise appear to be sorted out at the secondary or area level farmer committees at which Irrigation Department field staff and engineers are invariably present. A score of "2" is earned for Operations.

☛ 3 **Data Collection**: is sufficient information being collected to determine if targets and objectives are being met?

The data collection program which was expanded considerably during the rehabilitation process has been maintained since the rehabilitation project was completed. Water level readings in main and secondary canals are supported by rating curves that allow discharges to be calculated at some 50 locations. Rainfall data are now available from over 10 locations. All these data are collected on a daily basis, and in some cases twice a day.

There are now accurate records of the command area of each canal, including the unofficially irrigated areas as well as the official areas. However, no records appear to exist to determine if there have been any further changes in irrigable area following the detailed surveys of 1982-84.

The only weak link in the data collection program is that yield information is not readily available from the Agriculture Department, and it is still collected on the basis of administrative boundaries rather than by canal commands.

Despite this, the data collection program is superior to most, and is not seen as a constraint to performance improvements. The score earned is "2."

☛ 4 **Management Framework**: are available data used as part of a systematic process of control for operational performance and evaluation for assessment of outcomes and impacts?

There is still some apparent room for improvement in this category. As part of the rehabilitation project, overseas training in computing was provided to several staff, and a computer provided at site to process the daily information. Due to transfer of the trained staff, breakdown of the computer and lack of a clear management framework, the information available is not processed as well as it could be. Although daily records exist on paper, they were never computerized, and thus have not provided a good basis for evaluating performance within the system.

Although the operational management of the system is undertaken according to the objectives, the risk in not having a more analytical assessment of past performance is that it becomes harder to adjust to unusual conditions. As long as the reservoir is full, or at least has sufficient water to permit continuous flow without serious difficulty, the existing management approach is adequate. In the event of a drought, however, there is the possibility that more precise knowledge about actual water consumption in different areas, the conveyance losses, and other critical factors is not available to those involved in making more difficult seasonal decisions.

Despite this state of affairs, there have been several efforts at system level to assess performance in terms of overall water issues in relation to reservoir storage and irrigated area, and the staff are able to claim with justification that the system is performing better than it was a decade earlier. The very fact that these performance improvements are talked about indicates that there is some degree of responsiveness to performance in a reasonably systematic manner. Furthermore, the presence of functioning farmer organizations and joint farmer-official committees at higher levels means that a capacity for systematic assessment of performance is present.

Given the overall use of the data for management purposes, the situation at Gal Oya in 1993 is regarded as intermediate, and a score of "1" is earned.

☛ 5 **Rewards, Incentives and Willpower**: is there sufficient motivation to improve performance of the organizations and individuals involved in system management?

Within the context of the overall institutional conditions of the Irrigation Department, Gal Oya presently appears to be characterized by a relatively high degree of motivation and interest in improving performance at system level. Both the senior engineers currently in charge of the system have voluntarily accepted a posting in a relatively unpopular and remote location in order to get early promotions. This suggests that there is now some degree of incentive provided to engineers who are willing to take on more challenging assignments.

Similarly, there is considerable motivation for the Irrigation Department staff in dealing with a maturing and effective hierarchical farmer organization. Irrigation complaints no longer reach district and political levels, when in the past they dominated high level meetings. The farmer-official relationship appears cordial and relaxed, in contrast to many other systems in the country.

A further evidence of motivation is that the daily data collection program has continued more or less uninterrupted despite civil war and unrest that cuts off the bottom quarter of the system. Information on water conditions is still taken to the boundary between the two main ethnic groups in the area, and collected from there for entry in the registers in the main office.

There is undoubtedly room for improvement in terms of institutional conditions. To a considerable degree, the particular individuals assigned to Gal Oya during the past decade have taken more interest in improving performance than is generally characteristic in the Department. There are few tangible rewards to managing what appears to be one of Sri Lanka's best systems: salaries do not reflect high performance, and there are few opportunities for receiving other rewards. There is little or no feedback from either the Irrigation Department or the Irrigation Management Division despite the submission of regular reports on system conditions.

Therefore, a score of "1" is earned in this category.

Sources: Same as Appendix A; authors' recent visits.

APPENDIX C
MAHI KADANA SYSTEM, 1993

R. Sakthivadivel and D. Hammond Murray-Rust

C.1 System Overview and Objectives

The Mahi Kadana system is situated in Gujerat State, India. It has a total irrigable area of 212,000 ha, making it one of the largest systems in the State. It is a run-of-the-river system with a diversion weir at Wanakbori, constructed in 1958, but with regulated flows from a reservoir at Kadana, 70 km upstream, that was completed in 1978. The reservoir is filled almost every year, so that the main canal system can receive its full design discharge of 187 cumecs during the kharif season (15 July- 15 November) and in the rabi or winter season (15 november - 15 March). During the hot season of April to July less water is available and the command area is significantly reduced.

The system is designed to use canal water to irrigate a total of 260,000 ha during the three seasons. This is supplemented by extensive pumping of groundwater that enables a further 180,000 ha to be irrigated, or a total annual cropping intensity of 2.08. Groundwater usage is increasing due to favorable electricity tariffs, but there is a persistent increase in ground water levels that is becoming a serious threat to production.

The cropping pattern is mixed. During the kharif season between 90,000 and 100,000 ha of rice is cultivated, much of this in the heavy clay soils of the lower half of the system adjacent to the Arabian Sea. In well watered parts of the upper half of the system there is considerable rice cultivation, but tobacco and bananas are also widely cultivated on sandy loam soils. In the colder rabi season wheat is widely grown, while tobacco planted in September comes ready for harvest in January or February. Heavy soils are frequently left fallow in this period. Other important crops are pulses, millet, and some sorghum.

A significant feature of the system is that it is operated under the "shejpali" system. This system is intended to match supplies and demand as closely as possible. Before each season the total water resources are estimated, and the area that can be irrigated for the ensuing season determined based on the experience of previous years. Farmers, having been informed of the proposed cropping pattern, then make individual applications to receive irrigation water, and are given an application number. This then entitles them to receive water on request during each of the two-week rotation periods specified by the Irrigation Department. Normally the main and branch systems run continuously, as do most distributaries. thereby leaving the task of matching supply and demand to the karkoon or work assistant, a field level staff member of the Irrigation Department responsible for approximately 1000 ha. He is supported by 4 or 5 irrigation laborers or chowkidars who are responsible for passing requests for water to the karkoon, and recording which farmers receive water for which crop during each two-week period. This information is subsequently used for billing purposes.

The overall objectives are, therefore:

- to match water supplies at the system head with the demand created by the actual cropping pattern;
- to irrigate 260,000 ha from gravity supplies in a mixed cropping pattern; and
- to assess irrigation fees on the basis of actual number of irrigations received during each season.

C.2 Performance Improvement Capacity Audit: 1993 Conditions

Summary of Audit:

Issue # 1:	Design Considerations:	Score = 2
Issue # 2:	Operational Considerations:	Score = 1
Issue # 3:	Information Considerations:	Score = 1
Issue # 4:	Management Considerations:	Score = 1
Issue # 5:	Institutional Considerations:	Score = 1
	Total:	Score = 6

The audit at Mahi Kadana has been undertaken following two years of collaboration between IIMI, the Gujarat Irrigation Department, and the Water and Land Management Institute at Anand. In this collaboration substantial progress has been made in the improvement of information and recognition of the need to improve the overall performance of the system. A further collaboration is now under discussion and is expected to start in early 1994. This audit will therefore help in determining the impact of the interventions to be included in the new project which focus on the adoption and utilization of an effective management information system and use of a performance framework that responds to real-time information on system level conditions.

☛ 1 **System Design**: is the physical infrastructure is capable of being managed to meet the overall system objectives?

There appear to be no significant design constraints to achieving higher performance at Mahi Kadana. The main canal system runs more or less at full supply level, there are 54 cross-regulators in main and branch canals to control water levels when discharges are below the maximum, and control over water can be maintained into the head of every distributary, minor and sub-minor that are served by the main canal system.

The "articulated" nature of the system incorporates a capacity to control discharges right down to the outlet level. Each outlet, serving approximately 30 ha, was provided with a sliding gate to enable discharges of about 1 cusec (28.3 l/sec), and in many locations drop structures or small cross-regulators provided close to outlet and sub-minor structures so that the appropriate discharge can be maintained.

Measurement structures or rating tables exist for all offtakes (other than direct outlets) from the main and branch canal system, making it possible to determine how much water is delivered to approximately each 1000 ha (distributary commands actually vary from 665 to 7665 ha). Normally the water delivered to each karkoon can be directly measured, except in larger distributaries where there are no measurement structures provided below the head regulator.

The density of control structures and high number of measurement locations are entirely consistent with the objectives of the "shejpali" system matching overall water supplies to actual crop demands, and the system earns a score of "2" in respect of design.

☛ 2 **System Operation**: are the planning, operational and maintenance inputs resulting in a water delivery pattern that supports fulfillment of the overall objectives?

The operational pattern in Mahi Kadana is complex. In the main and branch canals, wherever possible, water deliveries are continuous but are controlled to match the anticipated demand during each season. This requires a considerable degree of adjustment at the various cross-regulators, and at head regulators of canals served directly by the main system. It appears that there are few problems in maintaining constant water levels.

At secondary levels and below, however, some problems are observed. The chowkidar (irrigation laborer) is supposed to inform the karkoon of which farmers want water during the next day or two, and the karkoon then has to work out a schedule of water deliveries that match these demands to the available supplies. It is apparent that this matching is an ad-hoc process: there is no systematic schedule of which farmers will receive water, particularly when demand is high in the kharif season, and there is no capacity to ensure that deliveries are really at or close to the designed level of 1 cusec. The result is that water deliveries are not predictable and not very equitable. Head end portions of distributaries and minors appear to get more water and can grow more rice, while tail end farmers receive less water and have to grow less water demanding crops.

Further, although farmers are expected to make applications for water before the season starts, they can still receive water without such an application if they are willing to pay a penalty of 50% cess on the standard water charges. Unauthorized irrigation (legal but late applications) now represent 60% of all irrigation: this means that demand is never really known until late in the season, and the procedure for matching the uncertain demand to supply becomes tenuous.

Maintenance in distributaries is moderate. The sandy loams in the upper portion of the system are susceptible to erosion, so many secondary canals are much wider than designed, and it is hard to maintain adequate head upstream of offtakes. Many gates are broken or missing, and this further undermines the capacity of karkoons to match supply and demand effectively.

The combination of a well-managed main and branch canal system and a rather weaker management at secondary and tertiary level earns a score of "1".

☛ 3 **Data Collection:** is there sufficient information being collected to determine if targets and objectives are being met?

The pattern of data collection closely matches that of operations. The primary cause of this is that the major performance indicator used is Area Irrigated per Day Cusec (AIDC). This indicator, actually a measure of depth of irrigation water applied, is required for each canal that is served from the main and branch canal system. The water side of this equation is easy to measure given current infrastructure, records appear to be completely up to date and accurate, thereby meeting the normal expectations for a well managed main canal system.

The data collection process at lower levels in the system is less effective. There are no water data for conditions within the secondary or tertiary canal system, and no information about field level water conditions. At field level the chowkidar has to keep a daily record of each farmer receiving water for every plot that has a separate application number. This information is than passed on to the karkoon, making it possible to match water supply and area irrigated. However, in calculating the AIDC no account is taken of crop type irrigated, nor of soil differences, so it does not clearly indicate the overall adequacy of water deliveries.

There is much less information available on other important aspects: groundwater levels are not monitored regularly, rainfall records are slow in reaching managers, groundwater utilization remains completely unmeasured or monitored, yields are poorly documented.

Since the data collection is mainly intended to evaluate canal water supplies with very little information included on the agricultural production system, it earns a score of "1".

☛ 4 **Management Framework**: is available data used as part of a systematic process of control for operational performance and evaluation for assessment of outcomes and impacts?

The data collected is used in two primary ways: determination of overall use of surface water, and revenue collection.

AIDC is calculated for every canal with a head regulator in the main and branch canal system (it does not cover minors and sub-minors that are served by distributaries, not for direct offtakes along the main canal system). It is also aggregated to Section and higher levels. This information is not used for in-season water management, but as an estimate of how much water is required for the next season. Because of insensitivity to soils, crop type, groundwater utilization, etc., it represents a very conservative mechanism for water allocation: systemic imbalances between different canals appear to have developed.

One reason for this is that all requests for water, all communication of information, and all recording of information is undertaken by hand, and involves a veritable army of clerks using huge ledgers. Extracting useful information from this system is very time consuming. Although innovations in record-keeping at field level have been introduced and adopted, the use of this data for in-season management awaits the introduction of the proposed computerization of daily data and adoption of the prototype Management Information System over the next year.

Similarly, revenue billing is slow and way behind timetable. The objective of only authorizing irrigation to farmers who are up to date in payment of bills cannot be accomplished, and arrears are enormous. The MIS system will alleviate the problems of delays, but whether it will lead to an increase in revenue is another matter.

The relatively narrow focus of this management framework earns the system a score of "1".

☛ 5 **Rewards, Incentives and Willpower**: is there sufficient motivation to improve performance of the organizations and individuals involved in system management?

Although the Gujarat Department of Water Resources is typical of a large, technically oriented bureaucracy, there are clear signs of change. Promotion is not strictly by longevity of service, giving some incentive to try hard. The AIDC is used in assessing whether certain staff do a relatively better or worse job, and the performance indicators are used to a limited extent.

Recent changes (in 1993) suggest a new willingness to be innovative. Rotational irrigation between distributaries has been introduced for the first time: canals are closed for 4 days out of every 16, enabling the canals to be operated at full supply discharge for the remaining time and minimizing head problems associated with deteriorated canals. This change was accompanied by a reasonably effective information system, and it appears that farmers accepted these changes in good faith. Similarly, the area targeted for irrigation in kharif 1993 has been increased to 110,000 ha. This figure was determined by challenging each manager to achieve the previous maximum performance in terms of area, thereby showing a willingness to use past performance as a guide to the future.

There is also keen interest in development of new technology for evaluating performance. The pilot MIS has been strongly supported by senior engineers, and there is a clear commitment to deal with other aspects of performance, including closed attention to problems of waterlogging and conjunctive use.

The capacity for change at lower levels in the system remains largely untested. In one pilot experiment, measuring devices were installed within a distributary command at the boundary between karkoons, thereby enabling their relative performance to be compared. The computerization of information may be a threat to the lower level staff who have previously worked in an information vacuum.

The system, in much the same manner as for operations, data collection and use of a management framework, earns a score of "1".

Sources: Authors' Personal Experiences

APPENDIX D
KIRINDI OYA SYSTEM, 1989

Douglas J. Merrey and R. Sakthivadivel

D.1 System Objectives

The Kirindi Oya Irrigation and Settlement Project is located in the dry zone of the southwest quadrant of Sri Lanka, about 260 km from Colombo. Five ancient reservoirs were upgraded in the late 19th century, and an anicut constructed across Kirindi Oya to divert water from the river into these reservoirs. In the early 1980s, with assistance from several donors, the Lunugamvehera Reservoir was constructed, along with right and left bank canals. The project was planned to augment the water supply in the existing systems (about 4500 ha), and permit settlement of about 8320 farm families on about 8320 ha of newly irrigated lands on the right and left banks of the river. Because of cost overruns, only about half the new lands were opened up when the reservoir was commissioned in 1986. Since that time the government has continued adding some new lands under a Phase II investment program, but shortages of water have limited this area.

The broad objectives of the system were the same as for other settlement schemes in Sri Lanka:

- to increase food production (especially rice);
- to settle landless people thus providing opportunities for employment and increasing incomes.

The specific objectives of the system changed as the project was being constructed. The initial objectives were to provide irrigation to a total of 12,934 ha (including the 4500 ha already irrigated), double cropping of rice on the lowlands (poorly drained soils), and on the uplands, non-rice crops like cotton and pulses to be grown in the dry season, with rice in the wet season. A cropping intensity of nearly 200% was envisioned. In 1982 the objective of double cropping of rice on lowlands was confirmed; rice would be grown in the wet season on uplands and intermediate soils, and other field crops (OFCs) in the dry season. In 1986 and again in 1987 the objectives were again revised to include more OFCs and less rice; the planned cropping intensity was reduced to 170%. These changing objectives reflected the growing recognition that the original estimates of water availability were over-optimistic, and that by Sri Lankan standards Kirindi Oya is a severely water-short system.

IIMI began its research in Kirindi Oya in 1986. In 1990 IIMI presented a final report to its donors on the findings of its diagnostic research; since 1990, IIMI has been implementing a second action research phase of work in Kirindi Oya, trying to address some of the problems identified in the first phase. This report reflects IIMI's findings as of late 1989 to early 1990.

D.2 Performance Potential Audit

Summary of Audit:

Issue # 1:	Design Considerations:	Score = 1
Issue # 2:	Operational Considerations:	Score = 1
Issue # 3:	Information Considerations:	Score = 1
Issue # 4:	Management Considerations:	Score = 0
Issue # 5:	Institutional Considerations:	Score = 1
	Total:	Score = 4

☛ 1 **System Design**: is the physical infrastructure capable of being managed to meet the overall system objectives?

This system was built at the same time as the Inginimitiya system (Appendix F), following the same design criteria. The storage capacity of the Lunugamvehera Reservoir is 198 mcm; this is supplemented by the storage capacities of the smaller old tanks. Nevertheless, since its commissioning in 1986, the system has faced serious water shortages, as is true of Inginimitiya. The reservoir inflow has been about 30-40% less than planned. This represents a serious gap in estimating the of available water, and has had serious consequences for the new settlement areas of the scheme.

These shortages have been exacerbated by competition for water between the old and new areas. The older area farmers have been able to increase their average cropping intensity from about 160% before the project to about 200%. The cropping intensity in the Phase I new areas averaged less than 100% up to 1990. This has caused serious social and economic problems for the new settlers.

IIMI's research showed that the right bank main canal was not able to carry the design flow of 13 m^3/s at its head; flows even below this lead to overtopping of the banks in some areas. Further, the main canals are characterized by a rather large number of gated cross regulators: 14 control structures over the 30 km length of the right bank canal. During the period under review, it was difficult to maintain steady flows in the main canals, which in turn affected deliveries to the distributaries.

The field canals are designed on the one cusec (28.3 l/s) principle. Some field channels are larger as they serve larger areas. But some one cusec field canals serve more than 20 ha; in these cases, the capacities of the field canals to meet peak water requirements (for example during land preparation) are not adequate. In addition, many of the distributaries' capacities are inadequate to meet the total demand of the field channels; that is, the total of the field channel capacities exceeds the capacity of the distributary, even without taking into consideration conveyance losses. IIMI has documented that the design underestimated the peak water requirements, by using over-optimistic assumptions about efficiencies and seepage and percolation values.

The field canals are generally designed on the one cusec (28 l/s) principle. Some field channels are larger as they serve larger areas. But a few one-cusec field canals serve more than 20.; in these cases, the capacities of the field canals to meet peak water requirements (for example during land preparation) are not adequate. In addition, many of the distributaries' capacities are inadequate to meet the total demand of the field channels; that is the total of the field channel capacities exceeds the capacity of the distributary. IIMI has documented that the design underestimated the peak water requirements, by using over-optimistic assumption about efficiencies and seepage and percolation values.

Finally, IIMI's study documents that the design, which assumed rice as the main crop, limits the options available to farmers if they grow the now-recommended mixed cropping pattern. To meet the different requirements of a mixed cropping pattern, especially one that includes rice and OFCs, is very complex and needs better water control structures and adequate drainage facilities which are not provided in the existing design; thus the design of the system imposes severe limitations on the potential cropping pattern.

Considering all of these inconsistencies between the design and the objectives of the system, a score of "1" is earned.

☛ 2 **System Operation**: are the planning, operational and maintenance inputs resulting in a water delivery pattern that supports fulfillment of the overall objectives?

IIMI observed nearly all the seasons beginning with 1986-1987 maha; and made detailed water measurements in 1987-1988 maha, 1989 yala, and 1988-1989 maha. Planning was somewhat ad hoc; to a considerable degree this can be attributed to the weaknesses of the farmer organizations and joint management committees, which were just being organized during this period. The Department's planning primarily consisted of analyzing water availability, making assumptions about likely inflows into the reservoir, deciding on the extent in the new areas that can be irrigated (after allowing for irrigation of the older areas), and planning the seasonal schedule based on the design assumptions. Although the project is intended to support a mixed cropping pattern, most of the area cultivated during this period was planted with rice.

Actual operations generally deviated considerably from the plans. Land preparation tended to take 6-9 weeks, not the four weeks assumed. After land preparation, a rigid operational schedule was implemented; but the Department rarely kept to this schedule, as it tried to respond to rainfall and reservoir shortages. The schedules were too rigid for such a dynamic situation; on the other hand the operations were erratic and unpredictable because there was no systematic and predictable response to rainfall and other events. In those seasons where the reservoir was perceived as having adequate water for the season, management was lax; in those seasons when the reservoir was perceived as getting too low, there was more careful monitoring and adjustment to conserve water storage. Most seasons were extended beyond the planned date, in response to the delays in starting.

The system design assumes that there will be rotations within field channels; but such systematic rotations were rare. The system does include measuring devices at important division points (unlike Inginimitiya); but these were not used systematically to monitor quantities. IIMI's own measurements demonstrated significant opportunities for improving water efficiency.

Maintenance of all levels of the system was poor. Farmers were late in cleaning field channels if they did it at all; distributaries and main canals were not systematically de-silted, and there was minimal effort to maintain banks and structures. Some of the problems were the result of poor quality construction, and some effort was put into rectifying some of these problems. During this period there was construction underway in Phase II as well; most Department staff were more concerned about meeting construction targets, and supervision of operational staff was often lax during this period. This varied: in water-short seasons, there was more intensive management and supervision.

Overall, there was significant scope for improving operational management performance; therefore a score of "1" seems appropriate.

☛ 3 **Data Collection**: is sufficient information being collected to determine if targets and objectives are being met?

Data on reservoir water levels, inflows into the reservoir, and releases from the main sluices are recorded regularly. Rainfall data are also collected regularly. Some data on levels at key control points were collected, though not necessarily converted into volumes. These data are usable, and were used to some extent during water-short seasons to make adjustments in the water delivery schedules. The Department of Agriculture did collect some data on crop areas and yields but these were not used in system performance monitoring or evaluation.

Overall, the data collection was slightly better than reported for Inginimitiya (Appendix F). It was not adequate for high performance, but other constraints were more important; therefore a score of "1", is earned.

☛ 4 **Management Framework**: are available data used as part of a systematic process of control for operational performance and evaluation for assessment of outcomes and impacts?

At the time in question, there was no systematic management information system and information that was available was used in an ad hoc way to make day-to-day decisions; it was rarely used for systematic control and planning. Nor was there at that time a systematic process of consultation with farmers. As in Inginimitiya, the primary management objective seemed to be to conserve water in the reservoir to get through water-short seasons, and minimize complaints by issuing water generously in surplus seasons. This short term perspective had serious consequences for the overall system performance: each season small parts of the system were provided water for rice, but there was no long-term planning process to maximize the use of water over time.

