FINAL REPORT

on the

Technical Assistanct Study

(TA 846 SRI)

IRRIGATION MANAGEMENT AND CROP DIVERSIFICATION

(Sri Lanka)

Volume II

Kirindi Oya Project

June 1990

International Irrigation Management Institute

P O Box 2075, Colombo, Sri Lanka

Please direct inquiries and comments to:

Dr R. Sakthivadivel
INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE
P. O. Box 2075, Colombo, Sri Lanka.

Tel: (01) 565601 IDD: 94-1-565601
Tlx: 22318, 22907 IIMI HQ CE Fax: 94-1-562919

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PREFACE

The research reported in these three volumes was made possible through a Technical Assistance grant from the Asian Developnent Bank, and through the close cooperation of the Government of Sri Lanka. **IIMI** is grateful to both for their support, assistance, and cooperation during the study period. We pay special tribute to the project and field level officers in the two systems studied, Kirindi Oya and Uda Walawe. Without their active cooperation and assistance the study could not have been completed. Their positive approach to the study is especially appreciated since during most of the period they were working under very serious constraints and threats due to the disturbed conditions in the country, and since our study was somewhat critical of the management of the projects.

Our major objective in this study has been to identify and diagnose problems affecting the performance of the two systems, and recommend practical steps that could be taken to solve these problems. Thus, we measure our success as much by the impact of our study, i.e., its usefulness to our clients the irrigation agencies, policy makers and donors, as by its contribution to irrigation management knowledge itself.

The present report reflects some additions and changes over the Draft Final Report. Volumes II and III provide detailed analyses of our data on Kirindi Oya and Walawe, respectively. We have added a new chapter to both volumes analyzing changes that occurred during the 1989/1990 maha season, i.e., since the Draft Final Report. In both systems very significant developments have occurred, some of them in response to the Draft Final Report itself. We have also revised the chapter on crop diversification (Chapter 6) in the Kirindi Oya volume to include additional potential crops, and the chapter on irrigation system performance (Chapter 4) in the Walawe volume to include data from the same distributaries for maha 1989/1990. Otherwise, we have made corrections and clarifications throughout the other chapters, to reflect comments and suggestions received from various readers.

For volume I, containing the overall recommendations and conclusions on both systems, we have not changed the original recommendations, which still stand, except for some editorial corrections. We have added additional sections providing additional recommendations and observations for both systems, based on the more recent fieldwork.

This Final Report provides the data base for the proposed Phase II study, which will be an action program to field test and evaluate some of the recommendations contained in this report, and will also provide additional data required for overall system planning and performance monitoring. Taken together, this work should provide a model of the kind of impact management-oriented field research can have on improvement of problematic irrigation systems.

CHAPTER I

INTRODUCTION

CONTEXT OF THE STUDY

This study of Irrigation Management and Crop Diversification was carried out under a Technical Assistance Agreement (T.A. No. 846 -SRI) dated 27 November 1987, between the Government of the Democratic Socialist Republic of Sri Lanka (GOSL), the International Irrigation Management Institute (IIMI), and the Asian Development Bank (ADB). The study was implemented by IIMI in the Kirindi Oya and Uda Walawe projects in southern Sri Lanka in close collaboration with the agencies in charge of development and management of these projects. It addresses, through field-level research, priority issues of importance and relevance to the two projects in the processes of irrigation system management, with particular attention given to the requirements of crop diversification.

PROGRESS OF THE: STUDY

The study commenced on 1 February 1988 and was of 30 months duration, including an additional four months' extension to finalize the Final Report. The first season of field research in the Kirindi Oya project was started in March 1988 which corresponded to the delayed **maha** (or "mid") season of 1987/1988. Due to the unsettled social and political situation that prevailed in the study area as well as inadequate water availability at the storage reservoir, only two seasons of research (maha 1987/1988 and yala 1989) could be captured during the period of study in addition to the last maha (1989/1990) season. The Draft Final Report synthesized the research results of the two seasons of completed study along with the preliminary results obtained during the ongoing maha 1989/1990. This Final Report includes an additional chapter on the impact of the draft final report on the implementation of the project, analysis of research results of the maha 1989/1990 as well as incorporation of suggestions received on the draft report.

REPORTING OF THE STUDY

An Inception Report (IIMI 1988a) was submitted in mid-March 1988 at the end of stage 1 of the study. It contained the findings of the literature review, and the research proposals and program, detailing data collection, field observations, analysis, and expected results, and other details of implementation for stage 2 of the study covering four seasons of field research. The identification of the sub-system for research was also part of the research planning described in the report. A Progress Report (IIMI 1988b) and an Interim Report (IIMI 1989a) were submitted in October 1988 and April 1989 respectively during the on-going research. The Progress Report described the progress in the implementation of the first season of field research, and preliminary findings. Based on the full season research of yala 1989, a Seasonal Summary Report (IIMI 1989b) was prepared which summarized the findings of that season. The Draft

Final Report analysed the results of all the previous seasons including a preliminary assessment of the work during maha 1989/1990. This report was reviewed at the meeting of the Project Central Coordinating Committee on 15 February 1990 and a committee was constituted under the chairmanship of the State Secretary for Irrigation to suggest remedial measures urgently to improve the management of the project. The Draft Final Report was also reviewed at a tripartite meeting (ADB, GOSL and IIMI) held on 20 March 1990. This Final Report incorporates views and comments of the tripartite meeting and others. It also contains further analysis and recommendations for improvements and follow-up studies which are considered necessary.

The Appendix to chapter 1 provides extracts from the Inception Report on the selection of the sub-system and Figures 1.01 to 1.05 (maps and scheme layout) for easy reference regarding field research locations.

IMPLEMENTATION

Field offices: A house was rented at Tissamaharama to serve as field office for research staff and also as residential accommodation for the research officers.