This state of affairs leads to a score of "0".

☛ 5 **Rewards, Incentives and Willpower**: is there sufficient motivation to improve performance of the organizations and individuals involved in system management?

The 1986-1987 maha was disastrous: drought led to significant crop failures, for which the Department was perhaps somewhat unfairly blamed. This definitely affected staff morale. However, between that season and 1990, there were personnel changes, and an increase in interest in system management. Even before IIMI's 1990 report, the Department implemented some organizational and procedural improvements to make water management more effective. The disturbed civil conditions made system management especially difficult, as government officials often felt threatened. In fact, the efforts of some officials to continue managing in these conditions was remarkable.

Farmers remained very discouraged and demoralized. Crop failures, and lack of cultivation in too many seasons, led to increasing poverty; many settlers were unable to remain permanently in the scheme; and there were reports of mortgages, leases and sales of land. Efforts to organize farmers were not effective, in part because the effort was inadequate, and in part because of the disturbed conditions in Sri Lanka at that time.

For most of the period, there was inadequate attention and support from the head office; Colombo-based officials rarely visited the scheme. Further, under the prevailing conditions of government employment in Sri Lanka, there is no system for encouraging and rewarding good performance; no significant rewards or incentives are given to officials. The motivation that exists is on a personal level.

IIMI documented that in spite of the personal interest of some staff, overall the lack of significant incentives and willpower had an important impact on performance of the system. A score of "1" is earned.

Sources: IIMI 1990; Merrey & Somaratne 1989; Berthery et al. 1989; Sakthivadivel, Fernando & Merrey 1992.

APPENDIX E
KIRINDI OYA SYSTEM, 1993

R. Sakthivadivel and Douglas J. Merrey

E.1 System Improvement Objectives

Realizing the importance of improving Kirindi Oya system performance in the wake of large scale criticism by the public and farmers, the Asian Development Bank (ADB) funded the inter-disciplinary field research carried out by IIMI with close co-operation of the Government of Sri Lanka and implementing agencies, especially the Irrigation Department; this diagnostic study had identified a series of problems affecting the performance of the Kirindi Oya project, and recommended practical steps that could be taken to solve these problems. The recommendations were related to the following four broad areas:

- Water resource management for long term performance;
- Cropping pattern changes;
- Water management to suit the resource, design and management interactions;
- Institutional strengthening for improved system management.

IIMI and the Government instituted a follow-on study to implement some of the recommendations arising out of the Phase I study through participatory action research wherein the research activities are being implemented by the agency officials and farmers, and the process and outcomes of the research are being monitored and documented by IIMI researchers.

The four main areas of research during this phase are: main system management; tertiary system management; pilot studies for crop diversification; and institutional strengthening.

The participatory action research initiated in May 1991 will come to an end by February 1994. Although there has not been significant progress in switching to diversified crops by farmers - the system remains more or less rice-based during maha and yala seasons, and OFC cultivation in the yala season only during water-short years - there have been significant changes in co-ordination, system water allocation, system operations, and organizational and institutional incentives. The research has demonstrated the process to be adopted for action research and potential for improving performance through institutional and organizational changes.

Under the main system operational management component, the following activities were undertaken:

- Development and implementation of seasonal water allocation plans.
- Development and implementation of an operation plan for the older reservoirs (Ellegala Irrigation System -- EIS).
- Improvement of main canal operation through and improved management information system.
- Improved maintenance management through farmers' participation.

The participatory approach preparing cultivation plans helped the agency officials understand the complete plan and the rationale for, and impact of their overall decisions. This understanding has created a good climate and working relationships among agency officials. The process of participation, consultation and consensus building among different line agencies has helped officials to interact with farming communities more confidently and successfully in the implementation of the program. The cultivation plan developed for the project took account of: type of crops, planting time, extent of cropped areas, location of the area and volume of water required. Based on the inflow conditions under three water availability scenarios (above normal, normal and below normal), and the hydraulic behavior of each sub-system, guidelines for each season (maha and yala) were drafted and was discussed with the agency officials and farmer representatives.

Water budgeting, water balancing and preparation of detailed operational plan for each sub-system and implementing them in a transparent way, keeping the farmers informed about the water availability and water demand and operating the system to match these, are the various activities implemented through the line agencies by forming sub-study groups for each major area of innovation.

Under improving the main canal operation, four major innovations were introduced initially to the right bank main canal, later to the Ellegala systems and, lastly to the left bank main canal: introducing an irrigation management information system (IMIS), operation of reservoirs and tanks under minimum operating level rules (MOLR), training in monitoring and feedback mechanisms, and accounting for rainfall contribution while operating the main system. According to the views and ideas expressed by our informants (both farmers and agency officials), the data collection and communication program introduced under IMIS has had an impact on the daily operation of the right bank system.

The `maintenance management' component had direct results and impacts over the entire project area. This activity is intended to develop and field-test the maintenance procedures as a basis for a maintenance manual. The internalization of the concept of `diagnostic walk-throughs` is one of the key impacts in this program. More importantly, the recently implemented Rectification of Irrigation Deficiencies (RID) in the old areas followed this method to inventorize the rehabilitation requirements in all sub-systems. A complete analysis of the maintenance data generated a clear idea about the trend of expenditure which in turn leads to organizational and procedural arrangements required to reduce the cost of maintenance.

The following activities were undertaken under the tertiary system management:

- institutional strengthening;
- tertiary maintenance management;
- acquisition of agricultural inputs;
- operation during land preparation and crop growth period.

Institutional changes contemplated under this component could not be implemented effectively because the scarcity of water made it impossible for farmers. Many settlers no loner reside full time in the scheme. By working with the resident farmers, motivating and assisting them to cultivate non-rice crops not only during the yala season but also during at least some maha seasons, would in the long run create the conditions necessary for the majority of other farmers to also participate. The farmer community is resisting the cultivation of other field crops (OFCs); there is an urgent need to help farmers overcome the various difficulties associated with growing OFCs. Water savings that have been achieved in the Kirindi Oya right bank main canal are primarily through better main system management. At present, it may be premature to turn over the system to farmer organizations when they are not ready to operate, maintain and manage even the tertiary systems.

The promotion of OFCs in Kirindi Oya has been a part of accepted Government policy since the inception of the scheme. The main reason for suggesting the adoption of this cropping plan is to minimize the problem of water shortage in the system. In 1990, it was suggested to pilot-test the possibility of OFC cultivation during both the maha and the yala seasons as a remedy for the water-short situation as well as to increase the profitability per unit of water and to demonstrate the practicability of OFC cultivation during both seasons to all the farmers.

Activities undertaken under the OFC pilot program included: assessment of OFC cultivation in highland areas under rainfed conditions, assessment of OFC cultivation in irrigated land with limited irrigation, determination of the economic performance of paddy cultivation in both the old and new areas in order to understand farmers' decisions in taking up OFCs. Results show that it is quite possible to establish OFCs during maha under rainfed conditions but that irrigated OFCs are far superior.

The special study on salinity problems in the Ellegala system points out that by proper management of water distribution, provision of adequate drainage, and adopting suitable crop husbandry methods, the problem can be overcome.

From the organizational and institutional standpoint, there have been a number of changes. On of the most important contributions of this research has been to bring all the line agencies together, to discuss problems among themselves, and arrive at an agreed plan before meeting farmer representatives in the project management committee. This has helped to a great extent in solving many water related conflicts.

E.2 Performance Improvement Capacity Audit

Summary of Audit:

Issue # 1:	**Design Considerations:**	**Score = 1.5**
Issue # 2:	**Operational Considerations:**	**Score = 1.5**
Issue # 3:	**Information Considerations:**	**Score = 2.0**
Issue # 4:	**Management Considerations:**	**Score = 2.0**
Issue # 5:	**Institutional Considerations:**	**Score = 1.0**
	Total:	**Score = 8.0**

☞1 **System Design:** Is the physical infrastructure capable of being managed to meet the overall `system objectives?

During the system improvement phase, no major change in the system as constructed was contemplated; however, as in any new project, there was a certain mismatch between system design and operational practices. Some of the design problems have been overcome by adjusting and modifying operational practices. System parameters such as canal efficiency and seepage and percolation losses actually measured in the field were used in preparing revised targets and scheduling of water; wherever the total capacity of the turnout is greater than the full supply discharge of the distributary, additional discharge is conveyed by encroaching on the free-board while operating the system in a continuous mode; otherwise rotation among turnouts is practiced in those distributaries.

A new procedure has adopted to identify and prioritize maintenance requirements (walk-through survey), and get them executed through farmers' participation. The Irrigation Department has identified critical sections based on farmers' complaint and their own observations and rectified the defects by selective lining to reduce seepage, improving the slope of the canal, and strengthening the canal bunds to carry the desired discharge to the tail ends. In the old Ellegala system, a new program with funds provided by the donor called Rectification of Irrigation Deficiencies (RID) at the distribution level was implemented with close collaboration of farmer associations. This has helped to improve water control in distributing the water.

The problem of water shortage in the Lunugamvehera reservoir is real. Efforts have been made to overcome this water shortage by effectively utilizing the rainfall, preventing surplussing of water from Ellegala tanks, tapping shallow groundwater wherever available, and reusing the return-flow and drainage water to the maximum extent possible.

An important aspect which was not given due consideration at the time of design is the provision of drainage facilities for raising other field crops in upland areas while raising paddy in the low land areas especially during the maha season. This has not yet been solved and needs immediate attention. Also, in view of the experiences gained in operating the system for the last eight years, we can identify locations where regulating structures must be introduced for operating the system for a mixed cropping pattern.

Based on the above considerations and the fact that design deficiencies were overcome by operational adjustments and selective repair and maintenance, a score of "1.5" is earned.

☛ 2 **System Operation**: Are the planning, operational and maintenance inputs resulting in a water delivery pattern that supports fulfillment of the overall objectives?

With the initiation of participatory action research, a systematic effort was made to develop a water allocation plan among the old and the new systems through farmers' participation based on actual observed inflow into the reservoir for the last eight years and the water rights of old area farmers. The water allocation plan is now more or less accepted and has been implemented starting from maha 1992/93. Consequently, the planning for water has become more systematic. The project management committee has become fairly strong with farmers representatives demanding a better service while all the agency officials are united to meet the farmers' requirements. This has led to a healthy dialogue and decision-taking process. The introduction of the Irrigation Management Information System (IMIS) and the new improved procedure adopted for main canal operation including the effective use of rainfall, has considerably improved the water use efficiency of the system. Although the target set for land preparation is 5 weeks it has in actual practice taken roughly six weeks which is much better performance than 9 weeks for land preparation in the initial stages of the project. A comparison of RBMC maha 1992/93 performance with previous maha seasons is presented below to show the trend in water saving achieved in the Kirindi Oya project.

	1990/91	1991/92	1992/93
Crop	Rice 3.5 months	Rice 3.5 months	Rice 3.5 months
Average duration of land preparation	6 weeks	6 weeks	6 weeks
Area cultivated	2530 ha	2980 ha	2518 ha
Targeted duty	2.44 ha	2.44 ha	2.44 ha
Rainfall	1.01 m	0.70 m	0.30 m
Achievements			
Actual duty (ex-sluice)	2.53 m	2.35 m	2.52 m
Ex-sluice + Rainfall	3.54 m	3.05 m	2.82 m

The results achieved in the Ellegala System are due to operation of the five tanks in the system by keeping their respective water levels just above their MOLs in order to accommodate run-offs in the tank catchments following the maha rains. As a result of operating the system this way, no tank located at the tail spilled during the season, unlike previous maha seasons. This contributed in a very significant way to water savings in the main reservoir and may help to extend the cultivation area in the new system at a later stage. The use of a display board at the resident engineer's office helped him to make more informed operation decisions. The water balance study allows the Irrigation Department to plan water allocations from the Lunugamvehera reservoir in a more rational way. The Ellegala tank duties for maha 1992/93 varied from 2.05 acre-ft/acre to 5.65 acre-ft/acre, averaging 3.24 acre-ft/acre for the whole old area. Of this, about 50% were contributed by drainage and rainfall runoff from tank catchments. This leads us to conclude that the old system requires only 16,500 acre-ft of water in the maha season as against the present assumption that it needs at least 25,000 acre-ft.

Overall, there has been significant improvement in the main system operation; however, at the tertiary level, we could not introduce rotation in view of very weak farmer organizations. Once the farmer organizations get strengthened, we can achieve further reduction in per hectare water use; therefore, a score of "1.5" seems appropriate.

☛ 3 **Data Collection:** is sufficient information being collected to determine if targets and objectives are being met?

Data on reservoir water levels, inflows into the reservoir, and releases from the main sluices are recorded regularly. Daily rainfall, and evaporation data are also collected regularly. Flow data at distributary level are collected daily. During land preparation, progress of land preparation is collected on a sample basis.

In the old Ellegala system, data on release of water from the Lunugamvehera reservoir to individual tanks, inflow into the tanks, tank water level elevations, outflow from the tanks, surplus out of the tanks, drainage flow moving out of the system, and salinity of tank water are measured.

The Agricultural Department collects information on area irrigated by different crops, crop yields, input supplies, varietal uses and groundwater development.

Overall, the data collection in Kirindi Oya is much better than in many other projects within the country. The data collected are being used for in-seasonal monitoring as well as to subsequent seasonal planning. Therefore a score of "2" is earned.

4 Management Framework: are available data used as part of a systematic process of control for operational performance and evaluation for assessment of outcomes and impacts?

Prior to the inception of this action research, no systematic data collection program existed in the Kirindi Oya project. On several occasions, attempts were made to collect data but these attempts failed for reasons like inter-organizational rivalry, lack of funds for payment of incentives to the officers collecting data, lack of understanding on the part of field staff about the usefulness of data, and the attraction the Irrigation Department staff had for construction activities. Due to lack of monitoring and feedback mechanism, the system's operators lacked the necessary information on what was happening at main system level. Therefore, the easier solution to water problems at main system level was frequent gate adjustment at cross regulators and DC-offtakes.

After the introduction of IMIS, data on the daily discharges made to the distributaries are being collected by the irrigators (irrigation laborers) under the supervision of the work supervisors. The data thus collected are forwarded to the resident engineer by the work supervisors who are paid an incentive by IIMI for this. On receipt of the data, the engineer feeds them into the computer for converting the levels into discharges. Feedback on discharges to canals is provided to the work supervisors if there is a deviation from the target.

There are notice boards in the resident engineer's office as well as in the work supervisor's office for displaying discharges made to the distributaries in a particular tract or tracts for a period of one week. The irrigators and work supervisors are serious about collecting accurate data because they perceive that inaccurate data would be detected through use of the computer. The data collection and communication program introduced under the IMIS has had an impact on the daily operation of the right bank system. This management information system has since been extended to the left bank. With water allocation among the sub-systems agreed upon, the development and implementation of IMIS makes the main system function much more efficiently than in 1990. Therefore, a score of "2" appears appropriate.

5 Rewards, Incentives and Willpower: Is there sufficient motivation to improve performance of the organizations and individuals involved in systems management?

Any improvement in management functions requires redefining roles and functions of the personnel involved and/or a proper incentive for accepting additional work load. Our observations with regard to the left bank and Ellegala systems show that a major factor for the delay in transmission was related to the lack of incentives for work supervisors. In the right bank system, IIMI paid an incentive to the work supervisors for data transmission. They were enthusiastically involved in the process for this reason. In order to make the data collection process a sustainable one, the Irrigation Department must redefine the roles and functions of the lower level field staff, provide adequate incentives to accomplish this task, and introduce a proper monitoring and feedback system needs to be introduced at different levels of the hierarchy.

Farmers' organizations in this system are weak primarily for economical reasons. Unless the economic conditions of the farmers are improved through on-farm and off-farm activities, it will be very difficult to organize them for water management. The present procedure adopted by the Irrigation Management Division to select farmer representatives and of the distributary farmer organizations counter-productive and needs to be reviewed in view of the problems created by such changes.

All the line agencies are now working as a team in taking decisions and implementing them. This has been a new experience to the project officials and they are doing it with much enthusiasm. But how far this enthusiasm can be sustained without a proper reward and incentive structure is a moot question.

There is now improved attention and support from the head-office. This has to be further strengthened. Under the prevailing system of government services, there is no institutionalized mechanism to encourage and reward good performance. Unless this is changed, it is very difficult to motivate the field level officials to maintain good performance. There is a lot to be done to introduce appropriate institutional changes. Based on the above, a score of "1" is considered appropriate.

Sources: Research Data; Authors' Personal Experiences

APPENDIX F
INGINIMITIYA SYSTEM, 1993

Wasantha Kumara and D. Hammond Murray-Rust

F.1 System Objectives

Inginimitiya irrigation system is in the North Western Province of Sri Lanka some 175 km away from Colombo. The scheme covers a gross command area of 2643 ha. The scheme is in the dry zone of the country which means that a systematic supply of irrigation water is essential for agricultural development. The project started operations in 1985.

The objectives of the system are as follows:

☛ to meet the shortfall of moisture supply for crops on 1860 ha. of new land in addition to improving irrigation water supplies to 783 ha. of existing irrigated land;

☛ to maintain a cropping intensity of 165% with a target overall duty of 8.52 acre-feet/acre/year (1600 mm/crop/season) with rice monocropping in the wet season and a 80:20 ratio of rice to non-rice in the dry season; and

☛ to be an example of a well managed and well maintained irrigation project demonstrating high standards of water management, using the innovative 1-cusec (28.3) l/sec) design.

In 1991 a project involving IIMI, HR-Wallingford and the Irrigation Department was established with the primary purpose of introducing a computer-based decision support program for use by managers to improve overall performance from the system. This Appendix is based on the experiences with system management during the past two years.

F. 2 Performance Improvement Capacity Audit

Summary of Audit:

Issue # 1:	**Design Considerations:**	**Score = 1**
Issue # 2:	**Operational Considerations:**	**Score = 1**
Issue # 3:	**Information Considerations:**	**Score = 1**
Issue # 4:	**Management Considerations:**	**Score = 0**
Issue # 5:	**Institutional Considerations:**	**Score = 0**
	Total:	**Score = 3**

☛ 1 **System Design**: is the physical infrastructure capable of being managed to meet the overall system objectives?

The Inginimitiya reservoir project was designed to irrigate farmlands of 1600 ha of land from the left bank main canal and 1010 ha by the right bank main canal using the water from the reservoir whose effective storage capacity is 53,900 acre-feet (66.5 million m^3). However, since the commissioning of the system in 1985, the system is greatly troubled due to severe water shortage. This represents a serious miscalculation of available water from the catchment.

The Inception Report states the reservoir was expected to fill almost every year, but it has only done so twice in nine years. There is some suggestion the over-estimate of available water was necessary to justify the project; in any event, actual cultivation performance is way below design. Cultivation of the full irrigable area was accomplished only once in the last 15 seasons. The average cropping intensity during this period is only 79% compared to the planned figure of 165%.

Inginimitiya was one of the first systems designed by the Irrigation Department using the 1-cusec (28.3 1/sec) canal approach. This design requires all field canals to operate with a discharge of 1.0 cusec, limiting the total command area of a field canal to 16 ha. The designs for all field canals and their structures are identical and distributary canals are sized to meet the demand from all field canals simultaneously, plus a small allowance to meet losses along the distributary canal. The main canals are provided with sufficient cross regulators that water surface elevation along the entire length of the canal can be kept at or close to design elevations irrespective of total discharge entering the canal.

According to the original design guide lines, the free boards of the canals were recommended to be as follows:

field canals	-	0.50 m
distributary canals	-	0.50 m
main canals	-	1.00 m

These criteria were adopted during construction of the initial reaches of the project (Tracts 1 of LB and RB). Subsequently, halfway through construction, the technical guidelines were revised reducing the free board of the canals by more than 50%. The reduced free boards are:

field canals	-	0.15 m
distributary canals	-	0.15 m
main canals	-	0.50 m

The later part of the scheme was constructed according to the revised design guidelines. When the system was put into operation, it was observed that the canal reaches with the reduced free board could not carry the full requirement demanded, especially during land preparation. An important component of the 1-cusec design is the assumption that most, if not all, land preparation in the wet season will be undertaken using rainfall prior to the first water release from the reservoir. If rains are delayed, or farmers wait until water is released, the demand is higher than the canal conveyance capacity.

The main canals cannot convey the full demand of water to the tail end because of overtopping at the middle sections. When the extent of the turnout area is larger than 16 ha, water cannot be provided to all the fields through field canals during land preparation. In sections with high earth embankments, soil settlement was higher than expected further reducing the freeboard.

Errors in levels were observed in certain canal sections, especially in the secondary and tertiary canals, mainly due to poor communication between the Survey Department and the Irrigation Department during construction. The bench marks were located far away from each other so that it was difficult to cross check the accuracy of the levels. Although many construction errors of this nature have been rectified, it is still difficult at some places to control the flow at target levels.

Considering the above inconsistencies between design and objectives at all levels of the system, a score of "1" is earned.

☛ 2 **System Operation**: are the planning, operational and maintenance inputs resulting in a water delivery pattern that supports fulfillment of the overall objectives?

The actual operation of Inginimitiya varies significantly from the objectives laid down. The 1-cusec design calls for a strict rotational schedule among field canals based on the actual area. A 16 ha canal receives water for the entire rotational period of one week, but the time of water supply is to be reduced proportionally if the area is less than 16 ha.

The lack of any measuring devices below the reservoir headgates means that actual discharges cannot be checked in the field, and as far as can be ascertained, discharges into each secondary canal are set by negotiation between gate keepers and farmers. There is clear evidence that head end secondary canals get far more than their fair share.

Similarly, efforts to control the length of the season are ineffective. Although a starting and completion date for each season is set at the seasonal planning meeting, the end of the season inevitably is delayed. These delays appear to be caused by a combination of factors: inadequate conveyance capacity for land preparation, delays in starting land preparation by tail end farmers who are uncertain of their actual likelihood of receiving water, and a lack of tractors for land preparation using rainfall. Although the delays are known weeks before the end of the season, agency staff show no flexibility, and rely on a contentious and inefficient process that involves holding additional meetings, getting permission to extend the season from the civil authorities, and other bureaucratic procedures.

During the season, particularly when there is water shortage in the reservoir, the management efforts focus on conserving what storage actually remains. Water issues become unpredictable in terms of both timing and discharge, and there is little evidence that farmers actually can determine when water will be available to them in adequate quantities. There is evidence in some of the drier years that crops have been stressed, and it is obvious that yields are very low. These low yields may be the result of several factors, but lack of assurance of reliable water supplies may be a contributing factor.

When rainfall does occur, there is no systematic process for determining whether the system should be partially or fully closed, and no reliable information is provided as to when the issues will restart following the end of the rainfall. This merely adds to the overall uncertainties of the farmers.

There is clearly scope for significant improvement in operational performance that would provide more certain conditions for farmers. A score of "1" is earned for operational management activities at the present time.

☛ 3 **Data Collection**: is sufficient information being collected to determine if targets and objectives are being met?

The data collection is limited only to the reservoir/system level. The water level of the reservoir and the discharges through main sluices are normally recorded. The discharges into individual distributaries were not known until recently. In maha 1992, with the intervention of the IIMI/HR collaborative project, gauges were installed at key locations along the right bank main canal and the gauges were calibrated so that the discharges through most of the distributary canals could be recorded. There is no such system in the left bank main canal. However, the data were only used to support the INCA computer program introduced as part of the IIMI-HR project and did not significantly add to knowledge of field water conditions by agency staff.

Rainfall gauge readings are taken at two locations within the system. Pan evaporation data are recorded at one location. The data reported on area irrigated do not represent the time situation. It is merely assumed that all areas authorized for irrigation in any given season were fully irrigated, and that there was no unauthorized cultivation.

The Irrigation Management Division Project Manager collects crop data as and when the necessity arises for transmission to the head office in Colombo, but not in a systematic way.

This data collection program is considered deficient; a score of "1" is earned, which is slightly generous.

☛ 4 **Management Framework**: are available data used as part of a systematic process of control for operational performance and evaluation for assessment of outcomes and impacts?

There is no effective management information system currently used by the system managers at Inginimitiya. The little information available is not used in a systematic management process. The managers' response to proposed improvements by introducing an MIS is negative. Under the IIMI/HR collaborative project, a decision support computer model was introduced but the managers were not prepared to make use of. They did not have the interest to use the model to help make better informed decisions.

The gaps in the decision making process make it extremely difficult to implement the decisions taken at system level. The major decisions are normally taken at the cultivation meeting usually held before the season starts. The Project Management Committee which meets once a month takes decisions on routine matters. The approach used in making decisions creates a lot of trouble in implementation: little or no data ares used; rather guesses and unsubstantiated speculation on rainfall, crop water requirements and other information are substituted for a more scientific approach. The validity of the decisions taken at these meetings is always questioned by the farmers. The inadequate participation of the farmers in taking decisions often makes it difficult to obtain their support in implementation.

Instead, system operations, maintenance and seasonal planning are conducted in an ad hoc manner. If farmers complain enough, more water is released, but the primary management objective at system level is to try to conserve water in the reservoir rather than plan proper released on the basis of a seasonal calendar.

The lack of interest in using an effective information system as part of a systematic management framework results in a score of "0".

☛ 5 **Rewards, Incentives and Willpower**: is there sufficient motivation to improve performance of the organizations and individuals involved in system management?

Motivation of the staff at system level is at a very low level. There is a clear mismatch between the officers' personal objectives and the system objectives. The technical staff are trained in construction and are inclined professionally to building the system rather than water distribution. They tend to lose interest once construction is over. The support from higher management in the agency for activities related to water management is also very poor. Inadequate compensation and lack of job security too contribute to the low level of motivation.

For the last eight years, there have been only a few successful seasons. The generally poor performance has resulted in frustration of farmers. Many farmer organizations do not function properly simply because of lack of interest or confidence by farmers. Without tangible results, it is difficult to encourage farmers to get involved in organizational activities.

The extent to which agency staff are unwilling to take more interest in performance was demonstrated in the dry seasons of both 1992 and 1993. In both years there was sufficient water for a partial cultivation, particularly if non-rice crops were grown. In 1992 the Irrigation Department delayed making a decision (the excuse being that they were waiting for April rains, a statistically rare occurrence) so that no cultivation was ever approved, leaving 13 million m^3 of water unutilized throughout the season. In 1993 decisions were delayed until June and only 200 ha (30% rice, 70% non-rice) were cultivated despite having 15 million m^3 available. A more motivated agency staff could have done a far more effective job.

This low level of motivation is a serious constraint to system performance. Therefore, a score of "0" is earned.

Sources: Recent research data; Authors Personal Experiences; IIMI (1992)

APPENDIX G
CHASHMA RIGHT BANK IRRIGATION SYSTEM, 1993

Carlos Garces-Restrepo and D. Hammond Murray-Rust

G.1 System Objectives

The Chashma Right Bank Canal project is a major perennial surface irrigation system that, once completed, will cover a gross command area of about 280,000 ha of land on the right bank of the Indus River in Central Pakistan, stretching between the Chashma and Taunsa barrages. The area spans two provinces: the North West Frontier, and the Punjab, in a 60 to 40 percent proportion.

The system objectives are as follows:

- to match water deliveries in main, secondary and tertiary canals to crop water requirements;
- to support a mixed cropping pattern that will maximize the area irrigated given the maximum allocation of 141 m^3/sec; and
- to increase water allocations per unit area so that crop production will not be constrained by water shortages.

This is the first major system in Pakistan to specifically attempt to match supplies and crop demands. It is in stark contrast with the long tradition of supply-based systems that deliver relatively small volumes of water to watercourses, leaving farmers with no alternative but to leave part of their land fallow each season unless they have access to shallow groundwater.

G.2 Performance Improvement Capacity Audit

Summary of Audit:

Issue # 1:	**Design Considerations:**	**Score = 1**
Issue # 2:	**Operational Considerations:**	**Score = 0**
Issue # 3:	**Information Considerations:**	**Score = 0**
Issue # 4:	**Management Considerations:**	**Score = 0**
Issue # 5:	**Institutional Considerations:**	**Score = 0**
	Total:	**Score = 1**

Because the system is still under construction, a number of observations about performance included in this Appendix may be subject to change at the time of final project completion. However, the first phase has been operating for some 8 years (almost identical to Inginimitiya and Kirindi Oya Irrigation systems in Sri Lanka) and that provides a considerable body of information on current performance. IIMI is undertaking detailed observations in selected parts of the Stage 1 area under a Technical assistance Grant from the Asian Development Bank. Comments included in this Appendix will help towards formulation of final recommendations at the end of the Technical Assistance in 1994.

☛ 1 **System Design:** is the physical infrastructure capable of being managed to meet the overall system objectives?

Comparison between monthly flows in the Indus River at the Chashma Barrage (offtake point) and flows required by CRBC show that unless allocations to the system are changed the water resource at the system head is not a limiting factor in meeting system objectives. The main canal, at least in Stage 1 (Stage 2 is not fully operational, and Stage 3 is yet to be constructed), is adequate to meet the full demand from each distributary as long as discharges in the main canal are above 43 m^3/sec. In the initial estimate of required discharges for each 10-day period, a calculation which makes allowance for effective rainfall, there are only two 10-day periods when demand and losses are less than this minimum value. However, hydraulic modelling indicates a severe freeboard problem when discharges exceed 90 m^3/sec, thus limiting the maximum discharge into all distributaries simultaneously, and this may result in conveyance problems in Stage 2 and 3 when they are completed.

At secondary canal level there are few design limitations: the distributaries were designed with sufficient cross-regulators to maintain the design water surface elevation over a wide range of discharges. However, the canals were constructed with a wider cross section between the intended design in order to permit the canal to fill up with sediment up to the desired cross section. This sedimentation process is based on constant discharge at full supply level. However, the design anticipates a fluctuating discharge in secondary canals in response to changing crop demand. In Stage II some canals have been constructed to the final design cross section while others are deliberately over designed in the same manner as the Stage 1 secondaries. This indicates a lack of a consistent approach in dealing with the genuine problem of sedimentation in the system.

At the tertiary level in Stage I, even after eight years of operation, the structures at the head of each watercourse consist only of a 22.5 cm (9 inch) diameter cement pipe. This diameter permits a far greater water supply than designed to enter the watercourses, but no formal control mechanism has ever been installed. Discharge can be partially controlled using a concrete plug in the top reach of the tertiary canal that creates a backwater into the pipe and reduces or stops the discharge. In many cases, however, farmers can, and do, block the pipe itself either partially or fully to reduce discharges into watercourses to avoid crop damage by overirrigation.

The lack of a proper control mechanism at the watercourse head is the result of on-going inter-agency disputes. It appears that in 1993 a decision was made to provide a traditional Adjustable Proportional Module (APM) at the head of each watercourse. However, this does not include any control device to allow discharges to be properly managed when demand falls significantly below the maximum discharge permitted by the APM.

Given these inconsistencies between design and objectives, particularly at secondary and tertiary levels, a score of "1" is earned.

☛ 2 **System Operation**: are the planning, operational and maintenance inputs resulting in a water delivery pattern that supports fulfillment of the overall objectives?

Before this question can be answered, it is necessary to bring into perspective the existing institutional arrangement under which the system's operating plan needs to be implemented. Because of the inter-provincial nature of the CRBC system, two government agencies are involved in the day to day operations. The Water and Power Development Authority (WAPDA) is responsible for the operation and maintenance of the main canal *including* the manipulation of head gates of all off-taking canals. On the other hand, the Provincial Irrigation Department (PID) is in charge of distributaries and minor canals. This situation is not replicated anywhere else in the country and poses additional demands on managers in both organizations.

The WAPDA operational management plan for Stage I fully addresses canal safety concerns; but it does not discuss how the main system needs to be managed in order to respond effectively to changes in crop water demand. The current operational policy is merely to maintain the main canal at full supply level irrespective of actual demand. If incoming discharges are significantly below the designed full supply discharge, then WAPDA uses the cross-regulators to head up water to full supply depth. This results in a loss of velocity and increases sedimentation upstream of the cross-regulators.

At secondary level, all distributaries run at more or less full supply level, partly to meet sedimentation objectives discussed above and partly because of on-going disputes between PID and WAPDA. In theory the PID determines discharge required every ten days into each distributary in response to the crop demand and requests WAPDA to deliver this water into each canal. In practice, there is no indenting system because canals are run more or less full, and PID does not have accurate information on actual cropping patterns until after the season is over.

There are minor changes in the distributary discharges between winter and summer seasons. This appears to be a limited response to the high frequency of deliberate closing of watercourses by farmers in the cool months when evapotranspiration is low. If the PID did not get discharges reduced, there would inevitably be overtopping of distributaries towards the tail end. In the 1992/1993 rabi (dry, winter) season, for example, some watercourses were closed as much as 70% of the time by farmers; nevertheless secondary canal discharges were maintained at or close to design discharge during the same period.

A significant impact of this over-supply of water for long periods is a serious rise in the water table in Stage 1 areas: if not addressed soon, it may result in long term environmental and crop damage.

The response to these operational problems appears to be to provide escapes at the tail of distributaries and even in watercourses so that any excess water can be drained into the Indus. This appears to be a complete contradiction of the initial design objectives of matching water supplies to crop water demands.

Because operations deliberately maintain full supply levels and discharges throughout the system and because there is no effective response to crop demand the system does not earn any points.

☛ 3 **Data Collection:** is sufficient information being collected to determine if targets and objectives are being met?

Very few data are collected in Chashma Right Bank system. In the main canal, WAPDA records discharge into the canal and discharges at the regulator and escape at the end of Stage 1 (approximately 78 km downstream). After making theoretical calculations of losses the balance between inflow and outflow is assumed to be the amount delivered to the Irrigation Department. However, the discharges into individual distributaries are not known and until 1993 WAPDA made no effort to install gauges or undertake any calibration of discharges through the distributary headgates that remain their responsibility.

At secondary level, the Irrigation Department takes some measurements of water levels in the old Paharipur System that was incorporated into Stage 1 but does not measure water levels in any systematic manner in the new parts of Stage I. Even where stage readings are taken, the accuracy of the associated rating curves is highly suspect.

Information on cropped area and crop mix is collected by field staff of the PID, but it is not cumulated in any systematic manner and made available to system level managers until after the end of the season. This is because the mechanisms for collecting crop data are still geared to revenue assessment, not as a source of information for system operational management.

Similarly, rainfall data are not collected by the PID and made available to system managers within the time frame necessary to make appropriate adjustments to gates. It is therefore not possible to see how the theoretical discharge pattern determined at main system level during the design phase which incorporates allowances for effective rainfall can actually be implemented because no real time rainfall information is available.

Similarly, there are no effective mechanisms for measuring other pertinent information, particularly depth to the water table and discharges in drains.

This data collection program is considered to be inadequate to meet system objectives and no score is earned.

☛ 4 **Management Framework**: are available data used as part of a systematic process of control for operational performance and evaluation for assessment of outcomes and impacts?

There is no effective information system in place. This is hardly surprising given the lack of availability of routine monitoring data. Officials of both WAPDA and PID do not respond effectively either to the limited information they collect or to information provided by other agencies operating in the system command, and show little interest in finding out what the actual situation is in the field.

This lack of a management framework is a very serious deficiency in a system that has specifically stated objectives of matching water supplies to crop demand. Instead, the management framework is not better (and actually rather worse) than that used by irrigation managers in systems that are specifically supply-based, top-down administered systems.

The system objectives cannot be met with the current information management system, and the lack of a management framework for determining whether objectives are being met results in a score of "0."

☛ 5 **Rewards, Incentives and Willpower:** is there sufficient motivation to improve performance of the organizations and individuals involved in system management?

In a broad way, managers of CRBC consider that assessing the performance of the system is an important element of their work. For WAPDA, the performance of the system is directly related to keeping the main canal hydraulically stable and safe, and managing the unlined portion in such a way that sedimentation continues to build up a stable regime section. Because of the on-going construction of the canal in Stages 2 and 3 and thus the lack of water issues to those areas at designed levels, substantial flows have to be returned to the river by means of escapes at the major cross-regulators regardless of the negative impact on water levels required for irrigation distribution purposes. WAPDA staff have shown little interest in operational matters or in system performance: they have not installed any gauges to measure water levels or gate openings for eight years, and have not responded effectively to rising water tables except through proposing more escapes.

The PID's concern for system performance should be more obvious since they have the primary responsibility for indenting. It is this process that is intended to match cropping patterns, evapotranspiration demand and water supplies. The lack of concern with actual cropping patterns results primarily in disputes over which set of figures might be more representative rather than attempting to reconcile different pieces of information.

It is clear that because farmers are obliged to close watercourses with considerable frequency in the winter, and at the same time have been able to increase the area under rice in the wet season from the designed level of 12% to an average of 25%, that there is no effective control over water supplies in either season.

Since the water elevation at the tail-end of the canals has been established as the main indicator of performance in supply-based systems, efforts on the part of field staff are usually concentrated on this particular point in the system. There is a lack of corresponding interest in regulation of flows into canals. The lack of measuring structures or calibrated sections in head end areas of canals means that even if they did indent seriously, they could not check whether discharges received were the same as discharges requested. At the administrative level, performance is evaluated on the basis of water fees collections and undue efforts are concentrated here.

With current incentives from both WAPDA and PID that favor only administrative efficiency, promote on the basis of longevity not performance, and do not provide any financial or other incentives for good performance, it is unlikely that there will be significant interest in making changes to operational management, in improving the information collection program, or using that information in a systematic manner to improve performance.

The lack of serious motivation to improve performance results in no score being awarded.

Sources: Recent research data; Authors' Personal Experiences, IIMI (1993)

ANNEX G

IRRIGATION MANAGEMENT IMPROVEMENT PROJECT

Does Assessing Irrigation Performance make a Difference ? Results from a Comparative Study of Three Irrigation Systems

Douglas J. Merrey, Alfredo Valera and Lalith Dassenaike

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Does Assessing Irrigation Performance make a Difference? Results from a Comparative Study of Three Irrigation Systems

Douglas J Merrey, Alfredo Valera and Lalith Dassenaike

1. INTRODUCTION

There are many studies assessing the performance of irrigation systems and diagnosing the causes of the level of performance achieved. But there are few systematic studies of the processes of irrigation system management and little systematic documentation of how system managers presently monitor and assess performance, and what performance indicators they use, if any[1]. Studies of the performance of irrigation in Third World countries almost inevitably document a gap between expectations and reality. High levels of water use efficiency, agricultural production, and farmer prosperity, and therefore high economic returns, are always predicted in planning irrigation schemes. Low levels of efficiency, low production, farmer poverty and inadequate economic returns are all too frequently the reality. These disappointing results are attributed to a wide variety of causes, depending on the disciplinary and other biases of the analyst.

The lack of good documentation and understanding of the management process itself -- how decisions are made and implemented and by whom, what information is available to managers and how they use it, the formal and informal objectives of managers, farmers, and other stakeholders, how performance is measured, and how feedback processes from past performance affect future performance -- remains a critical gap that must be addressed if performance is to improve.

There is a large literature on methodologies for assessing irrigation performance, and performance indicators that can be used (see Rao 1993). But surprisingly, there is presently little information available on how irrigation managers actually assess performance, and what indicators they use. One pre-requisite to introducing new methodologies and indicators is surely an understanding of what is actually practiced at present in a given system.

The main objectives of the study reported in this paper are:

a. to document systematically the management process on three irrigation systems, with special reference to the performance assessment methodologies and indicators actually used by the managers;

b. to assess the actual performance of the systems; and

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[1]. Chambers (1988), Raby and Merrey (1989), Nijman (1991; 1992), Vermillion and Murray-Rust (1993), and Adnan (1993) are among the few exceptions.

c. to find out whether the use of a systematic management cycle that includes appropriate performance assessment methodologies and indicators -- or their absence -- affects the actual performance of the systems.

An additional objective was to identify the potential for improving system performance by introducing changes in the management and especially performance assessment processes of the systems studied, and make recommendations to the management agencies. These recommendations are included in the case study reports to the collaborating agencies, but not repeated here.

This paper can be most profitably read in conjunction with the paper by Murray-Rust et al. (1993) entitled "Performance Improvement Capacity Audit: A Simple Methodology for Identifying Potential Interventions to Improve Irrigation Performance," also being presented at this Internal Program Review. The methodology described in that paper is a straightforward set of questions to guide diagnosis of the potential for a system to respond to particular kinds of interventions; it is complementary to the results presented in this paper, which addresses the question of the relationship between the presence and quality of the management process on a given system, and its performance.

The following section of this paper describes the analytical framework used in the study, and the working hypotheses that guided it. The third section describes the research methodology and research questions, and also provides some background information on the three sample systems; it also presents data on the actual performance of the systems. Section four presents the results of the comparative analysis of the three systems, while the fifth section summarizes the main conclusions and next steps.

2. ANALYTICAL FRAMEWORK AND WORKING HYPOTHESES

2.1 Introduction

This paper makes explicit use of a framework for analyzing performance described in a recent paper (Bos et al. 1993), which is itself derived from other recent performance frameworks found in the literature (Small and Svendsen 1992; Murray-Rust and Snellen 1993). Assessment of performance, whether by a manager, researcher, or donor, requires a framework as a basis for interpreting and responding to data. The types of analytical framework and performance indicators required depend on the purpose for which they are used: a policy maker has different requirements for information, and will wish to see different indicators of performance, than a manager of a canal system, or a farmer. This study focuses on operational management of canal systems; therefore the framework used should be appropriate for the objectives of managers of canal irrigation system.

2.2 The Management Cycle

Following Bos et al. (1993) and consistent with the general management literature, "management" is conceived as a cyclical process consisting of sets of tasks. These management tasks can be grouped into the following categories:

* **planning,** the process by which objectives are set or modified, operational targets identified and an implementation plan established,

* **implementation** of the agreed plan,

* **monitoring** of implementation to ensure that operations are being carried out at an acceptable level of performance, and to develop sufficient information for managers to use in the

* **evaluation** of whether the broader objectives were met. The results of this evaluation then feed back into the next planning stage.

If one or more of these categories of management tasks is absent, the management cycle is incomplete and ineffective (or non-existent). Therefore, *the first working hypothesis is that the presence of a management cycle that includes all four of these categories of tasks is a necessary condition for achieving good performance.* The <u>quality</u> as well as presence or absence of the management cycle will affect performance outcomes: weaknesses in the management cycle even if it is ostensibly complete will lead to lower levels of performance.

2.3 Performance Assessment

A necessary ingredient in an effective management process is the use of a system for assessing performance and responding to the findings of the assessment. Performance assessment is concerned with two simple questions, reflecting two types of performance (Murray-Rust and Snellen 1993):

* The question "Am I doing things right?" is concerned with assessing **operational performance**, i.e., routine implementation of plans. It specifically measures whether targets are being met at any given moment in time and thus requires measurement of inputs and outputs regularly.

* The question "Am I doing the right thing?" is concerned with assessing **strategic performance**, i.e., whether available financial and human resources are being used effectively, and whether achieving operational targets also meets the broader objectives of the system.

The managers of canal irrigation systems are primarily concerned with operational performance and secondarily with strategic performance; higher level managers in the responsible organization as well as policy makers and planners may be more concerned with strategic performance.

An effective system for performance assessment will have the following basic characteristics:

* Collection of a minimum set of data which are accurate and made available to managers in a usable format in a timely manner;

* A set of targets which the manager is attempting to achieve;

* An associated set of standards describing the acceptable range of values around targets.

* An appropriate set of performance indicators, which combines the target values of a particular performance parameter, and the actual values. Values alone are data, interesting but not sufficient to assess performance. They must be compared with targets and the associated standards to be meaningful indicators. It is therefore sometimes useful to express indicators in the form of ratios wherever possible.

* A capacity to use the performance data to monitor operational implementation on a real-time basis, evaluate the results in terms of whether broader objectives were achieved, and use of the evaluation in the next planning cycle.

If one or more of these characteristics of the performance assessment is absent, the performance assessment system is incomplete and ineffective. *The second working hypothesis is therefore that the use of a performance assessment system is also a necessary condition for achieving good performance.* Indeed, an effective performance assessment process is by definition a component of an effective management cycle.

2.4 Creating the Conditions for Good Performance

The adoption of an effective management process including a system for performance assessment, and appropriate performance indicators are necessary but not sufficient for achieving good performance. The creation of institutional conditions that enable or require managers to improve performance or maintain high performance is also important. Most public irrigation organizations around the world ignore this requirement: some government agencies do make the necessary human and financial resources available at least in principle; but they very rarely have a structure of incentives that rewards good performance or discourages poor performance. Managers' accountability -- and irrigation management agencies' accountability -- to their clients is rare in Third World countries. There are all too many cases where new management procedures, or systems for monitoring system performance, have been introduced into settings lacking the institutional conditions necessary for their success.

Therefore, *the third working hypothesis is that institutional conditions which both enable managers to do their jobs effectively, and provide effective incentives to encourage good personal performance are necessary conditions to achieving good irrigation performance.* The incentive structure, including a system for objectively measuring and responding effectively to individual or group performance, must be linked to the management cycle and the system for assessing irrigation performance.

2.5 Assessment of Irrigation Performance

To this point we have discussed management cycles and performance assessment in the abstract. The next stage is to apply these to the specific problem of canal irrigation system management. We begin with the assumption that an irrigation manager is providing a service to a set of customers -- the farmers. That service is primarily water supply. The water supply is only one of several important inputs to the agricultural process. Some irrigation management agencies also have important responsibilities for providing other inputs as well. But usually the canal managers are responsible for and have (in principle) direct control over this one major output, water. The quality of the water supply function, interacting with other inputs, will have a major direct effect on agricultural performance. It is likely to have important, but less direct, impacts on other parameters, including economic performance, social well-being, and the environment.