Staffing -- International: The following senior staff of IIMI worked on the study:

Dr R. Sakthivadivel, Engineer/Team Leader
Dr C.R. Panabokke, Agronomist/Senior Associate
Dr D.J. Merrey, Social Scientist
Dr M. Kikuchi, Agricultural Economist

Dr P. S. Rao, Team Leader associated with the project up to 22 August 1989, left IIMI and Dr R. Sakthivadivel succeeded him from that date.

Staffing- National: Research Associate: Mr W. A. A. N. Fernando (Irrigation Engineer), based in Tissamaharama, was in charge of field research operations and coordination and supervision of research activities in both Kirindi Oya and Walawe projects until 15 March 1990. After his tenure with IIMI was over, he went back to his parent Irrigation Department to assume charge as Deputy Director, Moneragala Range.

Research officers: The following research officers worked on the project.

Mr P.G. Somaratne, Sociologist
Mr B.R. Ariyaratne, Agricultural Engineer
Mr A.P. Keerthipala, Agricultural Economist (till 20-12-1989)

COUNTERPART

Mr B.K. Jayasundera, senior irrigation engineer, was nominated by the Irrigation Department as counterpart for the study. After his transfer from the Kirindi Oya project, Mr Sarath Wijesekera, his successor, was the counterpart for the study.

COMMITTEE

The first Study Coordinating Committee meeting was held on 11 May 1988 at the office of the Chief Resident Engineer in Debarawewa to discuss the Inception Report prepared by IIMI. The meeting provided useful suggestions for implementing the research project. The second Study Coordinating Committee (SCC) meeting was on 7 March 1989 at the office of the Chief Resident Engineer in Deberawewa; the second Study Advisory Committee (SAC) meeting was in Colombo on 16 March 1989 at the office of the Director, Irrigation Management Division. Mr T.C. Patterson, Manager, Asia West Division 1 of the Asian Development Bank participated in the SAC meeting and also visited the field research location on 13 March 1989. The Progress Report submitted in October 1988 was discussed in these two meetings and useful comments and suggestions regarding research were made by the members of the Committees.

The third Study Coordinating Committee (SCC) meeting was held on 25 May 1989 at the office of the Chief Resident Engineer in Deberawewa; the Interim Report submitted in April 1989 was discussed in the meeting. Crop diversification issues received particular attention at this meeting.

The Interim Report was presented to the Asian Development Bank at Manila in the third week of June 1989. In response to the suggestion made in this report, Mr Peter Smidt of the Asian Development Bank visited Sri Lanka during the second week of July 1989. During his visit, a number of decisions were taken, the most important one being the constitution of an action committee with all relevant state departments represented, to prepare an implementation plan for other field crops from yala 1990.

The fourth Study Coordinating Committee meeting was held on 25 October 1989 at the office of the Chief Resident Engineer, Tissamaharama, to discuss the Seasonal Summary Report. The third Study Advisory Committee (SAC) meeting was held on 16 November 1989 in Colombo, with the participation of Mr Peter Smidt. The research results of yala 1989 season were presented and the importance of improving the water delivery performance was brought out.

The fifth Study Coordinating Committee meeting was held on 27 March 1990 at the office of the Chief Resident Engineer, Tissamaharama to discuss the Draft Final Report and the draft terms of reference for a phase II research study prepared by IIMI. The fourth Study Advisory Committee (SAC) meeting was held on 20 March 1990 in Colombo, with the participation of Mr Peter Smidt from ADB. The draft terms of reference for phase II research based on the recommendations of the Draft Final Report were discussed in detail and the comments of the Study Advisory Committee were taken into consideration while reformulating the terms of reference.

COLLABORATION WITH THE DEPARTMENT OF AGRICULTURE

The research component on "On-farm Irrigation Management for Upland Crops" was to be conducted in collaboration with the Department of Agriculture. In order to carry out the research, an Agricultural Research Station had been proposed to be established at Weerawila. Because of the disturbed conditions in the study area, only a part of the proposed station with field channels could be established in April 1989. Some field crops had been raised in the research farm during yala 1989 with no systematic monitoring of water measurement. IIMI has been instrumental in establishing this research station, bringing it to the present working condition and preparing an agenda for taking up action and adaptive research. In addition, IIMI was also involved along with other line agencies in preparing the action plan for other field crops in yala 1990 as stipulated in the Memorandum of Understanding of a recent ADB mission. During maha 1989/1990, IIMI staff provided technical assistance and interventions to the operating agencies in developing an action plan for cultivation of non-rice crops in yala 1990 in respect of cropping patterns, cropping calendars, irrigation delivery scheduling and land preparation methods.

PROBLEMS AND ISSUES

It was unfortunate that the period selected for the research was socially and politically so unstable that contemplated research could not be implemented in full. Research staff had to be withdrawn often from the field for security reasons; the IIMI field vehicle allocated to the project was set on fire by an unknown group in July 1989. In spite of all these impediments, field research was carried out for at least three seasons and the credit for this must go to the field research staff.

ACKNOWLEDGEMENTS

In spite of the sensitive security situation and difficult circumstances under which they were functioning, the agency officials, field level staff, and farmers of the project area have offered excellent cooperation and assistance for the conduct of the field research which is gratefully acknowledged. Some of our observations have been critical and controversial, but this has not affected the wholehearted cooperation of officials. We are also grateful to the members of the Study Coordinating Committee and Study Advisory Committee for their comments and suggestions on previous reports, and to the Asian Development Bank for its continuing interest and strong support for the study.

Appendix

(Extract from inception report)

Selection of subsystem

The study envisages the selection of one sample subsystem in Kirindi Oya project, for intensive data collection and analysis (the intensive sample), supplemented by extensive and intermittent monitoring at the next higher level subsystem (extensive sample). Each sample subsystem should comprise the total command area of one distributary canal and its field canals and should also include both upland (well drained) and lowland (poorly drained) soils, The subsystem for Kirindi Oya should be selected in the newly developed Phase I area. Based on these considerations the following subsystems have been selected for the study.