Assessment of agricultural as well as socio-economic and environmental performance are also important to canal managers because they enable the manager to assess whether he is 'doing the right thing;' i.e., strategic management is dependent on performance assessment at these levels.

The range of indicators required for effective assessment of the performance of an irrigation system can be classified into three categories (Bos et al. 1993):

* **Water supply performance**, which deals primarily with the capture, allocation and conveyance of water from source to the fields through the management of the irrigation facilities;

* **Agricultural performance**, which addresses the direct outcome of water supply inputs in terms of areas irrigated and crop production;

* **Economic, social and environmental performance,** which deals with impacts of operational and agricultural inputs on the physical and socio-economic viability and sustainability of irrigated agriculture. These impacts are further removed in time and space from water supply performance but are essential for a full strategic assessment of operational performance.

The actual performance indicators most appropriately used on a given system under these three categories vary considerably depending on system-specific objectives. *Our fourth working hypothesis is that regular assessment of key parameters under all three categories is a necessary condition for good performance of canal irrigation systems and their sustainability.*

3. STUDY METHODOLOGY AND DATA USED

3.1 Data Collection and Analysis

This study was planned and carried out at the same time as the first draft of the paper on methodologies for assessing performance was being prepared (Bos et al. 1993). It was therefore designed as a preliminary test of the usefulness of that framework and the hypotheses that emerged. The first step was the development of a guide to data collection and analysis, including preparation of a list of specific research questions. Once this was completed, the work on one system in Sri Lanka began, while a proposal based on the data collection guideline was developed and approved for the studies of the other two systems.

The data were collected primarily through interviews, analysis of existing documents and agency records, analysis of any research data already available for the system, and field visits. Managers of the irrigation systems at all levels were interviewed, as were a small sample of farmers, including farmer leaders, on each system; in Sri Lanka, officials from other departments closely involved in the irrigation system management process as well as past managers were also interviewed.

The major focus was on the management processes and outcomes at the level of the main and secondary canals. The researchers attempted to understand what the overall management process on each system is, what performance assessment actually takes place, how it is done, what indicators are used, and what is the result. We were interested in both the <u>normative</u> process -- what is supposed to take place -- and the <u>actual</u> process -- what is really done; and the various actors' perspectives on the whole process and the outcomes. Finally, to the extent possible we made use of available performance data to evaluate the performance of the systems (in terms of the framework in section 2).

On two systems, those in Nepal and Philippines, a rapid appraisal was conducted for the purpose of this study. In both cases, IIMI approached the management agency and requested assistance in identifying an appropriate system, and sought agency cooperation for the studies. On the third system, in Sri Lanka, we used the site of an on-going research project, but obtained the agency's clearance for doing this study as a subproject related to the larger research project. We received excellent cooperation from all parties in all three systems. Three separate case study reports were prepared and form the basis for the analysis reported in this paper (Valera 1993a; 1993b; Dassenaike 1993). These case studies are being shared with the agencies for their information and comments before they are finalized.

3.2 Background Data on the Three Systems

3.2.1 Characteristics in Common

The three irrigation systems studied are all medium-sized rice-based systems in humid tropical or semi-tropical environments in Asia. The systems range in size from 1840 ha to 2643 ha. All three systems are relatively new. The two oldest system were commissioned in 1973 and 1974; one of these had additional work during the early 1980s, while the other was rehabilitated in 1989, with an additional area added fed from a neighboring river. The third system was commissioned in 1985. All three systems are government-owned but jointly managed with farmers' organizations. All three are gravity canal systems, with two being run-of-the river and one a reservoir system. The following subsections provide additional background data on each system.

3.2.2 Pathraiya Irrigation System, Nepal

The Pathraiya system is located in the Far Western Terai Region and Kailali District, about 800 km west of Kathmandu. The main system was completed in 1973 by the Department of Irrigation, Hydrology and Meteorology; the tertiary canals were completed by the Farm Irrigation and Water Utilization Division in 1983; at that time water users groups (WUGs) were also set up. In 1989 all the irrigation management functions were merged into the newly-reorganized Department of Irrigation (DOI). The system was designed to provide supplementary irrigation to a net command area of 1,840 ha of rice during the wet season. A 1981 survey indicated the net command area was only 1,333 ha, with another 400 ha of uplands irrigated by pumping from canals and shallow wells. The actual irrigated area may well be less than the designated area as there is evidence that water diversions from the river have declined since last measured in 1981.

The system was not intended to provide irrigation in the winter, but in fact water is provided to irrigate wheat and mustard on farmers' demand on about 40% of the area. There are about 530 owner-farmers, 100 tenants, and about 500 bonded laborers who are given small allotments of paddy land to support themselves. Average rice yields were about 1.8 t/ha in 1981, 2.24 t/ha in 1991, and about 2.43 t/ha in 1992. The system is in poor physical condition, with little regular maintenance being done.

The system is owned by the government and managed by the Department of Irrigation, a line civil engineering department. The district engineer of the DOI has overall responsibility for the system; he supervises an assistant engineer who is supposed to have operational responsibility; but his office is also in the district town, and he cannot get to the system easily on the poor roads, especially during the monsoon. Therefore, the on-sight overseer is actually in charge, nominally supported by about 27 other staff members. Farmers report that only about half of these are to be seen in the system. Most staff including the engineers and overseer have been in the system for only about two years; the maximum staff longevity is one man for seven years. DOI staff are primarily concerned with their construction duties and not with system operation.

At present, DOI does not have formal administrative guidelines and job descriptions in terms of which staff performance is evaluated; the process is presently subjective and open to abuse. Efforts are underway in DOI to prepare position descriptions for the staff.

3.2.3 Nayom-Bayto Rivers Irrigation System, Philippines

This is actually two separate systems diverting water from two adjacent rivers, but managed as a single entity. It is located on the central western edge of Luzon Island in the Philippines, in the Province of Zambales, about 300 km northwest of Manila. The Nayom River Irrigation System (NRIS) was completed in 1974, and again rehabilitated in 1988-1989. At that time Irrigators Associations (IAs) were set up as well. This system irrigated 1,148 ha cultivated by 1,155 farmers (many of whom are tenants). The Bayto River Irrigation System (BRIS) was completed at the end of 1989, with a service area of 800 ha cultivated by 779 farmers; the IAs were organized beginning before the construction, and participated in the construction process. The total command area is therefore 1948. Both systems divert water from the rivers to support rice cultivation for two seasons per year -- cropping intensity is a little less than 200%. Average yields have risen from 2.5 t/ha in 1990 to 3.85 t/ha in 1992. Because of the recent rehabilitation, the physical condition of the system is quite adequate.

The system is managed by the National Irrigation Administration (NIA), a government-owned corporation with a high degree of financial autonomy (Svendsen 1992). An Irrigation Superintendent is in overall charge of the system, supported by about 17 staff (including administrative staff and an institutional development officer); one of these is an engineer in charge of day-to-day operation and maintenance. The two engineers and some other field staff have been in the system since 1974, a remarkable degree of stability.

Under NIA's rules, it is expected that all systems in the Philippines will be financially viable, that is, cover its operating expenses by collecting fees and renting equipment. Staff performance is evaluated in terms of their contribution to financial viability; system performance is evaluated in terms of its viability index; and both staff and IAs are rewarded for achieving their targets. As will be seen, this incentive system is a major factor underlying the performance of NRIS-BRIS.

3.2.4 Inginimitiya Irrigation System, Sri Lanka

The Inginimitiya Irrigation System is located in the Northwestern Province of Sri Lanka, about 130 km from Colombo, in the dry zone of the country. The system was completed and commissioned in 1985. It is a reservoir-based system designed for double cropping -- rice in the wet season, and rice plus some other field crops (OFCs) in the dry season. The official command area is 2,643 ha, cultivated by about 2,600 families; an additional 400 families are thought to cultivate encroached (unauthorized) lands as well. Informal data suggest that about 40% of the farmers have leased out their land, though this is not legal.

The water supply has proven to be considerably less than planned. Therefore, in only one season to date has the entire area (under two main canals) been irrigated simultaneously; all other years either the left or right bank only has been cultivated, or there has been no cultivation at all. The average cropping intensity has therefore been about 79%, a little less than half the planned 165%. Paddy yields average around 3.5 t/ha, against the 4.0 t/ha target at the inception of the project. Despite being relatively new, the physical system is not in good condition: there are design problems as well as poor maintenance which affect water delivery capacity.

The system is owned by the government and managed by the Irrigation Department (ID), a line civil engineering department similar to DOI in Nepal. The Department is responsible for construction, and for management of the main system. A chief resident engineer is in overall charge; an irrigation engineer has responsibility for day-to-day operations, assisted by 8 other regular staff and a variable number of casual laborers. Some of these staff have been in the system since its construction. They are primarily interested in their construction duties, and indeed the department provides positive incentives for doing construction, but not for operation and maintenance. Evaluation of staff performance is ad hoc; there are no incentives to encourage better performance except for construction; promotion is by longevity in the Department.

Parallel to the ID is the Irrigation Management Division, which, through its project manager, is responsible for coordination and integration of farmers and various agricultural and irrigation services, and for promoting and strengthening farmer organizations. The project manager is assisted by an institutional development officer and a few institutional organizers. Farmer organizations exist on the field channels and distributaries, and there is a joint farmer-official project management committee for making overall system management decisions. The farmer organizations at Inginimitiya are generally weak and ineffective compared to those on some other Sri Lankan systems.

3.2.5 Basic Data on Performance of the Three Systems

Table 1 summarizes the available data on the performance of the three systems, using a number of commonly used performance indicators, most suggested in Bos et al. (1993). The agencies do not measure water flows on either of the run-of-the river systems (Pathraiya and Nayom-Bayto). Water is measured only at the sluice gates from the reservoir in the Inginimitiya reservoir system; the water duty, defined as the amount of water released per unit area has averaged 135% of the planned annual water duty since 1985; in 1992-1993 it was 114%, indicating a low but slowly improving level of efficiency. No measurements are taken within the conveyance system. Maintenance is observed to be rather poor except in Nayom-Bayto. Based on farmer interviews and observation, predictability, adequacy, and equity are generally inadequate in Pathraiya and Inginimitiya, but are not perceived as problems in Nayom-Bayto. Cropping intensities are on or above target except in Inginimitiya where there is a serious shortfall. Yields are low in Pathraiya compared to local officials' and farmers' expectations; they are higher in absolute terms but lower than planned in both Inginimitiya and Nayom-Bayto.

The indicators on financial viability clearly separate Nayom-Bayto from the other two: this is the only system where farmers actually pay irrigation service fees, and NIA uses financial criteria as its major indicator of performance for systems, for farmer organizations, and for evaluating its own staff. This is a significant factor in the differential performance of the three systems.

Overall, the data show that Nayom-Bayto's performance is positive overall in spite of not achieving its design target yields; while at both Inginimitiya and Pathraiya, there are significant gaps between expected and actual performance.

4. RESULTS

4.1 Analysis of the Management Cycle [Hypothesis 1]

The first working hypothesis states that the presence of a management cycle characterized by four categories of tasks is a necessary condition for achieving good performance. We broke down each of the four categories (planning, implementation, monitoring, evaluation) into sets of tasks, and scored the three systems based on presence or absence of these tasks, and their quality. Two of the co-authors separately carried out the scoring, and then resolved their differences, while the third author evaluated the rankings done by the others and suggested two minor changes which had no impact on the overall scores. Although the subjectivity may mean that different observers would differ on details, the overall ranking would undoubtedly remain the same. Table 2 presents the results of this exercise.

The differences between Nayom-Bayto and the other two systems are striking. Nayom-Bayto is characterized by a clear, systematic and well-articulated management cycle, which is followed rigorously. Both of the other systems exhibit serious weaknesses in the performance of management tasks. The absence of an evaluation and strategic management process to answer the question, "Am I doing the right thing?" is particularly striking. It is no surprise that these two systems exhibit a lower performance (and significant gaps between actual and expected or potential performance) than Nayom-Bayto. It is clear that in both Inginimitiya and Pathraiya, there is an urgent need to introduce a basic management process.

On first impressions, we had expected Inginimitiya to score higher than Pathraiya. This is because some Department officials considered Inginimitiya a good system, and there has been some investment in developing farmer organizations; while Pathraiya is a long distance from the country's capital and during the main growing season inaccessible even for district officers. But its more modest objectives and simpler operational plan lead to reduced expectations and a higher level of achievement relative to the modest expectations. Both authors who did the scoring agreed on the lower ranking given to Inginimitiya, though with slightly different scores initially.

The first working hypothesis is confirmed.

4.2 Analysis of the Performance Assessment Process [Hypotheses 2 and 4]

The second working hypothesis states that the presence of an effective performance assessment system is also a necessary condition for achieving good performance. The fourth working hypothesis is that regular assessment of key parameters under all three categories -- water supply, agriculture, and socio-economics and environment -- is a necessary condition for good performance and sustainability of canal irrigation systems. Table 3 summarizes the data on performance indicators actually used by the managers of the three systems.

All three systems use at least two performance indicators. Pathraiya managers (at the overseer level and below) monitor adherence of deliveries to the agreed rotational schedule; and farmer complaints. No other performance indicators are used by the managers of this system. Although some yield and area data are collected, these are not used by system managers in any way; and no performance assessment is done on any other parameters. By any measure, this system's performance assessment process is deficient, making it impossible for managers to intervene to improve performance.

In addition to the two used at Pathraiya, Inginimitiya managers use a few other indicators for water delivery and agricultural performance. "Water duty" is used only to assess performance at the end of the season, as required by the Irrigation Department's rules. Reservoir levels are monitored daily as they indicate whether the water supply is adequate to complete the season. The volume of water delivered to any point below the head of the main canal is not monitored. Although farmers' progress in cleaning field channels before a season begins is monitored, this is ad hoc and the Department does not use this indicator in management decisions. Nor does it monitor actual deliveries vis-a-vis the rotational schedule systematically.

The cropping calendar is monitored by the Department and in the first few weeks of a season, water deliveries are adjusted based on progress of land preparation. The Department does take note of whether land preparation has been completed by the target date, and whether the final water issue date of the season is adhered to.

The Irrigation Management Division -- but not the Irrigation Department -- tries to monitor the status of the farmer organizations, and farmers' incomes, though again these are not done regularly or used systematically by the Division. No environmental indicators (e.g., water tables, salinity, water quality) are monitored. Inginimitiya's performance assessment system is slightly more sophisticated than Pathriya's, at least in theory, but inadequate to achieve high performance.

The managers of Nayom-Bayto do follow a systematic process of monitoring performance, using a variety of indicators. For water delivery, NIA depends on "eyeball" observation of water levels and responds to farmer feedback; it does not measure volumes, a serious weakness as even the "eyeball" observations are increasingly inaccurate with changes in canal profiles. NIA has no idea how much water is actually delivered to the system. On the other hand, NIA does systematically monitor agricultural indicators, and uses the results in the management process. It measures IA performance systematically, in consultation with IA representatives, and uses the results, for example in providing financial incentives to IAs which exceed their quotas in fee collection.

The most important performance indicator from NIA's point of view is its viability index. This is the ratio of income (largely from irrigation service fees) and expenditures. It is used as a proxy for measuring farmers' satisfaction with its service, on the assumption satisfied farmers will pay, dissatisfied customers will not. Much of NIA managers' effort goes into ensuring the viability index is positive. NIA does not measure any environmental indicators.

Overall, it is clear that in spite of important gaps, the performance assessment system is relatively well developed at Nayom-Bayto compared to the other two irrigation systems, which is consistent with its relatively higher performance. Pathraiya and Inginimitiya have rudimentary systems for assessing water delivery performance. For agricultural performance, Pathraiya does no assessment while Inginimitiya monitors the crop calendar only. Nayom-Bayto's performance assessment system for water is also incomplete and rudimentary, but effective assessment of agricultural and financial indicators partially make up for this deficiency. None of the systems include assessment of environmental indicators. The results are consistent with hypotheses 2 and 4.

4.3 Analysis of Institutional Conditions [Hypothesis 3]

The third working hypothesis is that institutional conditions which both enable managers to do their jobs effectively, and provide effective incentives to encourage good personal performance are necessary conditions to achieving good irrigation performance. Incentives for good performance, linked to a system for objectively measuring and responding effectively to individual or group performance, and also linked to the management cycle and the system for assessing irrigation performance, will have an important impact on the overall system performance.

The two line civil service departments contrast sharply with the semi-autonomous government corporation on this parameter. Both Pathraiya and Inginimitiya officials are characterized by a lack of strong motivation or interest in the performance of the system. Neither agency has a systematic process of evaluating individual performance in relation to contribution to achieving system objectives; and neither agency offers any incentives for good performance in system management. Staff in both systems are far more interested in construction duties, for which there are incentives. Inginimitiya staff in interviews pointed out that if the Department offered comparable incentives for system management, these would affect their own priorities. Dassenaike's (1993) comment about Inginimitiya applies to Pathraiya as well: "Performance accountability is rare and commitment is virtually non-existent."

This state of affairs is, again, in marked contrast to the situation in Nayom-Bayto. NIA uses a formal performance rating system for its engineers based on the performance of the systems they manage. Thus, points are given for a system's water use efficiency (where measurable), "operations index" (a measure of cropping intensity), maintenance efficiency, collection efficiency (actual collections as percent of receivables), and viability index (income compared to expenditures). Bonus points are given for exceeding the targets for the operations index, collection efficiency, and viability index. Salary increments are affected by the annual performance rating.

Staff at all levels receive cash incentives when the viability index is better than "1." Similarly, NIA rewards IAs with contracts for collecting fees, by giving cash incentives when the IA exceeds defined collection targets. At the level of the agency, Svendsen (1992) has documented the positive impact of financial incentives over the past decade or so. At the level of the Nayom-Bayto system, the impact is also clear: data from 1983 to 1992 show a progressive improvement in the viability index over time; in 1990 after the rehabilitation and organization of more effective IAs, the index jumped from 0.81 (1988 and 1989) to 1.63 and 1.66 (1990 and 1991 respectively); in 1992 it declined to 1.19-- a still very good[2].

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[2]. This decline is explained in part by a large increase in expenditures, and to a lesser degree a slight decline in collection efficiency, which is attributed by some to personnel problems.

It is clear that the positive institutional conditions characteristic of Nayom-Bayto have had an important impact on the motivation of staff, and system performance; and that this is in marked contrast to the conditions in the other two systems.

5. CONCLUSIONS

The finding that presence of an effective management cycle, which includes the systematic use of performance assessment indicators, in an institutional context that encourages higher levels of individual and group performance, are strongly associated with good performance is certainly not surprising. It confirms expectations. However, the importance of these conditions as determinants of good performance has rarely been documented -- it is always assumed. The contribution of this paper is to demonstrate, in a sense, that IIMI and others doing similar work are on track.

It is likely that Pathraiya suffers because of the distance from the capital of Nepal, and its relative isolation even from the district town: in the monsoon -- the main irrigation system -- the roads are impassable and the engineers cannot visit. This also undoubtedly affects the availability of other inputs, and the profitability of agriculture. Nevertheless, the study also suggests that the DOI needs to pay greater attention to introducing basic management tools, not the least of which is incentives for making a greater effort in system management.

The results from Inginimitiya are especially disappointing in view of the system being regarded by the Department as one of its better systems and in view of demonstrably better performance on other Sri Lankan systems with similar water supply problems (Murray-Rust et al. 1993). More effort has ostensibly gone into institution-building than in the other systems, through the Irrigation Management Division, but with mixed results. Here again the Irrigation Department needs to introduce basic standard management tools, and provide incentives to use them in system management.

Nayom-Bayto is certainly not perfect: the lack of measurement of water volumes either at the intake from the river, or at key division points in the delivery system is a very important weakness that resulted in reduced yields in the most recent dry season. Further, none of the three systems studied monitors environmental variables, such as water tables, or water quality.

Nevertheless, Nayom-Bayto, aside from being characterized by a relatively complete and effective management cycle and the systematic use of performance indicators, is distinguished by two other characteristics absent in the other two systems: a strategic management process whereby NIA and farmers review the results of each season, and make adjustments to try to do better in the next season; and an institutional framework that rewards performance in terms that are directly linked to system management objectives. There is a high degree of accountability relative to the other two through the use of the viability index as a key performance indicator: accountability of NIA and its staff to farmers, and accountability of NIA staff to higher management.

We suggest that having an appropriate performance-oriented institutional framework is a pre-requisite to the introduction of an effective management cycle including a performance assessment system that works and a strategic management process that enables long-term improvement. Such a framework is therefore a key determinant of irrigation performance. Policy makers should focus their efforts on creating these conditions, rather than attempting to introduce practices for which there is no supporting framework, and no incentive structure.

6. ACKNOWLEDGEMENTS

The authors are very grateful to the farmers and managers of the three systems studied for their cooperation and assistance in collecting the data for this study. The case study results are being shared with agency managers, with the objective of assisting them to develop solutions to the problems identified. A special thanks goes to Hammond Murray-Rust, who commented critically on an earlier draft of this paper. Most of his suggestions have been used, but the authors remain responsible for the contents of the paper.

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Table 1. Basic Performance Data on Three Irrigation Systems.

Indicator[a]	SYSTEM Pathraiya	Nayom-Bayto	Inginimitiya
Water Supply Perf.			
Water delivery	not measured	not measured	reservoir only
Efficiency	not measured	not measured	135% actual[b] / planned
Adequacy[c]	poor	acceptable	poor
Predictability[c]	acceptable	acceptable	poor
Equity[c]	poor	acceptable	poor
Maintenance[d]	poor	acceptable	poor
Agricultural Perf.			
Area: actually irrigable / design (ha)	1300 / 2000 (65%)	1500 / 2000 (75%)	2643 / 2550 (104%)
Crop. intensity: actual / design	140[e] / 100 (140%)	164-170 / 179-185 (92%)	79 / 165 (48%)
Yield: actual in t/ha, 1992 / design	2.43 / ?	3.85 (85%) / 4.50	3.54 (88%) / 4.00
Economic Viability			
Total Financial Viab.[f]	low	119%	low
Finan. Self-Suff'y[g]	n/a	okay	n/a
Fee Collection/due	n/a	112%	n/a
Profitability	no data	no data	no data
Social Viability	no data	no data	no data
Sustainability	no data	no data	no data

NOTES ON NEXT PAGE

Notes to Table 1

a. The categories of indicators (in bold underlined letters) are drawn from Bos et al. (1993), but some of the indicators used here are based on what data are available.

b. Average water duty (volume of water per unit of area) since construction; the figure for the two seasons in 1992-1993 is 114% of the planned duty.

c. Based on interviews with farmers. The scale is somewhat subjective: "poor;" and "acceptable," i.e., no significant complaints.

d. Based on observation. The scale is "poor" and "acceptable" (see note c).

e. Winter wheat and mustard on about 40% of the area -- all at the head -- was not planned, and is done on demand, with no planning.

f. Based on allocations or income received compared to expenditure. Only Philippines monitors this directly (it is an indicator of performance, called collection efficiency). "Low" is a judgement based on observation and interviews with officials and suggests allocations are inadequate in relation to need.

g. Based on the ratio of income (from any source) to O&M requirements; the weak link is whether O&M requirements have been assessed properly. "n/a" means data are not available.

Table 2. Presence and Quality of the Management Cycle on the Three Systems.

Management Cycle	SYSTEMS Nayom-Bayto	Pathraiya	Inginimitiya
Planning:			
Clear objectives	2	1	1
Specific targets	2	1	1
Consultation with farmers	2	1	2
Use results previous seasons systematically	2	0	0
Implementation:			
Follow plan	2	2	1
Flexible implementation (responsive to rain etc)	2	2	1
Communicate changes to farmers	2	2	1
Monitoring			
Regular data collection	1	0	1
Indicators: compare actual target	2	1[a]	1
Use indicators to adjust ("Doing things right?")	2	0	0
Evaluation			
Use data to analyze results ("Doing right thing?")	2	0	0
TOTAL SCORE	21	10	9
Percent possible score	95%	45%	41%

Scoring: 0 = absent
1 = present but flawed or ineffective
2 = present, effective

[a] Field staff compare actual deliveries to the scheduled time of delivery.

Table 3. Performance Indicators Actually Used by Management Agency in the Three Systems.

System	Performance Indicators Used		
	Water Delivery	Agricultural	Others
Nayom-Bayto[a]	Supply status (by "eyeball" -- no measurement) Farmer feedback Maintenance: canals satisfactory / total canals	Area irrigated paddy yields crop intensity converted to "operations index")	Viability index Collection efficiency (these are used as proxies for farmer satisfaction too) IA performance: contract performance, fee collec. effic'y, no. of meetings
Ingini-mitiya[b]	Reservoir levels Water duty (total sluice release/area) actual deliveries/ rotational schedule[c] Farmer feedback Maintenance:[c] dates farmers clean field channels/date expected	Crop calendar: actual: plan Season start date (first water issue) Last water issue date End of land preparation Intensity, yield informally noted	Farmer satisfaction Farmer organize funds Farmer incomes
Path-raiya[d]	Actual deliveries/ rotational schedule Farmer feedback	none (yield & area data collected, not used)	none

NOTES:

[a]. NIA guidelines say supply status should be measured, but it is not in this system. The canal maintenance indicator, operations index (a measure of actual cropping intensity compared to potential), viability index (ratio income/expenditure), and collection efficiency (ratio total collections/collectables) are used seriously. Irrigators Associations' (IAs's) performance is also monitored continuously.

[b]. Farmers' satisfaction, organizations' funds, and farmer incomes are monitored only by the Irrigation Management Division, not by the Irrigation Department; these are not used by the Department to assess its overall performance, nor by the Irrigation Management Division for systematic monitoring of its institutional strengthening program.

[c]. These are monitored on an *ad hoc* basis but not systematically used in management.

[d]. The rotational schedule is monitored carefully; there is no other systematic performance assessment done at Pathraiya.

ANNEX H

IRRIGATION MANAGEMENT IMPROVEMENT PROJECT

Improving Irrigation Management Using Decision Support Systems: A Framework and Review of IIMI's Experience

Jacques Rey, Hammond Murray-Rust and Hilmy Sally

This Annex is a Draft Paper presented to the Internal Program Reveiw of IIMI held between November 29 and December 01, 1993. Based on comments and discussions, this paper is subject to minor revisions and will be published in a final format in the Advancement in IIMI's Research 1993

Improving Irrigation Management using Decision Support Systems: A Framework and Review of IIMI's Experience

Jacques Rey, Hammond Murray-Rust and Hilmy Sally

Abstract

The rate of adoption of computer based Decision Support Tools by irrigation agencies is slower than it has been in other sectors of activity. It is argued in this paper that a better methodology for both assessing the needs for and transferring Decision Support packages to irrigation managers could yield better results than what has been obtained in the past. The first part of the paper is an attempt to present such a methodology and supports the second part of the paper where a critical review of IIMI's activities in the field of decision support is presented. A number of conclusions and recommendations are explicited which could guide IIMI's research program towards a clearer vision of present and future needs, a better integration of methods and tools used by the institute and a lasting recognition of the particular importance of end-users involvement in this research area.

Improving Irrigation Management using Decision Support Systems: A Framework and Review of IIMI's Experience

Jacques Rey, Hammond Murray-Rust and Hilmy Sally

Introduction: Why Decision Support?

Many water management related problems diagnosed in gravity irrigation schemes are primarily due to a lack of *command* capability of the people in charge of managing them. Existing centralized *command* capabilities are often more administrative than responsive to needs, leading to a partial or total loss of control of the management over the physical process of water distribution occurring in the systems. Different types of answers have been promoted to "reinject" control into the system's management.

The first category of interventions envisaged tend to upgrade the physical system by rehabilitating or modernizing its structures. A second type of intervention aims at modifying the management framework and transferring operational responsibilities over the system to the users. A third category tries to enhance the capability of the existing management by introducing or strengthening decision support activities. These various options have been tried in isolation or combined with more or less success in many irrigation schemes. The first and second approaches implemented in isolation often brought little improvement as far as the problems of *command* are concerned. Examples of underutilized sophisticated structures or chaotic management by unprepared user organizations are numerous. The third approach addresses potentially the problem of *command* in a more straightforward manner but the interventions conducted so far reveal a lot of shortcomings and the rate of adoption of decision support tools by irrigation managers has been somewhat slower than might have been hoped.

The hypothesis argued in this paper is that it is often possible to improve the command capabilities of the irrigation systems managers (both planning and control) by introducing adequate decision support tools and following adequate modes of intervention. The first part of the paper will clarify the meaning of the word "adequate" used previously by providing a framework for identifying systematically the scope and nature of decision support interventions in irrigation schemes. The second part of the paper will put IIMI's experiences in the field of decision support in the perspective of this framework and identify present shortcomings. Some conclusions and recommendations for changes that should lead to greater adoption of decision support tools by irrigation managers are finally listed.

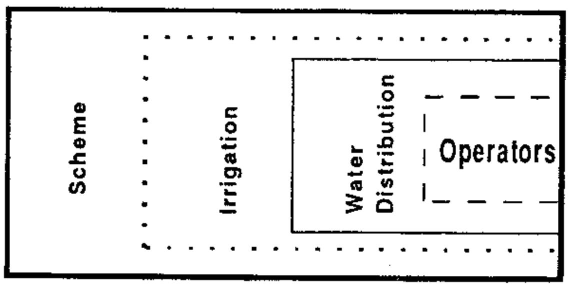
1. Elements for Understanding Decision Support Activities

1.1 Representation of an Irrigation System by Activities

a. A Byproduct of System Analysis: A Matrix of Activities:

Any attempt made to address problems of command in a system has to consider carefully the issue of defining an *efficient representation* of the system studied. This representation gains a lot in being *generic* for a type of system (replicability) and *dynamic* (predictability of system's evolution over time). Many perspectives have been envisaged for representing irrigation systems. The fact that a hierarchy of tasks and responsibilities are involved in the process of producing irrigated agriculture outputs led quite naturally to nested representations [1] emphasizing the role of sub-systems that provide outputs to larger subsystems which in turn convert these inputs into outputs of higher level. This representation thus introduces the notion of imbricated levels of management from the lower stages, onwards through system operators, the operational units (ex. water distribution), the irrigation system as a whole (water acquisition, distribution, application and drainage), the complete irrigated agriculture system and ultimately to higher levels which are not relevant to the scope of this paper (Fig. 1).

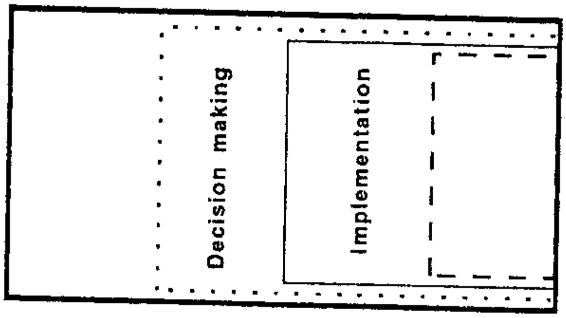
Figure 1
Nested Representation of an Irrigated Agriculture Systems



This representation introduced by Svendsen and Small for clarifying the boundaries of performance evaluation exercises can be further developed to become a useful model of the decision making processes and thus serve the purpose of understanding and classifying decision support needs.

The key notion underlying the subsequent developments is the notion of *management activity* which emerges from the consideration of a particular level of the nested representation and the description of the links between the higher subsystem at this level and all the lower subsystems. From a decision making perspective, this link can be adequately described as an exchange between a decision making level and an implementation level (Fig. 2) whose conjunction forms the management activity.

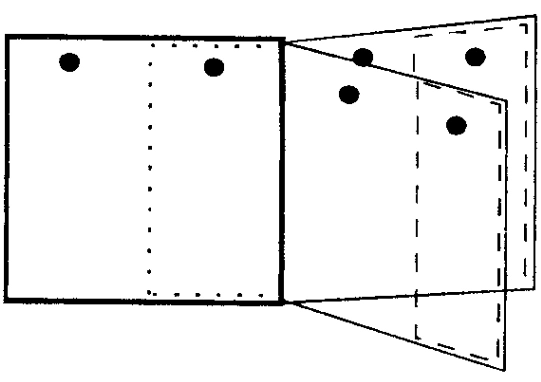
Figure 2
A Management Activity



As shown in figure 3 for the irrigation system level, a decision making level can be connected to several implementation subsystems, thus adding a dimension to the nested representation. The analysis can be conducted further in three steps corresponding to the three axis of communication emerging from the representation.

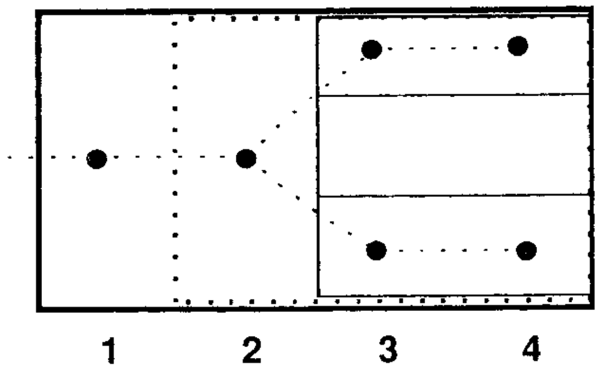
> A first step requires the understanding of the ***imbricated nature of the management activities,*** considering several nodes which can be described either as decision making nodes or implementation nodes depending on the level of the activity considered.

Figure 3
Decision Making and Implementation Nodes



Describing these nodes results in a decision making tree as shown in figure 4.

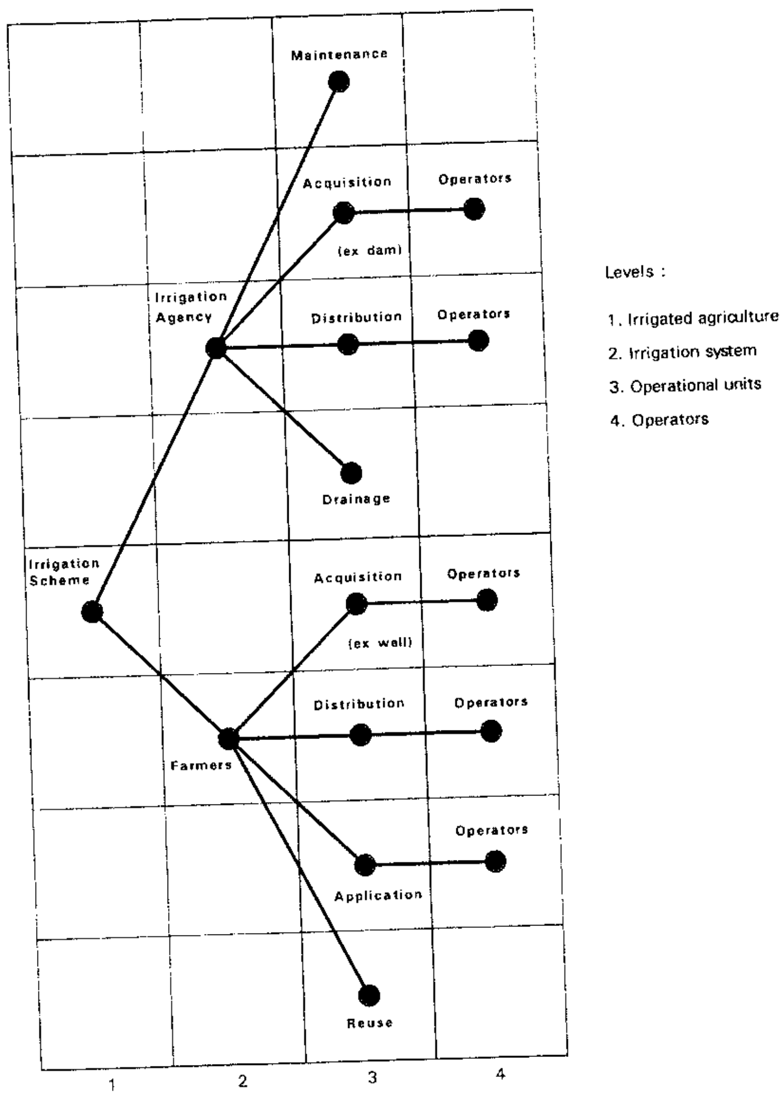
Figure 4
Decision Making Tree



A complete representation of the irrigated agriculture system would require discussion of a large number of nodes. At the same level as the irrigation system we find the agricultural, banking, marketing and farming systems which are all implementation levels of the larger irrigated agriculture system.

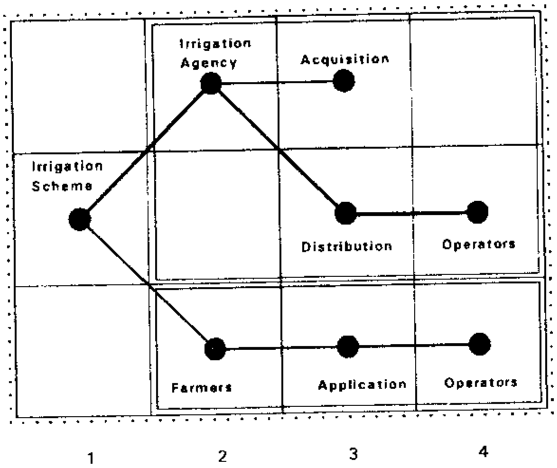
In addition to this, depending on the organizational structure of the irrigated agriculture system, the number of decision making nodes can vary. Decisions concerning the irrigation system can typically be shared between a public agency and the farmers or be completely in the hands of the farmers, leading to one or two nodes at this level. As an example, and since our analysis will be confined to the area of water management, a partial representation in the case of joint management can include the following nodes:

Figure 5
Decision Making Tree for Joint Water Management by Agency and Farmers



A simplified representation of the management activities up to the level called "irrigated agriculture system" or "production of crops using irrigation" in common use consists in the following partial list of nodes.

Figure 6
Simplified Decision Making Tree for Joint Water Management by Agency and Farmers



Following a branch of the tree across the different levels gives some insights into the nature of the links between the different nodes. All the nodes on a same branch share a common technical knowledge and exchange targets and commands alternately. As example the branch highlighted in Figure 6 can be explicited as follows:

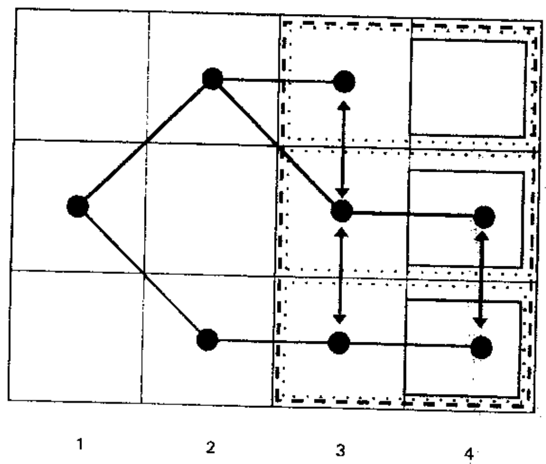
Table 1
Chain of Commands and Targets

Levels		Targets for the level	Commands for lower level
0	economic agricultural system	economic prosperity →	create income through irrigated crops (income for community)
1	irrigated agricultural system	↙ →	provide irrigation "service" (moisture for certain crops)
2	irrigation agency	↙ →	provide water distribution "service" (discharges)
3	water distribution unit	↙ →	implement operational plan (operations)
4	operators	operations ↙	

In the rest of the paper, these links between nodes of different levels are called *strategic links*.

> A second step requires examination of potential ***links between nodes at the same level of management.*** Instead of sharing a common knowledge as in the case of strategic links, the nodes grouped according to this second dimension share a common output. For example, when considering the output "moisture content in the root zone of the crops" the three management activities comprising acquisition, distribution and application can be grouped in our simplified representation.

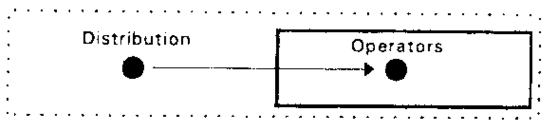
Figure 7
Tactical Links between Management Activities

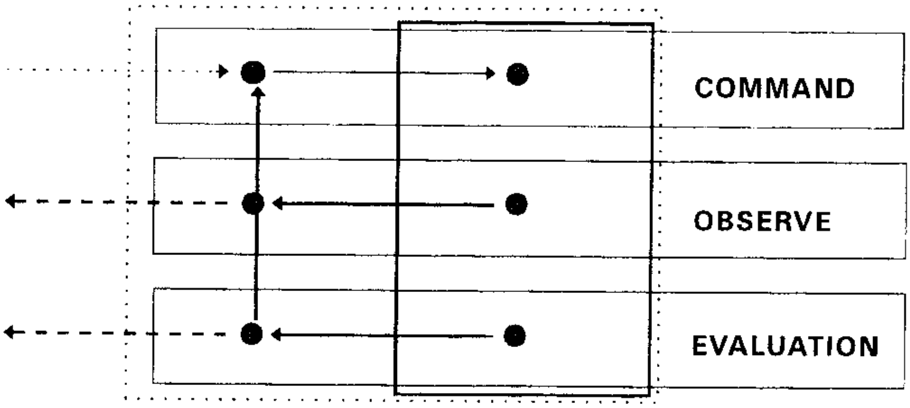


Apart from the physical link created by the flow of water between these 3 activities, exchanges of information have to occur at the level 3 for a smooth implementation of the commands coming from the level 2 with a view of optimizing the common output "moisture content in the root zone of the crops". These new links, hereafter called *"tactical links"* are introduced in figure 7. They are not of a hierarchical nature and have to be analyzed as *operating rules* clarifying the relationship between activities of the same level of management.

> A third step requires further detail on the ***functional representation of a management activity*** and identification of the supporting feedback information needed from the implementation level to obtain the commands transmitted through the strategic link. This dimension of the representation is derived from classical principles of system analysis which split the functional requirements for managing any system into 3 functions: command, observe and evaluate, as shown in figure 8 taking the management activity "distribution of water" as an example.

Figure 8
Functions within a Management Activity





The command function has been identified earlier as a direct origin of the strategic links between decision making and implementation nodes. The two new functions explicit the fact that a decision making node needs information on the present state of the implementation levels under its control (observe function) as well a regular evaluation of the effectiveness of its command (evaluation function) in order to operate satisfactorily.

b. The core of any activity: an optimization process:

As a consequence of the various links demonstrated between and within management activities, the decision making nodes have been introduced as core elements of these activities in charge of converting targets coming from a higher level into commands transmitted to lower (implementation) levels, taking into consideration direct feedbacks from these lower levels and information coming from other nodes of the same level (tactical exchanges), through the functional links. This decision making activity actually consists of an optimization process which can be mathematically explicited in generic terms as:

$u^* = Opt\ L[\ Q(y-y_t\ (OR)),\ C(u)]$

$u \text{ in } U$

$y = F(X, u, t)$

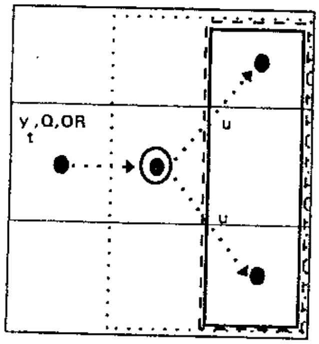
In this formulation, the meaning of the different symbols is as follows:

Opt	:	optimization
X	:	state of the management activity
y_t	:	output required from the management activity (target)
y	:	output obtained by the management activity
OR	:	operating rules leading to revision of targets
Q	:	quality of service provided by the management activity
u	:	command transmitted by the decision making level to the implementation level
C	:	cost involved in the implementation of command
L	:	combined criteria of achievements $(Q(y-y_t))$ and efficiency $(C(u))$ being optimized
U	:	set of admissible commands
u*	:	optimal command
F	:	dynamic description of the functioning of the management activity (logic between commands and outputs)
t	:	time

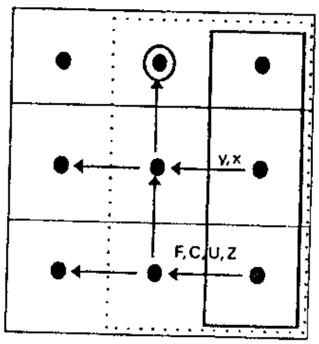
note: a simplified formulation $u^* = O(y,y_t,u)$ will be used later as equivalent.

The main purpose of elaborating this relatively complex formulation lies in the interest of developing a comprehensive list of the different variables or information required for conducting a generic optimization process and realizing that the 3 communication dimensions mentioned earlier are essential for obtaining this information. This is shown in figure 9 and table 2.