The intensive subsystem consists of the Distributary Canal (DC2) of Branch Canal 2 (BC2) on the Right Bank Main Canal (RBMC). It serves a command area of *91* ha in Tract 5. Each fanner has an allotment of 1 ha. There are thus 91 fanners. BC2, from which DC2 takes off, has a command area of 528 ha. The schematic layouts of BC2 and DC2 are shown in Figure 1.03 and 1.04 respectively. The blocking-out plan for DC2 is shown in Figure 1.05. While DC2 will form the intensive sample for the study, BC2 will provide the basis for the extensive sample from the next, higher level subsystem.

b

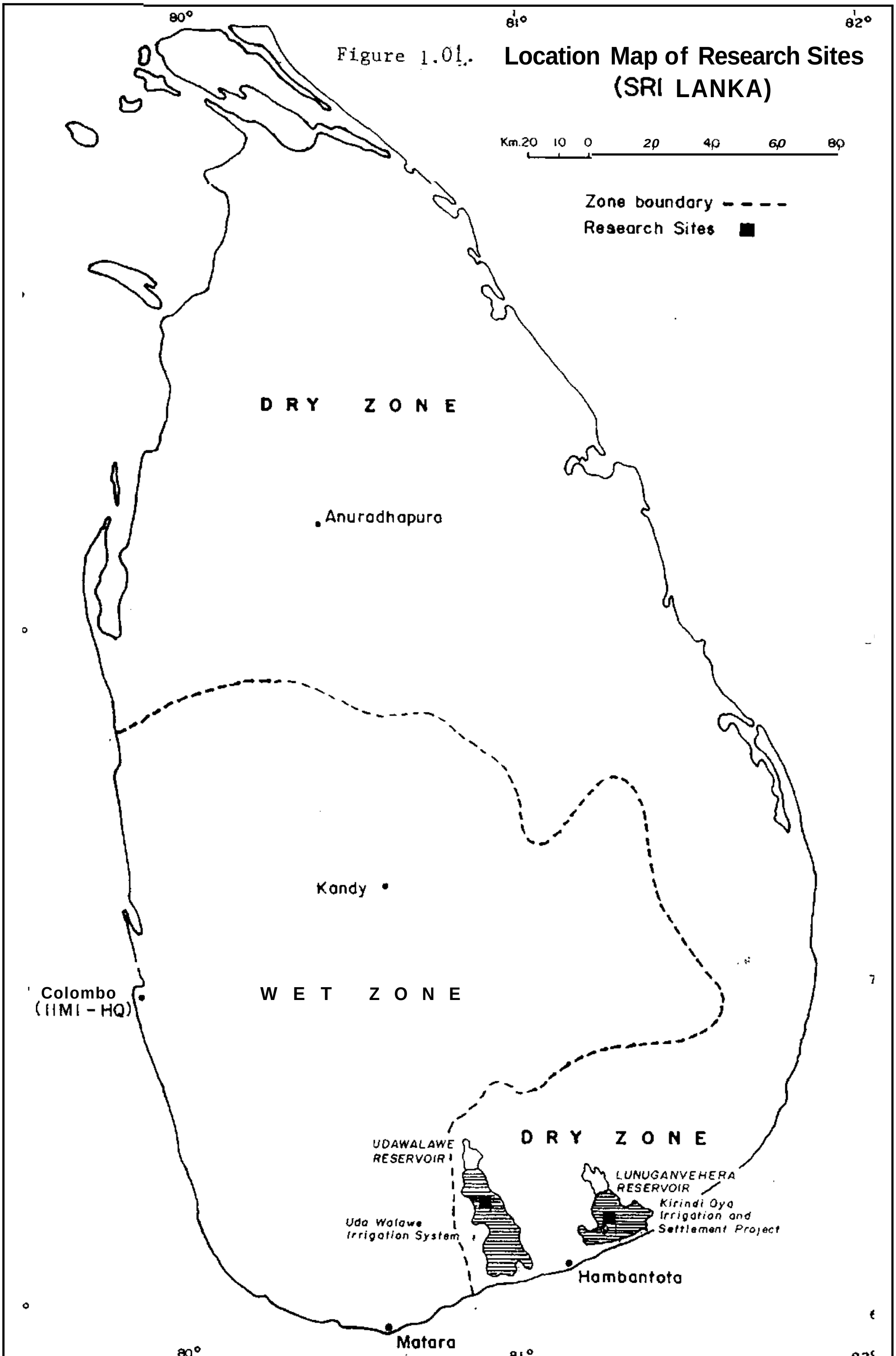


Figure 1.01. Location Map of Research Sites (SRI LANKA)