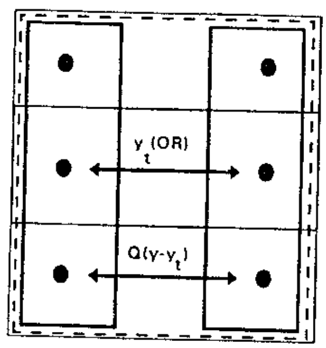
Figure 9
Communication Flows: Data used by a Management Activity



A: Strategic dimension
(different levels)



B: Functional dimension
(different functions)



C: Tactical dimension
(different outputs)

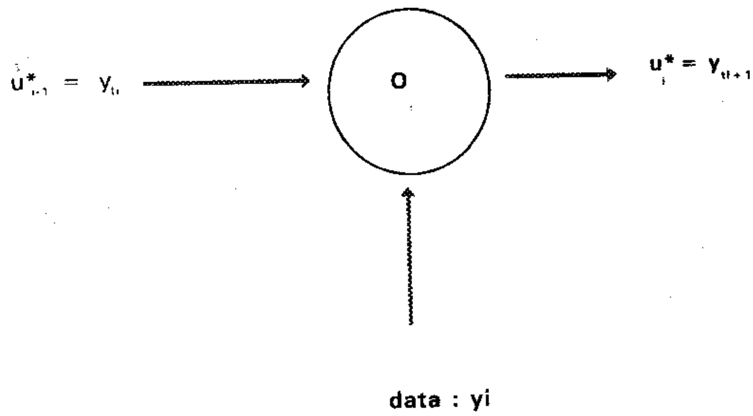
Table 2
Communication Flows: Data used by a Management Activity

Facets:	**A**	**B**	**C**
Communication:	Strategic	Functional	Tactical
Functional tasks:	Command (Optimization)	Observe (activity state) and Evaluate (activity effectiveness)	Observe (operating rules) and Evaluate (quality of service provided)
Data:	y_t, Q, OR u	y, X, F, C, U, L	y_t(OR), Q $(y-y_t)$

c. Some Implications of the Representation on Decision Support Analysis

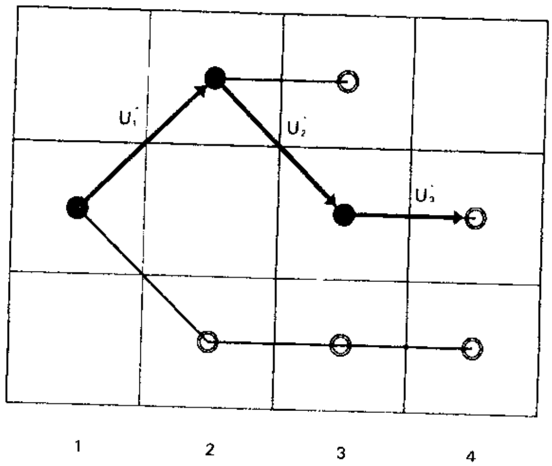
> *Cascade of optimizations:* as a consequence of the strategic dimension of the representation the dual nature (commands and targets) of the links between different levels was pointed out. Using the formalism introduced for describing the optimization process performed at each level, these exchanges between levels i-1, i, i+1 can be summarized as follows (where O_i designates the optimization process itself converting the targets y_{ti} into commands u_i^*):

Figure 10
A Decision Making Node



The cascade of optimizations leading to the formulation of an operational plan at the level 3 can be shown as an example using the simplified decision making tree introduced earlier in figure 6.

Figure 11
Simplified Decision Making Tree



(1) $u_3^* = O_3(y_{t3}, y_3, u_3)$ $\qquad y_{t3} = u_2^*$

(2) $u_3^* = O_3(O_2(y_{t2}, y_2, u_2), y_3, u_3)$ $\qquad y_{t2} = u_1^*$

(3) $u_3^* = O_3(O_2(O_1(y_{t1}, y_1, u_1), y_2\ u_2), y_3, u_3)$

The operational plan u_3^* can be considered as a local optimization of the level 3 if the target y_{t3} is frozen, or an optimization involving level 2 and up to level 1 depending on the level at which the targets are considered as being given and not obtained as output of a global optimization; with reference to the table 1 the difference in nature of the 3 problems (1), (2), (3) is summarized below.

Table 3
Different Levels of Optimization

Levels		Commands or degree of liberty u_i	Problem (1)	Problem (2)	Problem (3)
0	agricultural economic system	$u0 = y_{t1}$ income pattern within constraints	y_{t1}	y_{t1}	y_{t1}
1	irrigated agriculture system	$u_1 = y_{t2}$ cropping & related moisture pattern	y_{t2}	y_{t2}	u_1*
2	irrigation agency	$u_2 = y_{t3}$ discharges pattern	y_{t3}	u_2*	u_2*
3	water distribution unit	$u_3 = y_{t4}$ operations pattern	u_3*	u_3*	u_3*

These differences have direct implications for decision support interventions:

-> The level of decision considered has to be clearly identified.

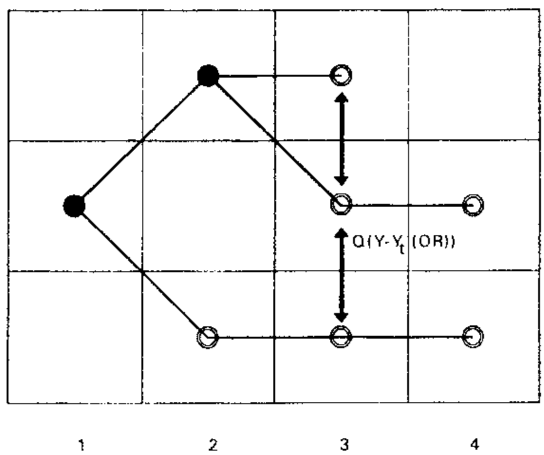
-> The decisions taken at a particular level involve ideally a backward optimization process from the *lowest operational levels* on the considered strategic line. If a low level is weak, any effort at improvement at a higher level is likely to be in vain.

-> It is worth investigating the targets used at a given level before "Freezing" them. The best entry points for decision support are the levels where strong targets already exist.

> *Nature of the tactical links:* As a consequence of the tactical dimensions of the representation, the notions of quality of service and operating rules have been introduced. These notions are essential for the optimization processes described in the mathematical formulation by the term $Q(y-y_t\ (OR))$.

This dimension is often ignored, which leads to rigid and compartimented decision making structures with a risk of conflicting relationships at the interface of management activities that share a common output without clear interaction rules. These interaction rules (Q, OR) have to be negotiated or fixed at a sufficiently high level in the decision making tree (level of integration). As illustrated with the example used earlier the level of integration where a "modus vivendi" can be established is level 1, for the water distribution and the application unit and level 2, for the acquisition and distribution units:

Figure 12
Levels of Integration



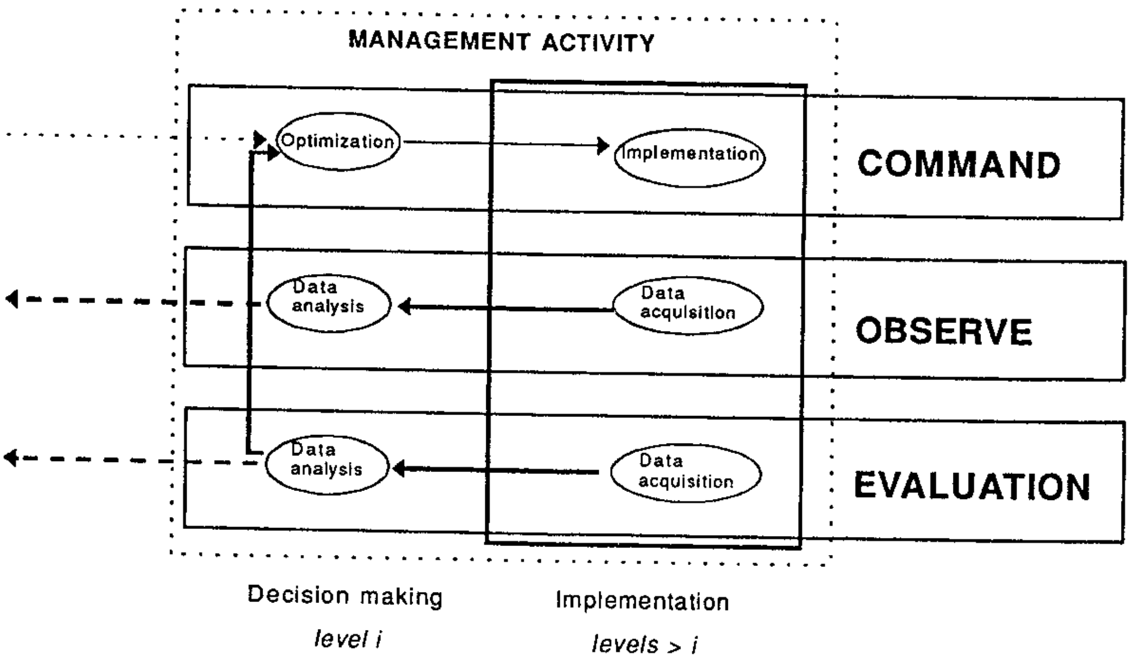
The analysis of this dimension implies that intermediate outputs on a tactical line must be considered as "services provided" and logically requires that we define the quality of these services. Standard definition of quality is usually comprised of the concept of *flexibility* captured by the notion of operating rules or ability to change the targets or service delivered on "clients" request, according to specified rules, and the concept of *precision* captured by the assessment of the gap $y-y_t$. The level of integration is thus responsible for clarifying the *operating rules* in terms of flexibility and the *sills of tolerance* in terms of precision. The implementation levels interacting according to the service concept are accountable for joint assessment of the quality of service provided and reporting up to the level of integration in case of conflict.

This concept of service has direct implications on decision support interventions:

->	targets used for making decisions must have a certain degree of flexibility which has to be clarified through the presence of clear operating rules.
->	joint and transparent assessment of service outputs has to be a "built-in" mechanism for the accountability of decision makers.
->	the negotiation of quality standards (flexibility, precision) at the level of integration has direct implications on the degree of sophistication (or cost) of the decision making capabilities required to achieve these standards. It can be considered in this respect as a prerequisite to effective interventions.

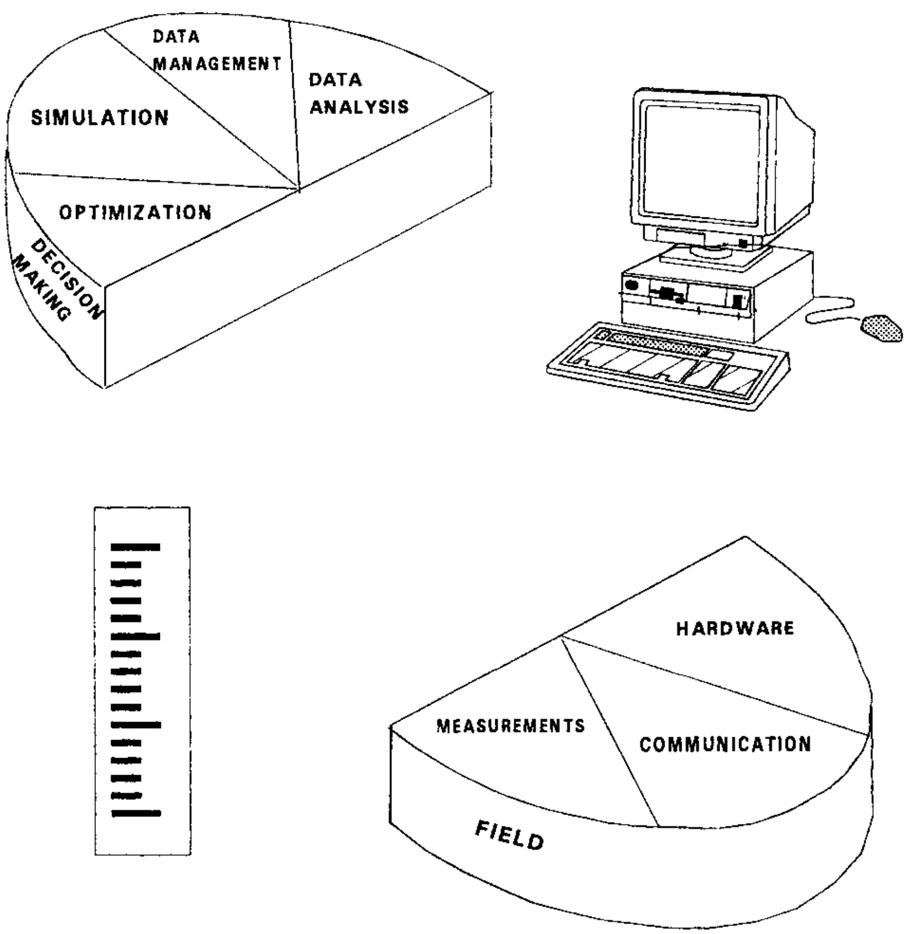
> ***Areas of technical interest:*** As a consequence of the functional dimension of the representation, the three main management functions, i.e. command, observe and evaluate, will by this stage have been identified; the basic layout of tasks implied by these 3 functions is mentioned below:

Figure 13
Three Management Functions and Tasks



The dual structure decision making/implementation of the management activity is reflected in figure 13. The technical areas requiring investigation while analyzing the different tasks can be further described. The optimization tasks can involve direct *optimization* technics (ex. linear programming) or iterative procedure through *simulation;* the use of the data provided by the observe function for on-line control and revision of targets requires efficient *data management* and *data analysis* facilities (ex. computation of discharges). The use of evaluation data can be done through the same means (ex. computation of indicators, cross analysis with GIS). Depending on the implementation level considered physical facilities may have to be mentioned as well: adequate *hardware* in case of structure operation (implementation task), *measurement* devices for data acquisition. In any case, *communication* facilities are a prerequisite for an efficient functioning of the management activity. The potential technical areas likely to be studied while considering decision support activities are thus summarized below:

Figure 14
Areas of Technical Interest



A non-comprehensive list of tools available to address these technical areas is listed hereafter.

Table 4
List of Tools Related to Technical Areas

optimization:	expert systems, mathematical models, linear programming, ...
simulation:	mathematical models, ...
data management:	information systems packages, databases, GIS, ...
data analysis:	statistical packages, spreadsheets, ...
hardware:	various devices automatic or not, ...
measurements:	various sensors, remote sensing, ...
communication:	various transmission facilities, radio, cable, motorcycles, etc.

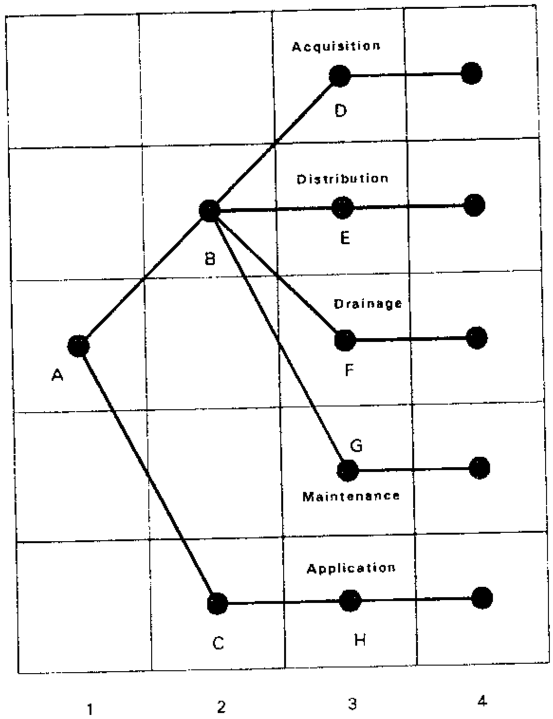
1.2. A Model for Management Intervention

In the previous paragraph a comprehensive representation of irrigation schemes was proposed from the perspective of decision making processes. This representation, which emphasized *communication flows* (three-dimensional matrix), *management tasks and functions* (command, observe, evaluate) and minimal *data requirements* (formalization of the optimization processes), gave some insights on the scope and constraints of decision support interventions (cascade of optimization, role of tactical links and areas of technical interest). In the light of this representation, *the notion of intervention* itself needs to be clarified in order to draw generic methodological lessons.

a. Different motivations, different modes of intervention:

> Referring again to a simplified decision making tree in the case of joint management by an agency and farmers (figure 15), ***the initial motivations*** for a decision support intervention can be numerous.

Figure 15
Simplified Decision Making Tree



Adopting the service concept terminology of relationships between agency and clients the need for improvement can come from various nodes:

On agency side:
- inability to satisfy clients at a given quality (nodes B, D, E, G)
- need to consider clients request for better quality (node A)
- necessity to reduce costs of service (nodes A, B, D, E, F, G)

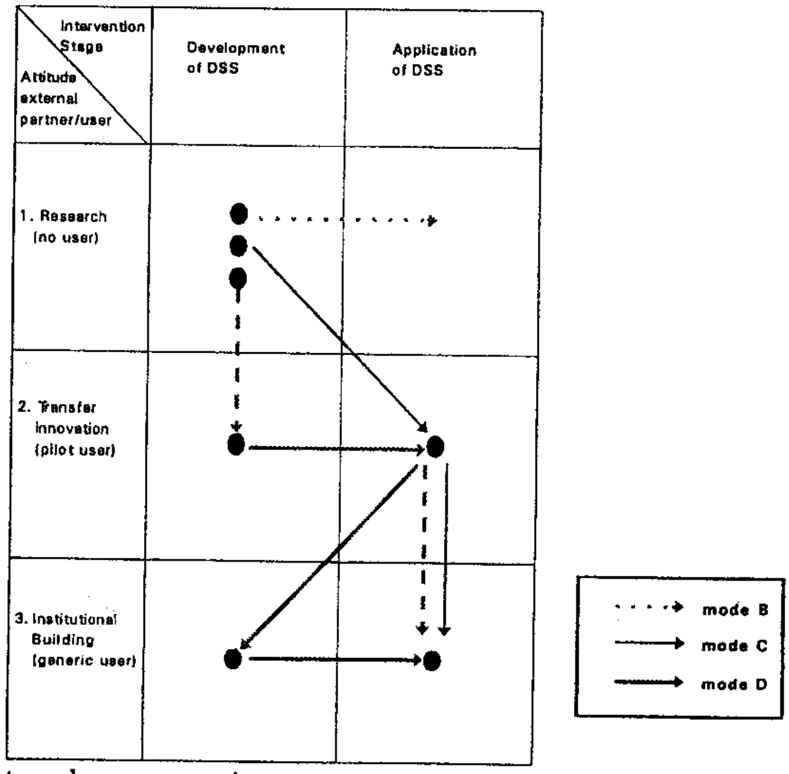
On the farmers side:
- inefficient use of service provided (node C, H)
- inability to formulate better quality standards (node A)

External (ex. policy maker, donors, researchers):
- poor overall performance of schemes or irrigation sector
- money available for schemes improvement or research study

In the first 6 cases, an initial symptom of non-optimal functioning initiates an improvement process which can lead to "demand driven" decision support interventions. In the last case "supply driven" interventions have to be handled extremely carefully.

> The ways of conducting the interventions are almost as numerous as the initial motivations. The interventions can be conducted internally or with the help of partners external to the irrigation scheme. In the case of external partners, 3 main ***modes of intervention*** can be distinguished and are illustrated in figure 16. The node for which is developed and then by which is applied the decision support system (DSS) resulting from the intervention is called user.

Figure 16
Main Modes of Intervention



This approximate typology comprises

- mode A: development and application of DSS internal to an agency.

- mode B: problem solving approach by external partner, leading to a transfer of results but not of tools nor methods.

- mode C: semi-participatory or turnkey approach by external partner leading to a transfer of readymade tools and methods for application of tools (pilot or/and generic).

- mode D: participatory approach with external partner leading to a transfer of methods for development and application of tools (pilot or/and generic).

b. Evaluation for Diagnosis: Improve What?

> *identification of key issues and critical management activities:*

Once initiated by an "initial symptom" the first real step of any intervention consists *in a global performance evaluation* of the irrigation scheme. The outline formalized by Svendsen and Small [1] can be used for delineating the boundaries and the type of this evaluation.

Table 5
Global Performance Evaluation

> boundaries:	
. management activity:	scheme
. life cycle process:	operation, maintenance
> evaluation type:	
. model:	goal oriented
. rational for assessment:	intervention in water management
.types of measures:	
1. level:	<u>output/impact</u>
2. scope:	achievement/efficiency (or quality/cost)
3. indicator:	direct
> source of standards:	external
> time dimensions:	series of points
> tools used:	interviews users, indicators, GIS, ...

This broad output/impact oriented evaluation permits identification of *key issues* determining the actual performance of the scheme. It is argued that the 3 main issues relating to water management coming out of this type of evaluation are in 90% of the cases:

1. water conservation
2. responsiveness of the distribution system to farmers needs
3. environmental impact of irrigation practices

All of these issues can be characterized by an output and a performance objective.

Table 6
Key Issue (Output, Performance Objective)

Issue	Output	Performance Objective
1	water use efficiency	external standards
2	quality of distribution	farmers satisfaction external standards
3	quality of soil, water, ...	external standards

The identification of a key issue leads to the consideration of *the management activities* involved in the production of the related output. At this stage, the decision making tree (cf. Section 1.a) of the system considered has to be drawn. For the key issues 1 and 3 the level of integration to be addressed is clearly the scheme, for the key issue 2 the level of the irrigation agency might be sufficient. With reference to the simplified decision making tree, the nodes to be considered are thus:

Table 7
Activities/Tasks involved in the production of the outputs corresponding to 3 key Performance Issues

Levels	Management activities of levels 1, 2, 3: Tasks at decision making nodes	Key issues		
		1	2	3
1	. seasonal land and water allocation	**		**
2	. water scheduling (agency)	**	**	*
	. planning irrigation (farmer)	*	*	*
	incl. operating rules & quality control			
3	. acquisition of water	*	*	**
	. operation of distribution network	**	**	*
	. maintenance of irrigation network	*	*	*
	. operation of drainage network			**
	. on-farm irrigation technics	**	**	**
	incl. operating rules & quality control			

While considering this list of activities/tasks a first prioritization has to be done in order to identify *critical activities/tasks* which have the greatest influence on the production of the considered outputs. As example common critical activities are highlighted in Table 7.(**)

> *identification of performance drivers:*

Being aware of potential sources of "non-performance" among the management activities (critical activities) a second type of performance evaluation focussing on these critical activities has then to be performed.

Table 8
Focussed Performance Evaluation

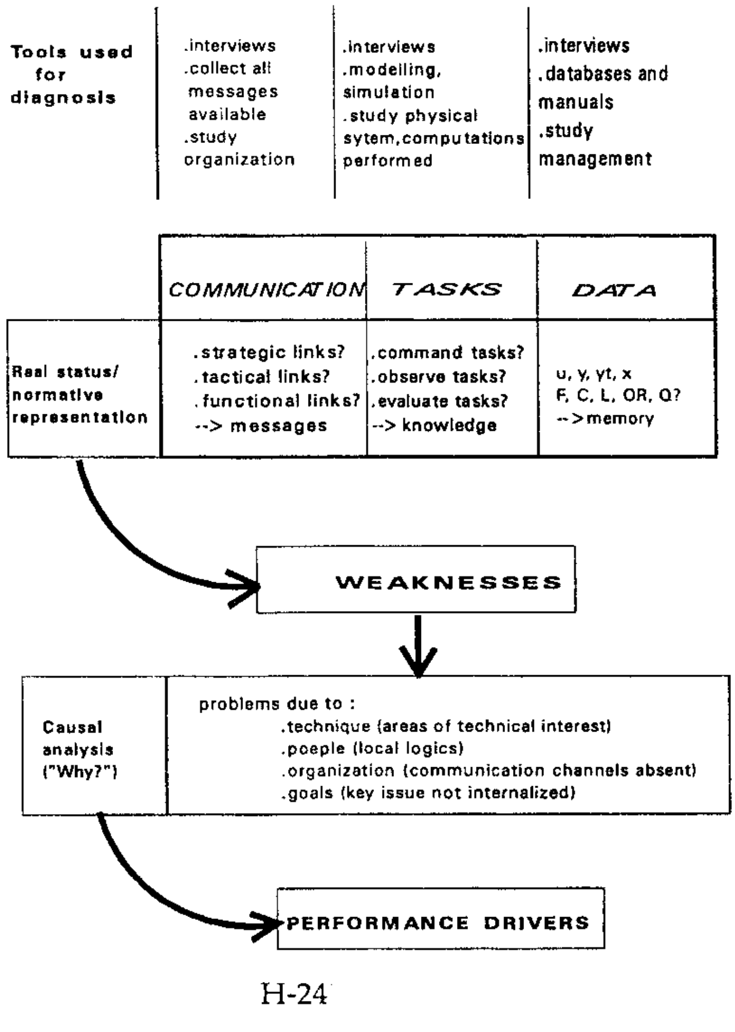
> boundaries:	
. management activities:	critical activities
. life cycle process:	operation, maintenance
> evaluation type:	
. model:	goal oriented
. rational for assessment:	intervention
. types of measures:	
1. level:	process
2. scope:	achievement/efficiency (or quality/cost)
3. indicator:	direct
> source of standards:	internal/external (normative)
> time dimension:	single point
> tools used:	indicators, questionnaires, simulation, ...

These focussed, process oriented, evaluations permit identification of the real *performance drivers* on which improvement efforts can be concentrated. A method of evaluation based on the normative representation detailed in Section 1.a is suggested hereafter.

Referring to the implications on decision support intervention derived from the "cascade of optimization" analysis, activities should be evaluated in order from lower to higher levels. This is of critical importance, because there is considerable evidence that if higher levels are evaluated first without considering strengths and weaknesses at lower levels, then intervention may simply fail.

It is proposed to evaluate the process-performance of a critical activity with a clear information system perspective, according to three view points: communication, tasks, data. For each of these view points one must proceed by assessing the real status, comparing it with the normative representation, identifying gaps and exploring the cause of detected weaknesses. The normative representation of the decision making level of any activity presented in section 1.a is completed in Annex. Indications for the evaluation process are given in figure 17.

Figure 17
From Critical Activity to Performance Drivers
(Information System Perspective)



The end product of this second performance evaluation should clearly highlight *the scope for DSS introduction* at critical levels in the scheme and pave the way for a well targeted action plan. It is interesting to note that the diagnosis as a whole can be an activity internalized within the scheme (mode A of intervention) and, requires as such methods and tools as detailed in the previous two paragraphs. This part of the intervention itself (diagnosis through output/impact evaluation and process evaluation) present a clear scope for decision support but the notion of "meta-diagnosis" (diagnosing the diagnosis capability of the agency) will not be discussed further!

> ***restitution of the diagnosis to the management scheme:***

This last step, which ends the complete diagnosis phase should be handled with great care and leads to a common understanding of the weaknesses detected, as well as a common vision of the actions to be taken in order to correct them, between all parties involved in the intervention. A formal document can be produced giving details on the tools and methods proposed for the action phase.

c. Elements for Action: Improve How?

> ***create an adequate management context for DSS***

A comprehensive diagnosis phase should provide all elements needed for a well targeted action plan. An abundant literature refers to the dangers of introducing decision support tools which do not fit in their host context and thus remain underutilized ([2], [3]). The successive clarification of key issues, critical activities and performance drivers through the light of an *information system oriented representation* leads to accompany any introduction of tools by subsequent upgrading of the communication and, if necessary, data acquisition systems. This "package" approach helps avoid the danger of creating the frequently observed *gaps between high data requirements* of DS tools and the capability of the management context to provide them in a reliable and sustainable manner. Moreover, the fact that the driving force of the whole analysis consists in a well identified, *key performance issue* biases the analysis of operating rules, quality of service, reporting and evaluation methods towards this performance issue and leads to an *"in-built" coherence between the improvements proposed and the strategic performance of the scheme.*

The importance of the mode of intervention has to be mentioned here again. It will be recalled that four modes of intervention exist: internal development (A), transfer of results (B), turnkey (C), and participatory development (D). Participatory approaches (mode C or D) are strongly recommended at the action plan stage. This type of approach which involves iterative design of tools and methods through interactive prototyping brings commitment from the user's side.

It also provides an unique way of truly assessing the potential of the management context for accepting and using proposed innovations. The assessment of additional training needs or the necessity of downgrading (or upgrading) the technical packages proposed is greatly facilitated by this approach.

All these steps are made easier if a lasting and visible commitment of higher levels of the irrigation agency's hierarchy is formalized through a working group or steering committee.

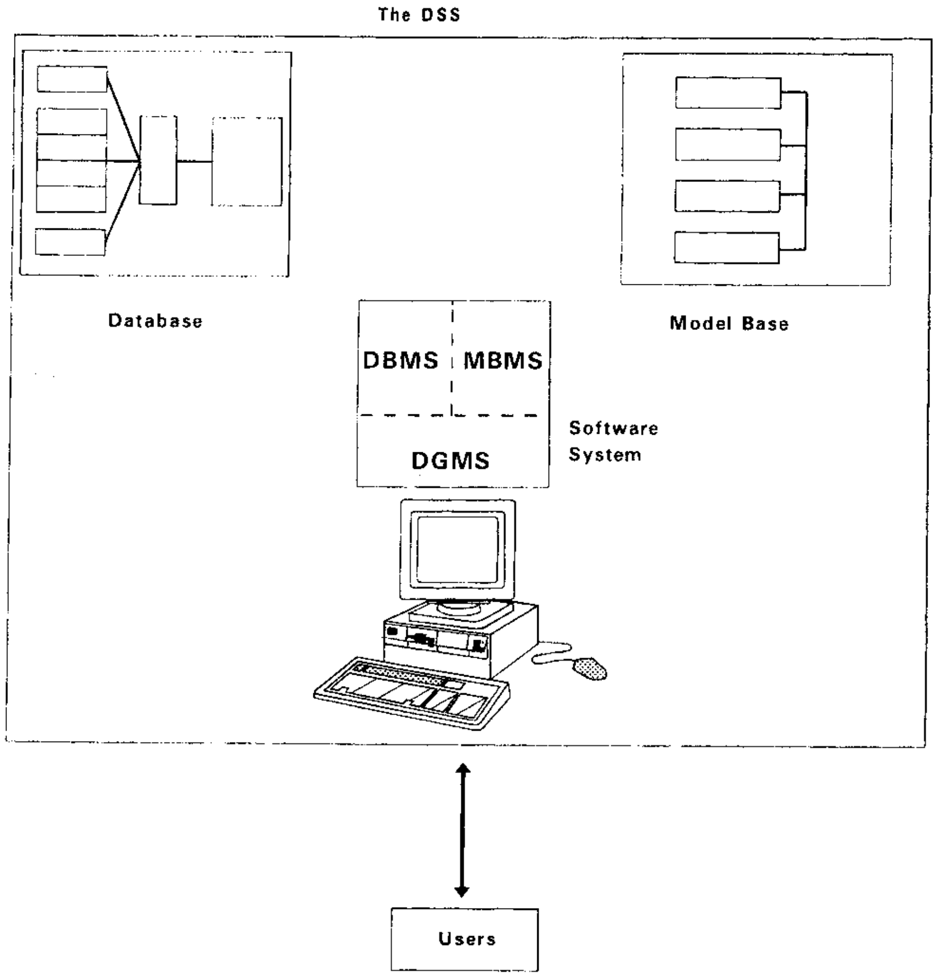
As a summary, an effective environment within which a decision support activity can originate and evolve includes:

- a lasting commitment of the irrigation agency's hierarchy steering the work of:
- a group of people sharing a sense of common performance objectives, trained on:
- a set of compatible and sustainable hardware and software technology, operable with:
- a set of data obtainable in a reliable and sustainable way.

> *design proper tools:* As far as the computer based decision support tools are concerned, the growing library of softwares provides numerous examples of technical standards. The choice of a type of tool is of primary importance. In most cases the computer tool itself while being only one element of the "action package" acts as a real and essential catalyst in the intervention process.

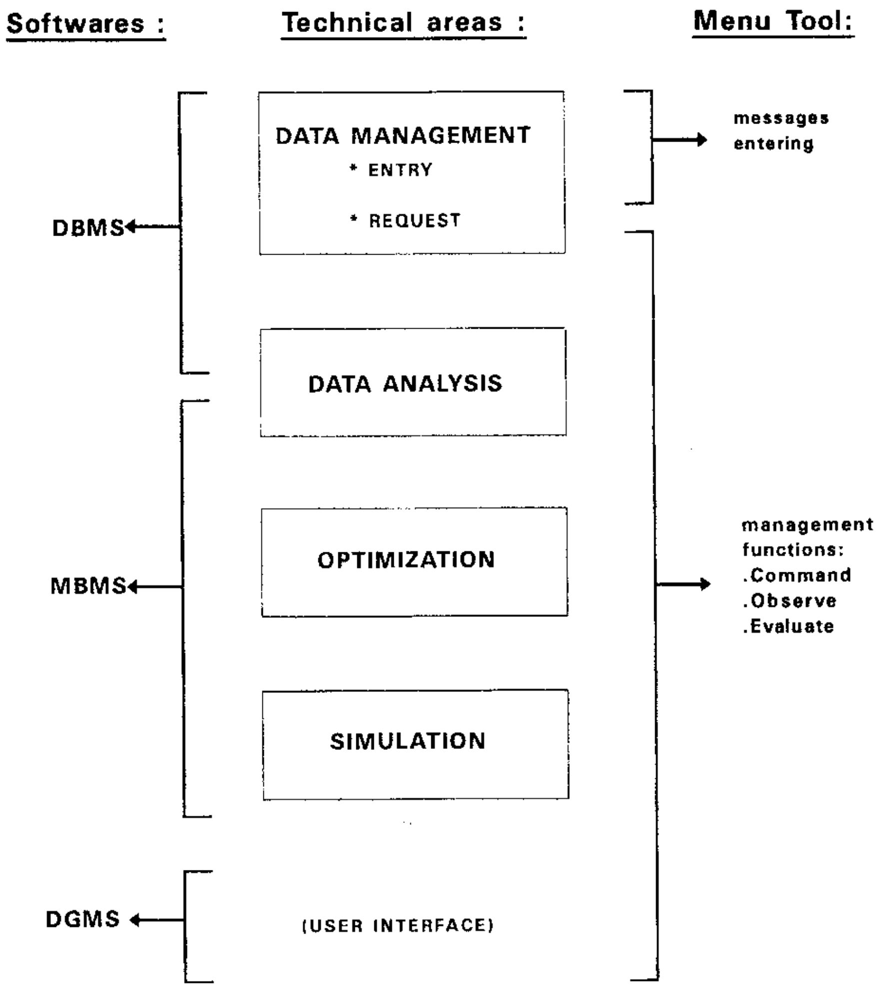
- structure of softwares: The information system approach tends to emphasize the role of a core database management software (DBMS) linking the *database* to *specific applications* via a model based management software (MBMS) which performs tasks on the available data and provides outputs to the user through an interactive *interface* generated by a dialog generation management software (DGMS), as represented in figure 18.

Figure 18
Components of a Decision Support System
(inspired from [2])



Usual links between the 3 types of packages (DBMS, MBMS and DGMS) to be selected and the areas of technical interest identified while studying the management functions are explicited below.

Figure 19
Link between Software Packages and Technical Areas for Decisions Support



- organizing the database: The representation detailed in Annex forms a conceptual starting point for organizing the database. It has to be operationalized on a case by case basis.

- knowledge required for the specific applications: It is rather difficult to list out extensively the type of expertise needed for formalizing and solving the decision making problems related to the water management tasks identified. Nevertheless, a few indications on tasks and related available tools are summarized in tables 9 and 10.

Table 9
Main Water Management Tasks

Level	Node activity	Command task	Observe task	Evaluate task
1	seasonal land and water allocation	Optimization (land, market, rainfall, water storage, crop water requirements, operational procedures)	cropping areas, water availability, socio-economic signals.	production indicators, market responsiveness
2	water scheduling	Optimization (crop water requirements, operational procedures)	cropping stages, soil moisture, meteorological parameters	soil/crop/water processes, indicators
3	distribution network operation	Optimization (operational procedures)	discharge, levels	hydraulic impact of operations, indicators
	irrigation network maintenance	Optimization (operational procedures)	rate of degradation, seepage, stricklers	hydraulic impact of maintenance, indicators
	drainage network operation	Optimization (operational procedures)	water tables, discharges	hydraulic impact of operations, indicators

Table 10
Main Computer Based DS Tools Available

Level	Node activity	Command task	Observe task	Evaluate task
1	seasonal land and water allocation	. expert systems . linear programming . salinity models	. GIS support	. models[1]
2	water scheduling	. crop water requirement models . management simulation models . water allocation models . salinity models	. GIS support	. modules for computation and statistical analysis . models[1]
3	distribution network operation	. hydraulic simulation models (groundwater, open channels, conjunctive) . automatic control algorithm	. hydraulic calibration software	. models[1]
	irrigation network maintenance	. hydraulic simulation models (open channels, option design alternatives) . sedimentation models	. computer modules for indirect assessment of hydraulic degradation in channels	. models[1]
	drainage network operation	. hydraulic simulation models (groundwater, open channels, conjunctive)		. models[1]

([1]) In case of simulation tools, there is a clear duality between their uses for supporting the command and evaluation functions. They can be used both to test alternatives at the command stage and to simulate the past for a better understanding at the evaluation stage.

> *possible step by step approach (mode A. C, D):*

Once the management context is felt as adequate and a first choice has been made concerning the type and degree of sophistication of the computer tool(s) envisaged the action phase per se can occur. A tentative chronological list of 9 steps is proposed hereafter. These steps start sequentially but obviously overlap while the action phase is progressing.

- *Define prototype with the canal manager:* Agreement has to be reached between the developers and the decision maker on a tentative configuration of the decision-support tool and its expected outputs through in-depth discussions of the various options available (simulation or not, choice of indicators, size of the data base).

- *Survey of the physical system:* Depending on the configuration of the tool, the availability of all basic data required to carry out the selected computations has to be verified (description of control structures, topography of the canal in case of flow simulation).

- *Build awareness among the staff:* At a very early stage, a general meeting of the staff likely to be involved in, or affected by, the installation of the decision-support tool should be conveyed by the decision maker. The proposed activity is then presented and a real participatory process initiated before embarking on any specific training. A careful review of the present job descriptions and of the modifications to be introduced is initiated.

- *Set up a data collection and transmission network:* Once the set of basic information relating to the physical configuration has been entered in the data base, the critical issue thereafter is to review, organize and systematize the information flows between the field and the decision-making center to enhance and update, on-line, the data base. Specific training of staff responsible for measurements, data recording, data transmission and data entry has to be carried out.

- *Introduce data analysis activities:* The first by-product of monitoring activities is that it provides a record of the actual state of the system commanded by the decision maker. Being aware of this state on a timely basis contributes to analyzing management practices and discussing problems. The computation of indicators can be progressively introduced.

- *Investigate the validity of targets:* The rules underlying the fixing of targets as expressed by the decision maker may be evaluated by comparing these targets with the real achievements of the system. Steps to improve, or revise, the rules can thus be initiated, when necessary.

- *Initiate control activities:* The frequency and magnitude of control activities is very much related to the accuracy of targets. Control is needed only if gaps between measured achievements and targets are detected.

- *Optimize decisions:* The rules underlying the elaboration of decisions as expressed by the decision maker may be improved or revised with the support of additional tools.

- *Work out a mechanism for evaluation:* A seasonal evaluation of the impact of the use of the decision-support tool on the management organization, and, ultimately, on the system performance, together with an assessment of possible improvements to the tool is essential.

As a conclusion of this section, a summary of the different elements presented as a model of management intervention is shown below.

Table 11
Summary of the Intervention Framework

Summary intervention	Type of DS tools used	Mode of intervention
1. diagnosis: . Key issues > critical activities . performance drivers > **scope for pDSS**	dDS[1] output/impact dDS[1] process	A, B, C, D
2. action: . clear strategic objective > appropriate environment . new technics, tools > **installation pDSS**	pDS[2] package pDS[2] tools	A, B, C, D

[1]dDs: diagnosis Decision Support
[2]pDS: process Decision Support

d. Elements for institutionalization (modes A, C, D)

Only a few generic remarks can be mentioned on this aspect. The process of institutionalization or transfer to a generic user is highly dependant on the various determinants governing the attitude of the user's community: politics, finance, organization, ... and the strategy adopted to make an innovative intervention internalized has to fit in this context. Nevertheless, some indications appear useful:

> The concept of pilot study is essential and implies systematic and extremely rigorous *documentation and evaluation methodologies.* The "product being sold" to a generic user needs to have clearly proved its quality; in addition to this marketing perspective the use of case studies for realizing the transfer itself is essential.

> With reference to the intervention model, "the product being sold" often consists in the "action package" only, provided that the output of the diagnosis on the pilot system has a recognized generic value for other systems. *This action package,* as detailed earlier, *is made of 3 components*: - the creation of a management context - appropriate computer tool(s) - a systematic installation methodology. Even if the "action package" is often identified by the computer tool itself ("use of model X", "installation of model Y"), the transfer does include obviously the 3 components.

> Successful transfers imply the true collaboration of two responsible partners: the supplier, presenting an action package tested on pilot intervention(s) and the receiver in charge of internalizing the package and proceeding further with dissemination. The receiver is the *"institutional home"* for the package transferred and certain characteristics are obviously required for playing this role truly; among them are: training capabilities, access to policy makers, lasting financial stability, good skills in needs assessment and evaluation techniques. As a matter of fact, few irrigation agencies have a research and training unit meeting these criteria.

2. Lessons from IIMI's Interventions in the Field of DSS

An overall assessment of IIMI's interventions in the field of computer applications for decision support is that there has been a relatively poor rate of success in achieving the goal of adoption by irrigation managers. There are some clear and positive exceptions to this overall assessment, and some particularly negative ones.

The variable success rate provides a timely opportunity to look back at why this may have happened, and what needs to be done in the future to ensure greater acceptance of applications that have clear applicability in the overall field of irrigation management.

This section is divided into two parts:

- a description of the different interventions attempted by IIMI during the past eight years and

- an assessment of the underlying causes that lead to successful and unsuccessful interventions.

2.1 Description of DSS interventions undertaken by IIMI and partners

During the past eight years IIMI has used computer models for decision support in a wide variety of ways in several different locations. Table 12 attempts to summarize the total list of these interventions, including information on the type of software, the locations where they have been used, and the primary agency responsible for their development. A total of 15 different DSS packages have been used in about 20 different interventions.

It is clear that there is no overall direction towards the use of either in-house development of software, or use of packages developed by other agencies. 9 of the packages have been developed directly by IIMI in close association with partners or using commercial shells, while 6 have been developed by agencies with whom IIMI had no close links during the development stage. However, in recent years it appears that there has been a greater emphasis on joint or in-house development of softwares rather than use of existing tools developed by outside groups.

The tools themselves fall into main technical categories, and a brief description of the categories and the constituent tools used in the 20 interventions are provided in Table 13. These categories represent different uses within the overall decision-making processes for irrigation managers, a distinction that is not always clear to casual observers.

Table 12
Partial List of Projects where DSS has been used by IIMI

Intervention Acronyms	Type of tool (& software) used	Location (& Date) of intervention	Tool Developer
1. TARC	water balance model (spreadsheet 'TARC')	Sri Lanka (1991)	IIMI (HQ)
2. PRO(KO)	probability inflow model (spreadsheet 'PRO')	Sri Lanka (1992)	IIMI (SLFO)
3. COMA	management simulation model (COMA)	HQ (1990)	IIMI (HQ)
4. IMIS (KO)	management information system (IMIS)	Sri Lanka (1991)	IIMI (HQ)
5. IMIS (UW)	management information system (IMIS)	Sri Lanka (1991)	IIMI (HQ)
6. IMIS (FORDWAH)	management information system (IMIS)	Pakistan (1991)	IIMI (HQ)
7. SIC(KO)	open channel hydraulic simulation model (RBMC, SIC)	Sri Lanka (1990)	CEMAGREF/ IIMI (HQ)
8. SIC(CRBC)	open channel hydraulic simulation model (RBMC, SIC)	Pakistan (1992)	CEMAGREF/ IIMI (HQ)
9. SIC(PAK, HQ)	open channel hydraulic simulation model (SIC)	Pakistan (1992)	CEMAGREF/ IIMI (HQ)
10. SIC(BF)	open channel hydraulic simulation model (SIC)	Burkina Faso (1992)	CEMAGREF/ IIMI (HQ)
11. RAJBAH	open channel hydraulic simulation model (MISTRAL/RAJBAH)	Pakistan (1990)	SOGREAH/ IIMI (PAK)
12. TANK(KO)	water balance model (ROSES)	Sri Lanka (1993)	CONSULTANT/ IIMI (SLFO)
13. EXP	Expert system (NEXPERT)	India (1989)	COMMERCIAL/ IIMI
14. LP(KO)	linear programming package (LINDO)	Sri Lanka (1991)	COMMERCIAL/ IIMI

15. MODIS(FORDWAH)	open channel hydraulic simulation model (MODIS)	Pakistan (1992)	DELFT HYDRAULICS
16. CROPWAT	crop water requirement & scheduling model (CROPWAT)	Pakistan, (Sri Lanka, Sudan) (1987)	FAO
17. Anderson-Maass	scheduling model (Anderson-Maass)	Indonesia (1988)	HARVARD
18. INCA	planning & scheduling model (INCA)	Sri Lanka (1992)	HR WALLINGFORD
19. SALT(PAK)	salinity model (SOWATSAL)	Pakistan (1990)	USU
20. ILWIS	GIS package (ILWIS)	Pakistan (1992)	ITC HOLLAND

Table 13
Partial List of Tools used by IIMI

Type of Tool	Software Used	Brief Description of Primary Uses
Hydraulic Simulation of Open Channel Flow	SIC MODIS RAJBAH	Modelling of water levels and discharges along canals; determination of gate settings to achieve water distribution plan; assessment of effects of desilting
Water Balance Models	'TARC' ROSES 'PRO'	Determination of inflows and outflows in reservoirs and irrigation systems
Planning and Scheduling Models	INCA CROPWAT ANDERSON-MAASS	Estimation of crop water requirements and canal releases required to match water supplies and demand
Management Information Systems	IMIS	Systematic recording of basic information for irrigation managers (discharge, area irrigated, rainfall, gate settings, etc), computation of indicators
Geographic Information Systems	ILWIS	Spatial analysis of system conditions and performance; inter-relationships between physical, managerial and socio-economic environments on performance
Management Simulation Models	COMA	Assessment of management needs and probable performance levels for different operational scenarios.
Linear programming packages	LINDO	Linear programming to optimize cropping pattern given a set of constraints
Expert systems	NEXPERT	Interactive reasoning process for prioritizing rehabilitation needs in small tank systems
Specialist Models	SOWATSAL	Evaluation of operations on salt balance.

Table 14 classifies the different projects into the various modes of intervention described in Part 1 of this paper. It is immediately clear that the majority of interventions (14 out of 20) fall into the category of Mode B, results generation, while modes C and D each only have 3 interventions. This confirms the overall assessment that few of the interventions have been successfully transferred from IIMI to irrigation managers.