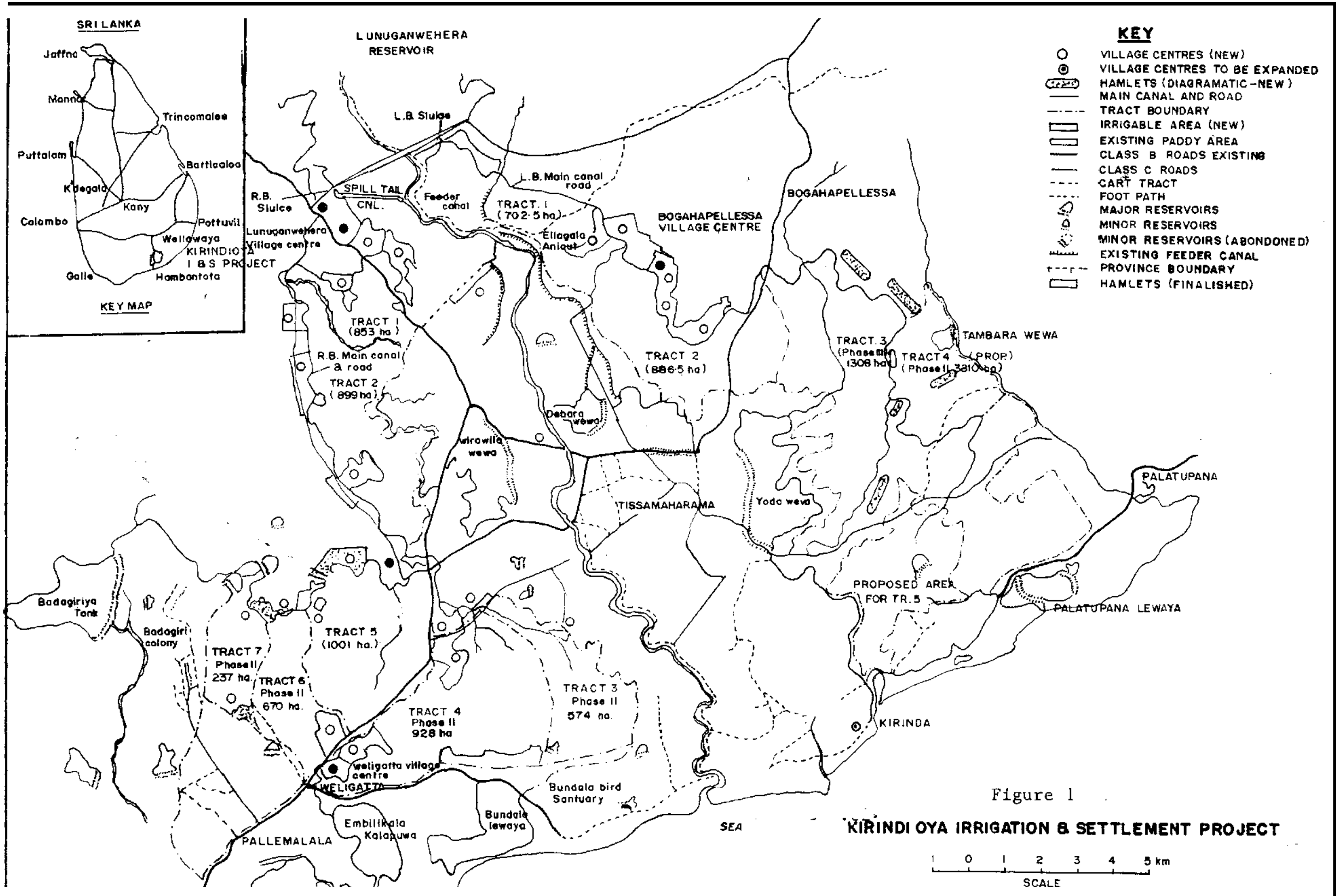


Figure 1

KIRINDI OYA IRRIGATION & SETTLEMENT PROJECT

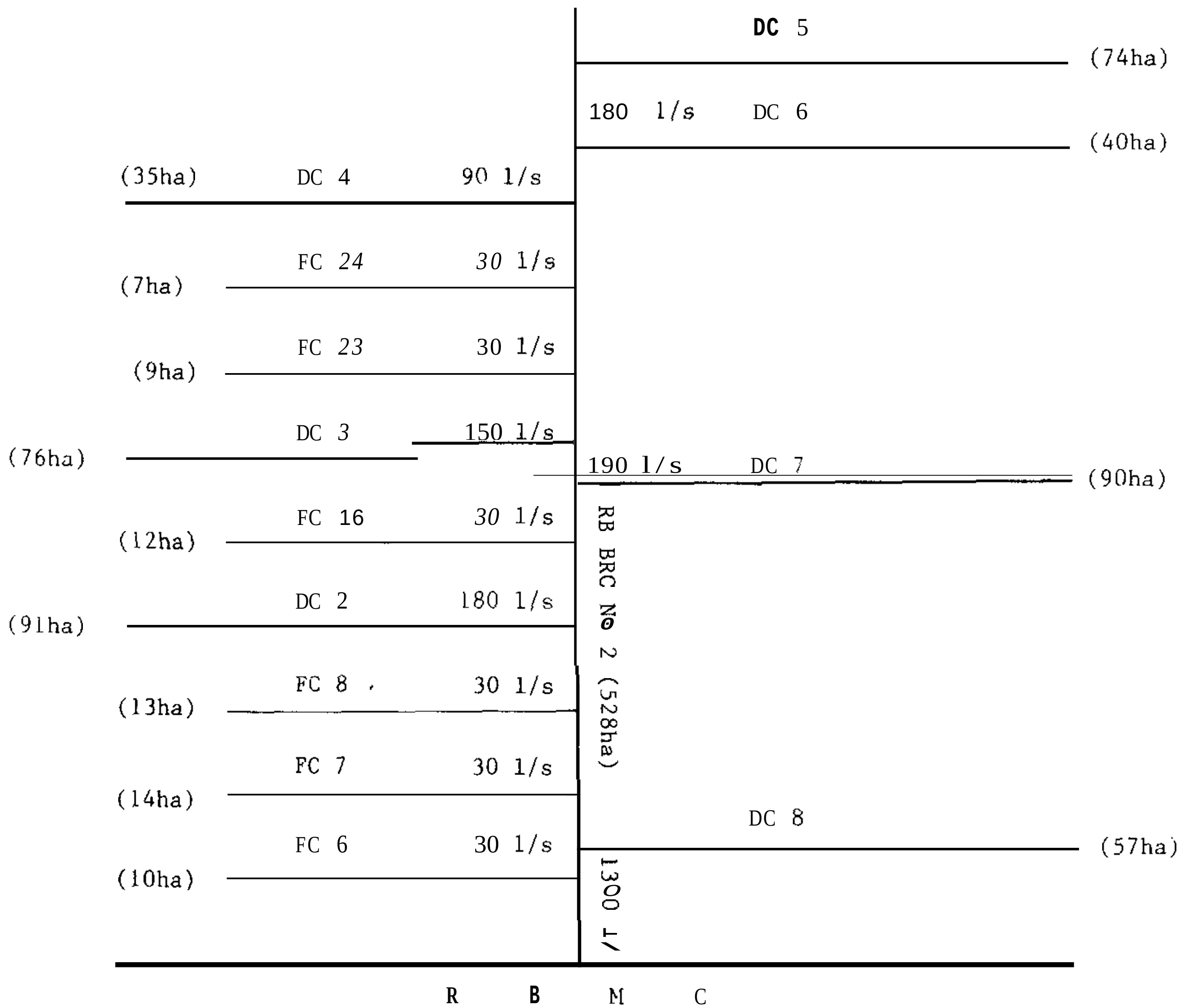


Figure 1.03. **Schematic** Layout of RB Branch Canal No 2, Tract 5, KOISP

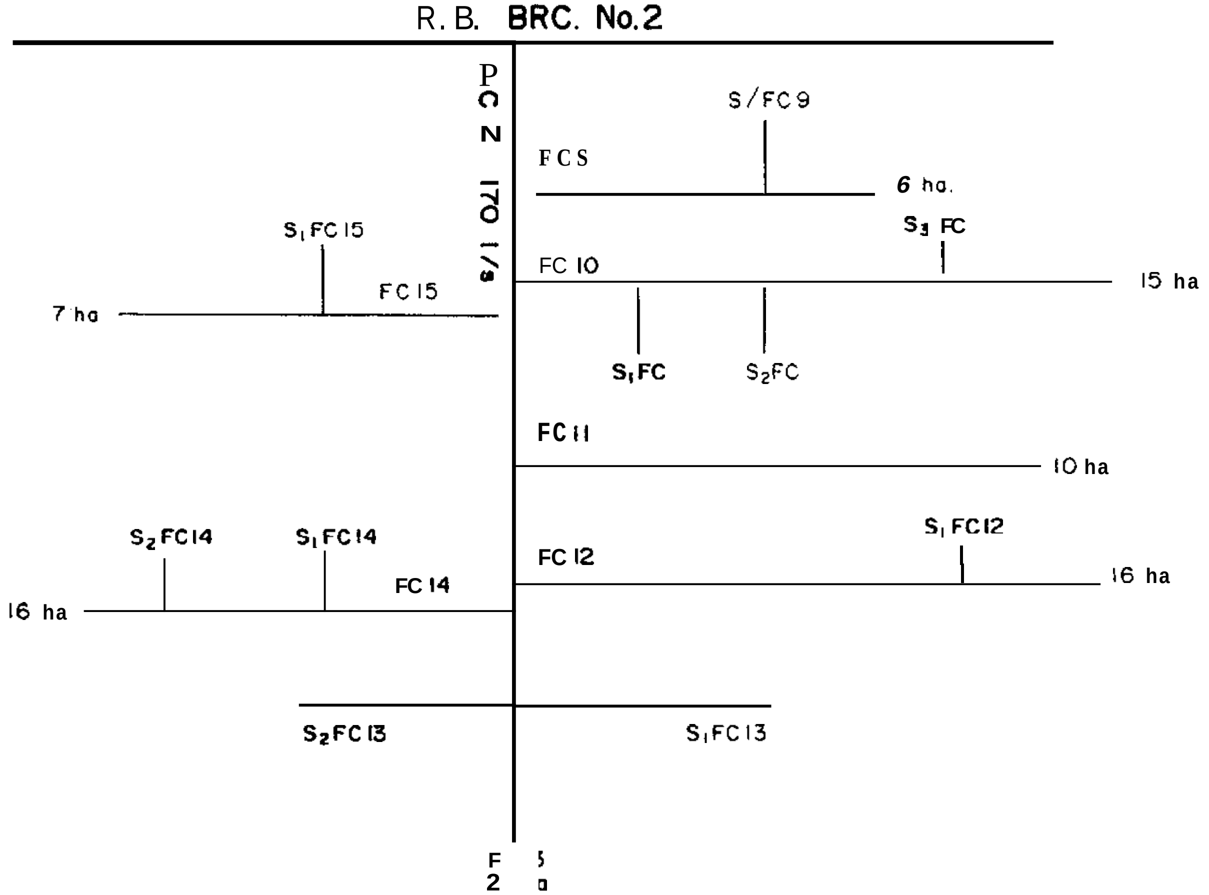
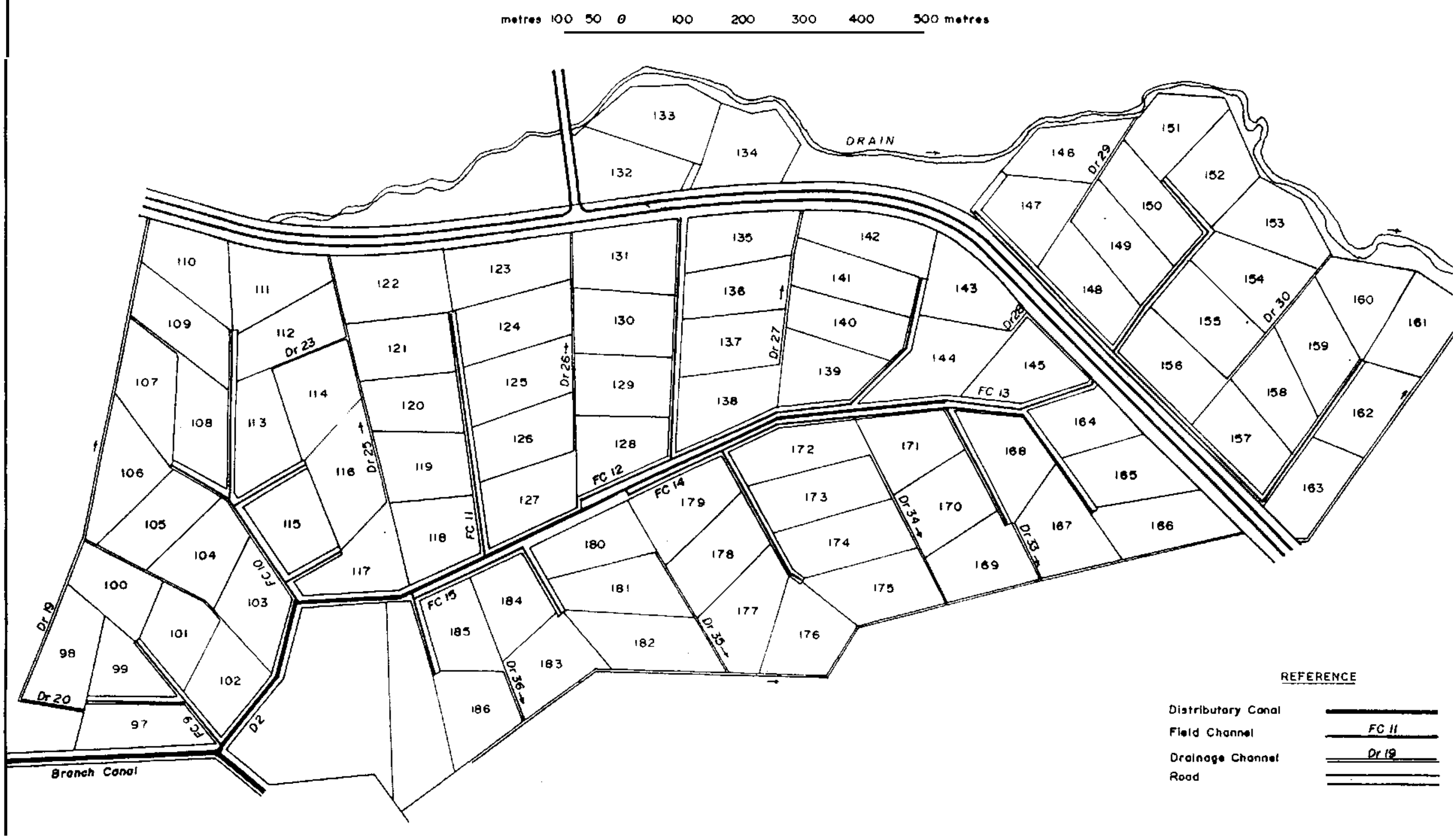