Table 14
Partial list of Interventions where DSS was used by IIMI
(organized by type of intervention and key issues addressed)

	Mode B results generation	Mode C turnkey transfer	Mode D participatory transfer
> water conservation . land & water allocation . scheduling . distribution . maintenance	*TARC, LP (KO),* *PRO(KO)* *TARC, CROPWAT* *SIC(BF)* *EXP*	*INCA* *INCA* *SIC(KO),IMIS(UW)*	*IMIS(KO), TANK(KO)*
> Responsive needs[2] . scheduling . distribution . maintenance	*COMA, Anderson-Maass* *SIC (CRBC),* *MODIS (FORDWAH)* *RAJBAH,* *SIC(PAK, HQ)*		*IMIS(FORDWAH, MEXICO[1])*
> impact environment . land & water allocation . scheduling . distribution . maintenance . drainage	*ILWIS(PAK)?* *SALT(PAK)* *SIC(FORDWAH)[1]* *RAJBAH, SIC(PAK, HQ)*		*IMIS(FORDWAH)[1]*

(1) proposed activity for 1994
(2) includes equity issue

2.2 Assessment of Reasons for Relative Success and Failure of Interventions

The reasons for the relative degree of success and failure of the DS packages to have an impact of irrigation management can be divided into a number of different categories:

- the nature of the intervention attempted,
- the nature of the DS package itself, and
- IIMI's own organization and tool development process

These three categories are interlinked to some extent, but the distinction is useful when attempting to find solutions to the problems identified.

a. The nature of the intervention

> *Introducing the intervention at the right level*

The detailed analysis in section 1.1 of this paper includes a distinction between various levels of activity within a typical decision-making process. The lowest level (level 4) deals with issues of collection and transmission of data which are further organized at the other levels in a way that presents useful information to managers. Sequentially above are level 3 that is concerned with operations, level 2 dealing with scheduling, and level 1 that addresses the broad allocation of land and water resources for the system.

DS packages rely on having strength at the lower levels if they are to be well received by managers. Consequently, tools introduced at, say, level 2 (scheduling) will have a low probability of success if there is not already strength at level 3 (operations). A clear example of this is in respect of INCA, a sophisticated scheduling tool but dependent on having a system that is already concerned with improving operations, and which has a well-established data base. Even though a data base was established in the early stages of the introduction of INCA, the operational aspects were never strengthened, and thus improved scheduling remained an abstract concept to the managers involved. Similarly, successful introduction of operational tools (level 3) depends on having a strength at level 4 (data base updated through a data collection and transmission system). The initial introduction as a day to day operational tool of the Kirindi Oya Right Bank Model, the prototype of SIC (KO), was unsuccessful because there was no data base being used, and managers did not fully appreciate the utility of the approach contained in the model. Once the IMIS (KO) was established, the opportunity to use SIC (KO) on a regular basis was somewhat enhanced.

The immediate conclusion from this is that successful interventions are ones that are well matched with the current level of management of the system in which the tool is used. In systems with little or no experience in systematic collection and management of operational data it is almost inevitable that levels 3 and 4 will be the best starting point. Once there is strength at lower levels, there is a high probability of being able to successfully introduce tools at higher levels.

The relative success of IMIS in different locations is a direct consequence of matching the tool to the need. In Kirindi Oya and Fordwah IMIS is used because it is the first and simplest step onto the road of DS: it does not rely on having strength at lower levels because it is the lowest level.

> *Getting managers to manage rather than administer*

A second difficulty encountered is that DS by its very nature addresses the way in which managers can make choices between alternatives. This is in many cases an anathema to staff of more bureaucratic or administratively oriented agencies because they are much more accustomed to following single course of action. Deviations from this course are often not tolerated by superiors, and many lower and middle level managers are simply afraid to make decisions in their own right. This bureaucratic set of pressures is extremely strong, and has been observed in several cases to override the interest and understanding of individual managers. Creating a proper management context ensuring a clear and lasting commitment from the agency's hierarchy (cf section 1.2.c) is thus often a prerequisite for DS intervention.

The experience in introducing several of these tools is that many agency staff either prefer not to take the risk, but merely wish to continue to administer the resources at their disposal. The use of the RAJBAH model for assessing opportunities to improve performance by selective desilting in Pakistan is a classic example: nobody really disputes the validity of the approach, nor of the performance improvements that resulted in the pilot testing, but it remains completely unused by anybody other than IIMI researchers. In part this is because the tool itself requires a lot of field data for calibration. At the same, institutional resistance was strong: Money is currently allocated by individual canal and the agency was not willing to consider alternative maintenance strategies that might involve reallocation of money between canals over a several year method.

By contrast, some programs do not offer choices: CROPWAT calculates water requirements, and the user has little capacity to control the values generated. Of course, the skill is in using the output, but that is a different issue.

> *The need for a clear performance oriented management framework*

In a more generic sense, however, it is clear that the success rate of tool introduction is directly interlinked with the degree of maturity of the irrigation agency towards adoption and utilization of an effective management framework. Three other papers in this IPR address this aspect ([4], dealing with comparison of performance in three systems in different countries in Asia; [5], addressing the issue of improvement of the capacity of irrigation agencies to improve performance; [6], addressing the need to have a clear statement of goals and how they can be achieved). All of these papers stress that without utilization of an overall framework that deals with performance (typical examples of frameworks are [1], [7], and [8], all of which address the same issues from different perspectives), the prospects of moving towards greater performance-responsive management are low.

If DS tool introduction is undertaken within a wider effort to improve responsiveness to performance, including such aspects as wishing to know about current conditions in the system or assessing the possible impact of different alternatives, then the likelihood of success is high.

This strongly indicates that a precursor to successful DS tool adoption is to go through a careful diagnosis process to identify what the management needs are together with the agency staff, find out what goals, objectives and targets they already have, and determine what type of DS tool is best matched to the current need (cf. section 1.2.b). If this is not undertaken, as was the case in COMA and INCA, then one ends up with an intervention looking for a location, a highly unlikely recipe for success.

b. The nature of the tool

Not unrelated to the above discussion is the recognition that the tool itself influences the degree of acceptance. While there is nothing new in this conclusion, it is clear that the developers tend to forget the level and capacities of potential users in their enthusiasm for getting "their model" used. Typical failures in this respect are developing models that are unfriendly, inflexible or apparently irrelevant ([9] contains a comprehensive review of presently available tools and highlights their shortcomings).

> *User Friendliness*

Many tools, especially those still in prototype, are unfriendly to users who are just embarking on using computers for any form of application. The unfriendliness may be in terms of interfaces (inputs and outputs), because there are still bugs that plague the tool, or because it requires more data or information than currently exists. A further problem associated with the turn-key mode of intervention is that the tool is viewed as a black-box, and there may be a lack of trust in what the algorithms are doing and thus a lack of trust in what the final output really means.

All of these are genuine causes for rejection by managers who are unsure or lack confidence in DS tools. The Anderson-Maass model used in Indonesia was particularly so, requiring highly tedious data input formatting with a single error leading to the program failing to run. Even a highly sophisticated mouse-driven program such as INCA with apparently a high degree of user-friendliness may intimidate people inexperienced with, or afraid of, mice.

GIS systems can appear as the worst offenders: these programs are complex, and it requires a great deal of patience and training to become a confident user. Further, the process of digitization of maps is slow, and this frustrates a potential user who wants a quicker turnaround of results from data. Of course, the input process for a good GIS system is an investment, albeit a long term one.

> *Flexibility*

A major drawback with many prototypes is that they lack flexibility. This is understandable, because the primary objective is to get the DS tool working at all during the development stage. However, flexibility represents a rather greater challenge for IIMI: DS tools need to be transferable between staff and offices, and yet they often end up accommodating a particular type of system design or agro-ecological set of conditions.

An example of lack of flexibility is the lack of a capacity in earlier versions of SIC to cope with the APM type of outlet structure prevalent in Pakistan because it was developed for Sri Lankan systems where all outlets were gated. It is possible to overcome some of these problems through krieging. Krieging, or fudging, is a process of doing something that gives the right answer even though it is fictitious: a special crop can be used to simulate land preparation requirements in INCA. In general, krieging is not only inflexible but highly user unfriendly because it leads the user to wonder just what the program is really doing.

> *Relating to Current Practices*

Even if a tool is easy to use and flexible enough to accommodate local conditions, it is important that it does something that the user can identify with. This is particularly true when a participatory mode of intervention is being adopted, because one of the first barriers to overcome is that if mistrust. If the program can generate the same results and outputs as has traditionally been done manually, then it is much more likely that trust and interest will develop in trying out new and more innovative things. There is nothing magic in this, merely a good approach to training. Unfortunately, tool developers are often lousy trainers.

This incremental approach of learning step by step is important, particularly if the user is expected to adopt and continue to use the tool long after the intervention has ceased. It also allows users the opportunity to learn how to adapt and modify tools to meet new requirements in the future.

c. Nature of IIMI's Tool Development Process

IIMI's internal organization and funding mechanisms appear to have a considerable impact on the likelihood of success of adoption of a particular tool. It is not a coincidence that almost all the tools have been used either in Sri Lanka or Pakistan. The reasons for this bias are discussed below.

> *Projects and Tool Development*

Tool development almost invariably takes a long time (and always longer than the developer will plan for) and yet most of our field studies are undertaken in the context of a time-bounded project with a finite budget. The net result is that almost all of the tools developed by IIMI have been developed by staff based in Headquarters.

At the same time, tools need testing and the easiest test sites are those where there are active field programs continuing for more than a couple of years. Sri Lanka and Pakistan have provided these opportunities, but other countries have not because project sites keep changing, and calibration becomes even more difficult to accomplish.

> *Ignorance and the Need for a Tool Library*

It is highly unlikely that IIMI staff outside of Headquarters know what tools are available: even the authors of this paper have probably skipped some of the tools used by IIMI researchers although two of them are based in Headquarters, so the chance of country-based staff having a global view of what is available and how to use it is minimal.

Ignorance of what is available means that the potential use of the tool is not built into the initial project proposal. It may be possible to include tool utilization as an add-on activity, such as the use of SIC (CRBC), but this runs the risk of being out of synchrony with the overall project timetable. The lack of clear scientific or research support for field staff from Headquarters is one contributing factor, and needs to be addressed as a matter of priority.

Allied to this is that the application and use of the tools needs to be far more widespread than is currently the case. It is of little value for a staff member to suggest to an agency that they try out a tool if there is no capacity to also undertake the subsequent training and adjustments to meet local conditions.

> *Common MIS platform*

The primary step of defining (a) generic management information system platform(s) which could be shared by researchers (and transferred to practitioners) for storing and analyzing basic hydrologic, hydraulic and agricultural data has not been done in a satisfactory manner as yet. This platform would support further addition of models and thus form a basis for dialog with model developers for interfacing. Conceptual analysis and technical choices on this matter should probably have been considered earlier as a research priority.

Conclusions and Recommendations

It is clear that there is considerable potential for using DS tools in support of irrigation managers, and IIMI has had some notable successes. However, it has had some notable failures and it is important to learn from these experiences so that future work in this area is more efficient and has a higher chance of success. The following conclusions and recommendations can be drawn so far from our experience.

☛ DS tools must match the existing strengths of agencies: if an agency is weak at a level lower than that addressed by a particular tool then the chances of successful adoption are very low. This point stresses the necessity of a thorough diagnosis before intervention.

☛ If an agency is relatively weak in terms of management, favoring a more administrative or bureaucratic style of implementation, or if there is only a weak data base for monitoring of current conditions, then the recommended course of action is to initially focus on the adoption of a Management Information System, and only graduate to tools that address higher levels when the agency is prepared.

☛ Agencies that already have tried to implement a management oriented framework, and are experienced in the use of performance indicators are most likely to be able to incorporate the more sophisticated DS tools into their normal working practices. This point stresses the importance of creating an adequate management context.

☛ Whatever the circumstances, DS tools must be user friendly, sufficiently flexible to be adapted to site-specific conditions, and be capable of replicating the existing working practices of the agency so that they build confidence both in the tool itself and their own capacity to use and refine it. The tools should be introduced as one component of an "action package" comprising a systematic methodology of installation.

- IIMI must, thus, as part of a focussed program of scientific support from Headquarters, build a more transparent library of DS tools so that all staff members are aware of what is currently available, what it does, and how it can be used; parallel with this should be knowledge of what tools are currently being developed, and a capacity in Headquarters to respond positively to ideas and suggestions for new tools or adaptations of existing ones.

- At the same time, IIMI must work on integration and standardization of DS tools and methods used in the various projects. A first step should be the definition of (a) common management information system platform(s) to be linked with modules for standard indicators computation and later with other models of use.

- Interaction with country-based staff must occur when projects are being identified and developed so that working DS tools can be incorporated into project scope and timetables; this includes provision for any training or other application of the tools by IIMI staff as well as those of counterparts and collaborators.

It is perhaps ironic to reflect that when IIMI was first involved in DS tools development there was considerable resistance: many staff felt that participating in tools development was not part of IIMI's comparative advantage. The philosophy at that time was that other institutions were better at tool development, and that we should, by and large, play the role of catalysts between developers and end-users. In retrospect, this catalyst role has not been particularly successful because the tools developed without interaction with IIMI have tended to meet with low levels of acceptance by agency staff. This is not because the tools are inherently inappropriate (although some may clearly be so) but often because the tools do not adapt well to the management philosophy that IIMI is currently promoting. Many of the tools generated by other research groups tend to include a sufficient technical bias that they lead the user towards "the optimal solution" rather than towards providing the manager with a range of options that better meet the realities of a complex and changing world.

At the same time, this is obviously not an advocacy for IIMI to spend resources on creating the tools themselves (solving fundamental equations, programming algorithms, ...) but to realize that our successes have often occurred when we work closely with developers in the process of expressing and identifying the real needs of users, designing input-output interfaces, etc., ([10]). This is a clear case where effective linkages with organizations in developed countries can assist IIMI in meeting the needs of our ultimate clients.

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Annex

Representation of the decision making process tasks of a management activity. Information system perspective

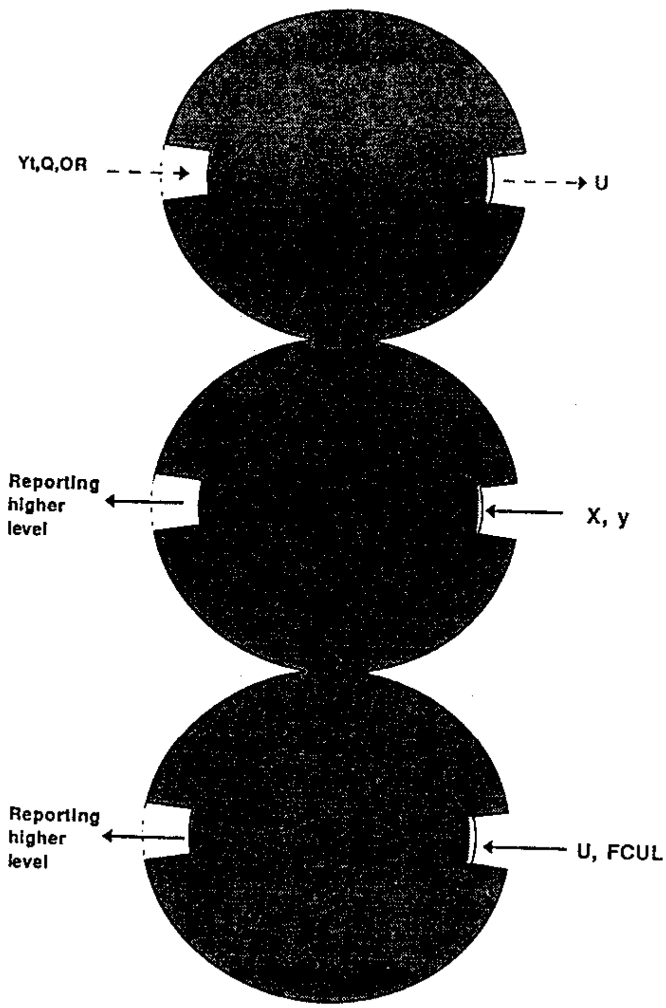
> Reference is made to the formalism introduced in the text for optimization problems:

$$u^* = \underset{u \text{ in } U}{\text{Opt}}\, L\,(Q(y-y_t), C(u))$$

$$y = F(X, u, t)$$

> Representation of communication flows:

Figure A1
Communication Flows

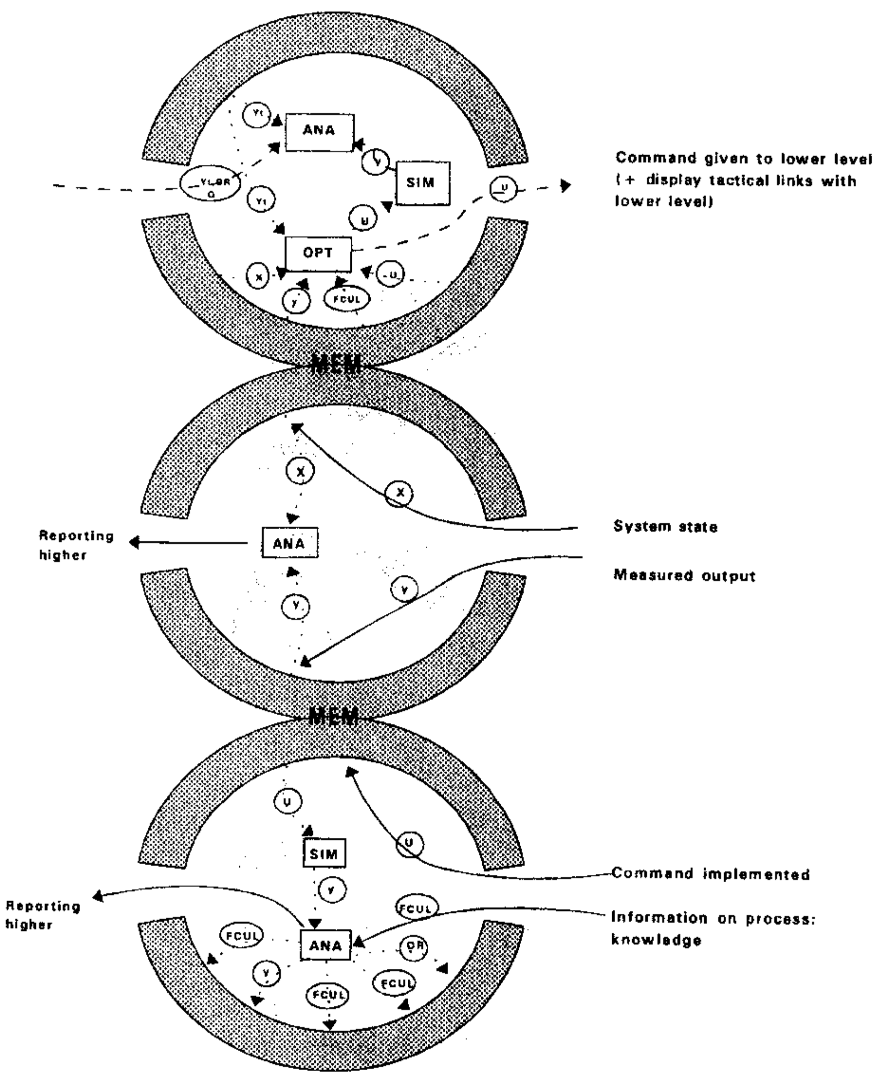


> Representation of computations:

the areas of technical interests identified in the text, will be used with the following abbreviations:

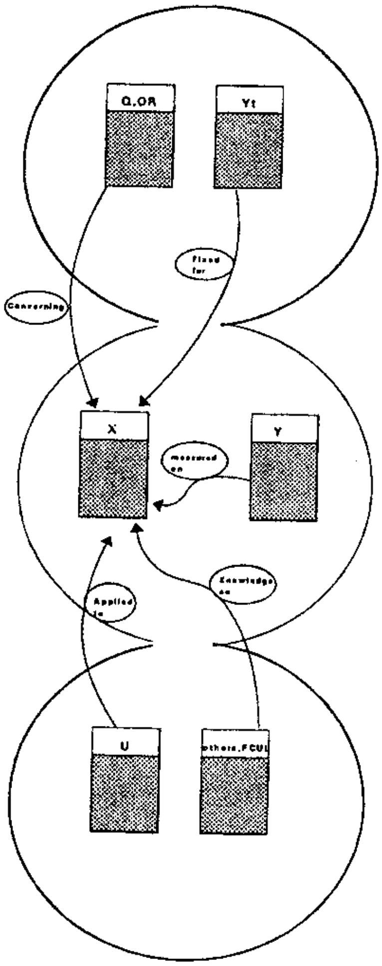
- Simulation: SIM
- Optimization: OPT
- Data management: MEM
- Data analysis: ANA

Figure A2
Computations



> Representation of data:

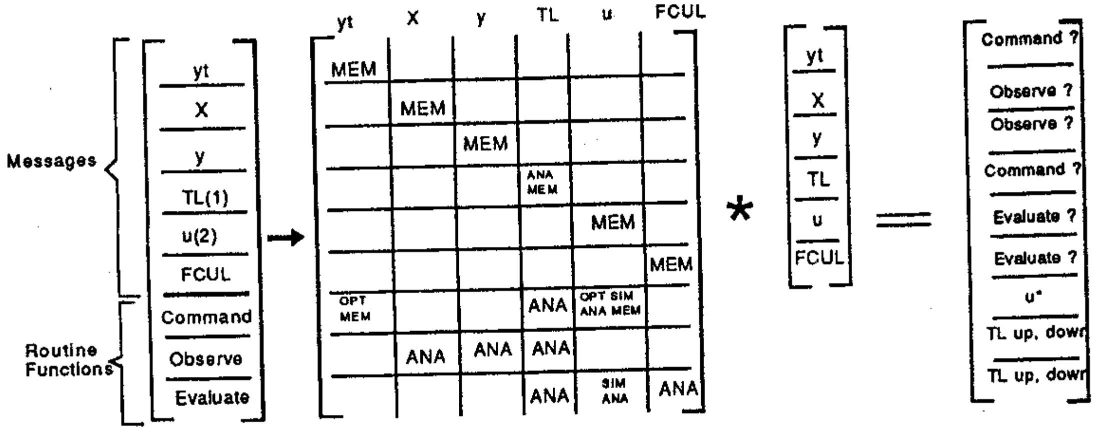
Figure A3
Data Base



> A coherent representation of the decision making process dynamic can then be obtained, emphasizing the role of management signals (receiving a message, starting a routine task), which are followed by a succession of data entries and/or computations (SIM, OPT, ANA, MEM) and the production of output messages. This representation is summarized by the equation:

input messages => [computations] * [database] = output messages

Figure A4
Communication, Computation, Data: A Dynamic View



(1) TL: Tactical links, Q(y-yt),yt(OR)

(2) u: Command having been implemented