Figure 1.04. Schematic Layout of DC 2, Tract 5 KOISP

Figure 1.05 **Blocking-cut Plan for DC 2 Branch No.2 of Kirindi Oya Right Bonk**



CHAPTER II

PLANNING AND MACRO-LEVEL ISSUES IN KIRINDI OYA PROJECT

AN OVERVIEW OF THE PROJECT

The Kirindi Oya project area is located in the dry zone of the southeast quadrant of the island, about 260 km from the city of Colombo. The service area of the project including the reservoir covers about 21,000 hectares (ha) on the left and right banks of the lower Kirindi Oya basin and a portion of the adjacent drainage areas.

The climate of the project area is tropical and is characterized by nearly constant year round temperatures (26 to 28oC). Evaporation is uniform throughout the year, with an annual average approximating 2100 mm. Mean annual rainfall is 1000 mm in the project area. The **maha** season (October to February) rainfall is approximately three times the yala season (March to August) rainfall.

Soils in the project area consist of well-drained reddish brown soils (RBE) in the upland and intermediate zones, and poorly drained low humic gley soils (LHG) in the lowland areas.

The Kirindi Oya project is being developed with financial assistance from Asian Developnent Bank, Kreditanstalt for Weideranfban (KfW), and the International Fund for Agricultural Developnent (IFAD). The project envisages augmentation of irrigation water supplies for the existing irrigation systems (Ellegala and Badagiriya) which cover about 4500 ha, provision of irrigation facilities through right bank and left bank main canals from the newly constructed Lunugamvehera reservoir for an additional area of approximately 8400 ha, and settlement of about 8320 families on the newly irrigated lands (see Figure 1.02). Increasing food production and providing employment through settlement of landless people are important national objectives for such projects.

Under phase I of the project, the reservoir at Lunugamvehera was commissioned in early 1986 and new and improved irrigation facilities were provided for 8775 ha of which 4584 ha were already under cultivation. Phase II construction, with Asian Development Bank financialassistance, commenced in 1987 and is intended to develop an additional 4100 ha of new land. The phasing of the project was necessitated by large cost over-runs and time delays, so that the Government had to seek additional assistance from the Asian Developnent Bank.

The project has been in operation for the past four years. During this period, it has met with a number of problem, many of which relate to faulty planning assumptions, and policy and management problems. The most important planning and macro-level issues relating to water distribution in Kirindi Oya are discussed below.

A REVIEW OF WATER RESOURCES AT KIRINDI OYA BASIN

The water resources potential of the Kirindi Oya basin has been a subject of discussion since the project was initiated. Over the years, there have been a number of estimates of water potential of the basin and the area that can be irrigated. This section critically reviews the various estimates of water availability and area of irrigation put forward by different agencies in their reports.

The first Asian Developnent Bank Appraisal Report

The Asian Developnent Bank in its 1977 Appraisal Report (ADB 1977) indicated that the average annual rainfall in the basin varies from 2667 mm in the mountains at the upper end of the Kirindi Oya watershed to 865 mm at the river mouth. The catchment area of the river at the dam site, 24 km from the mouth, is 914 sq.km. The estimated run-off coefficient varies from 0.10 to 0.45, as the average rainfall varies from 1270 mm to 2540 mm and the average annual reservoir inflow will be 393 mcm. Similarly, the inflow of the wewas (Tissa, Yoda, Debara, Weerawila and Pannegamuwa) will be 102 mcm and the average annual yield of the reservoir is 375 mcm. The cropping pattern suggested is 7428 ha of rice during the maha and the yala in lowland areas, and 5506 ha of upland crops (pulses, cotton, cereals) during the wet and dry seasons. The irrigation requirement of rice at the reservoir sluice level is asswned to be 1289 mm for the yala and 1244 mm for the maha; totalling 2533 mm. Similarly, the irrigation requirements during the yala and the maha for other field crops are asswned to be 1137 mm and 432 mm, respectively. The river discharge required to satisfy the above requirement is 382.74 mcm.

The Second Asian Developnent Bank Appraisal Report

In its 1982 Appraisal Report (ADB 1982), the Asian Development Bank divided the project into two phases. Under phase I, new and improved irrigation facilities were planned for an area of 8775 ha including 4584 ha of land presently irrigated under the old Ellegala and Badagiriya system. Under phase II, 4191 ha will be brought under irrigation, of which 2560 ha is upland, 670 ha is land with intermediate soils, and 961 ha is lowland. In the existing old systems, rice will be raised during both the maha and the yala seasons. The cropping pattern suggested for the new area is 71 percent lowland rice and 29 percent upland rice for the maha and 63 percent lowland rice and 37 percent subsidiary food crops during the yala season. A field efficiency of 90 percent and conveyance efficiency of 80 percent are assumed for rice crops and a field efficiency of 50 percent was assumed for other field crops. The total water release required from the reservoir for the above cropping pattern is 294 mcm.

In its 1986 Appraisal Report (ADB 1986), the Asian Development Bank had indicated that the precise impact of tank construction in the catchment area on the basin's water yield has not yet been quantified, but it has definitely affected the project's water resources. Based on a study of 20 years' inflow data for the reservoir, the average annual inflow is worked out as 319 mcm, with an average maha inflow of 205 mcm and an average yala inflow of 114 mcm. The combined average annual inflow into the old tanks has been estimated at about 102 mcm. The inflow in the Badagiriya Tank is the most significant: 51 mcm in the wet season and 31 mcm in the dry season.

The diversion requirement at the reservoir sluice level is assumed to be: for maha rice 1395 to 1888 mm; for yala rice 2001 to 2319 mm; for upland rice 776 mm and for subsidiary food crops 1121 to 1352 mm.

To assess the adequacy of the water resources, a reservoir operation study was carried out with the reservoir inflows corrected for the irrigation development in the catchment area. Furthermore, return flows from low lands in tracts 1, 2 and 3 on the left bank and tracts 1 and 2 on the right bank were taken into account. The reservoir operation study results show that the storage is insufficient to irrigate the total project area year-round under the envisaged cropping pattern. It is adequate, however, for a 100 percent cropping intensity for the maha season and about 70 percent on an average for the yala season. The average annual project diversion works out to 297 mcm.

Water Management Strategy Report

The Water Management Consultants (Water Management Consultants 1987) have introduced the concept of irrigation-secured rainfed fanning for intermediate and upland soils. The cropping pattern suggested by the consultants has been to a large degree taken from the one frequently encountered in the project area, namely rice fields in the lowest area and rainfed fruit trees on the higher ridges between the lowlands. Rainfed upland crops and watered vegetables are grown, either inter-cropped with fruit trees or as a uniform field crop mix. On the intermediate lands, farmers grow rainfed commercial crops; rather intensive in maha and less in the yala season.

The Kirindi Oya irrigation system is to be operated mainly for cultivating rice. Other cropping patterns differing in the mix of crops and crop calendars have been studied in view of the anticipated water shortages imposing either:

- restriction of the irrigated area; this measure would safeguard the planned yield per hectare on a reduced area.

- reduced water issues leading to a decrease of the specific yield.

To minimize yield decrease, decisions must be made on balanced water allocations during the time of water shortage in order to obtain the best possible results, which in most cases will lead to a combination of the above measures.

On the strength of these considerations and with the objective not to influence adversely the operation of the Ellegala system (whose present irrigation intensity is an average 167 percent), six irrigation regimes have been defined for various degrees of water scarcity in the Lunugamvehera reservoir for the following condition: the irrigated area and the irrigation intensity in the Ellegala system will remain the *same* under any of the six irrigation regimes. Each regime is characterized by the hectarage to be irrigated and by the irrigation intensity. The hectarage of the new area is to be kept constant under the 1st, 2nd and 3rd irrigation regimes. Only the water issues will be gradually decreased. Under the crisis regimes (4th and 5th) the hectarage of the new area is gradually reduced and the irrigation issues remain the same as for the third irrigation regime.

The consultants have worked out the water requirement from the reservoir for six regimes as given below:

Gross requirement mcm	Area cultivated %	Intensity of irrigation %
295	100	100
270	100	82
241	100	62
185	77	62
126	35	62
95	0	0

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Recently the Hydrology Division of the Irrigation Department reexamined the rainfall, stream flow and other hydrometeorological data available at the

Based on the analysis of long term (since **1935)** point rainfall at Tanamalwila, Sudupanwela and Ella, the long term annual average rainfall of the basin is estimated as **1596 mm.** The maximum average rainfall of **2229 mm** recorded occurred in **1944** and the minimum rainfall of **1070 mm** in **1970.** The temporal distribution of rainfall (Figure **2.1)** shows a downward trend of the basin rainfall and this decline was estimated as **4.5 mm** per year. It is not clear whether this is an indication of a long term trend or is due to changes in land use patterncoupled with deforestation. As a result of this downward trend, the run-off series could get affected.

A hydrometric station had been in operation at Ellegala from **1944** to **1952** and subsequently the site was shifted to Lunugamvehera dam site, which is about **15 km** upstream of the original site. This was maintained until **1979.** when the estimated annual basin rainfall was correlated with the annual stream flow, it was found that there was no acceptable correlation between these two events (correlation coefficient 0.60), indicating the presence of outliers or other erroneous observations or both, in the series.

In order to obtain a fresh stream flow series for comparison with the available original series, comparison of observed stream flow data at the new hydrometric station at Tanamalwila during 1986/1987 and 1987/1988 water years with the original historical series was attempted. The new hydrometric station is well equipped with modern instruments and intercepts **735 sq.km (78** percent) of Kirindi Oya catchment. The rating curve recently developed for this site is sufficientlyaccurate. The following is the summary of observations during these two years.

Water year rainfall	Basin average Tanamalwila (mm)	Run-off at at Tanamalwila. (mm)	Run-off/Rainfall %
1986/1987	**952**	**50 (37 mcm)**	**5**
1987/1988	1624	**446 (328 mcm)**	**27.5**

It was found from the original records that water years 1944/1945, 1970/1971 and 1973/1974 had similar rainfall distribution to the 1987/1988 water year. Moreover, the 1987/1988 water year rainfall was **1624 mm,** very close to the average. By comparing with the measured run-off in the 1987/1988 water year after making necessary corrections to the annual rainfall, it was found that the estimated run-off in the original data series was **40** to **60** percent higher. Results of this comparison are given in Table **2.01.** In this case, the incremental inflow from **169 sq.km** from the Tanamalwila gauging site to Lunugamvehera reservoir is computed on the basis of **120,000 m per square km.** On this basis the total run-off works out to **347 mcm.** This figure compares favorably with the inflow into the Lunugamvehera reservoir of **333 mcm** computed from Kittulkote hydrometric station (WaterManagement Consultants, May **1989: 10).** On the other hand, if one uses the area ratio for computation of increased run-off due to additional area of catchment contributing to it, then the total run-off works out to **387.5 mcm.** Using both the methods, the percent decrease in discharge has been worked out as shown in the Table **2.01.**

Table 2.01. A comparison of recent discharge measurements with original series

Year	Rain fall mm	Discharge mcm	Corrected discharge mcm	Excess as computed by Hydrology Division %	Excess as computed on area ratio %
44/45	1627	494	493	42	27.2
70/71	1696	548	523	50	35
73/74	1640	563	555	59	43.2
87/88	1624	347	347 (387.5)*	--	--

*387.5 mcm is the total run-off when area-ratio is used for computation.

The above comparison brings out the fact that the estimated inflow into the reservoir is less (on a conservative side) than previously assumed by anywhere between 30 to 40 percent. Additional data are needed both for rainfall and reservoir inflow to substantiate the above findings. It is suggested that a few more recording rain gauges be installed in the Kirindi Oya watershed and systematic data collection with respect to rainfall, run-off, and water use be initiated. The Hydrology Division has not used the above reduced inflow in their furth er computations. On the other hand, they have modified the observed historic series by omitting some years of discharge which they consider as outliers. Accordingly, they have come up with an estimate of dependable yield based on a modified annual inflow series which is nearer to normal distribution than the original inflow series as:

50 percent dependable flow	346 mcm
75 percent dependable flow	240 mcm

The above figures suggest that even when the rainfed cropping pattern suggested by the consultants is adopted, the intensity of irrigation with the 75 percent dependable supply arrived at by the Hydrology Division (240 mcm) will be sufficient to irrigate only 62 percent of the design area during the yala season. Gnce in four years, it will be less than 62 percent. During the last three years, both the old and the new areas in the Kirindi Oya project were raising rice during both the maha and yala seasons and were using an ex-sluice discharge of roughly 2.44 m/ha (8 acre ft/acre) during each season. The present use of water for rice cultivation is high compared to what has been assumed in the Appraisal Reports as well as by the water management consultant for maha seasons. In fact, the present use of water per ha is roughly 50 percent more than the requirement assumed by the Asian Development Bank and the consultants. Though the planning assumptions regarding water requirements for rice are not too far off from reality, the main divergency between the Phase II planning assumptions and the realityto day is, apart from the low reservoir inflows, the present rice monocropping system and the increased water allocation to the Ellegala system.

A number of issues arise out of the above discussions.

1. Do we have at the present state of developnent of the project, adequate information to estimate the reservoir inflow fairlyreliably? If not, what measures have been taken or are to be taken to get these data?

2. The present estimation of reservoir inflow seems to be on the high side by 30 to 40 percent. Also, upstream development in the catchment area seems to reduce the reservoir inflow. what will be the effect of this reduced flow on the proposed irrigated area in the project in the next 5 to 10 years?

3. The research conducted so far indicates that many assumptions made in the project proposal such as percolation losses, conveyance efficiency, land soaking and land preparation water use, land preparation period, and cropping pattern do not match with actual observations. The present water use is very much higher than what was assumed in the project design. Under these conditions, would it be possible to realize the project objectives contemplated in the original project proposal, or does this need a course correction at this stage?

AN ANALYSIS OF CROPPING PATTERN EVOLUTION

The relatively prosperous old Ellegala system (3734 ha) receiving its water supplies through interconnected tank systems diverted from the Ellegala diversion structure of the Kirindi Oya river existed before the construction of the Lunugamvehera reservoir. The farmers of the system grew their own local rice varieties which required about 5 to 6 months during the main maha season. The yala season which was called the "opportunity season" was used for raising short duration varieties of rice (5 month duration) when water supply was abundant, or for yala rainfed crops (mung and cucurbits) that could also use the soil moisture retained from the previous maha season. Between 1920 and 1950, the cropping intensity for irrigated rice was around 90 to 100 percent for the maha and 20 to 30 percent for the yala season. Average yields of rice during this period were on the order of 1.8 to 2.2 t/ha, i.e., about half the present yield levels (ADB 1982). It was only after the introduction of the new high yielding varieties (3.5 to 4.5 month duration) during the 1950s that intensive irrigation started in this area.

During the maha, the cropping intensity approached 100 percent in the Ellegala system while in the Badagiriya system (850 ha), another old irrigation system in the project area, the cropping intensity was 67 percent, giving an overall cropping intensity of 94 percent for the maha. In the yala season, because of water shortages, only 50 percent of the Ellegala area and 16 percent of the Badagiriya tank area were cropped with rice, while of the remaining area, about 2 percent was planted with pulses. The overall cropping intensity in the yala season is estimated at 45 percent, giving a total intensity of 139 percent for the entire existing rice areas. Of the cultivable upland area of 4,927 ha, only 1145 ha (23 percent) was planted with various crops like maize, sorghum and pulses. Of the planted area (1145 ha), 945 ha were cultivated with shifting cultivation and the remaining 200 ha was cropped regularly once a year. The yields of the subsidiary crops were low due to non-availability of irrigation water. The total cropped area before the construction of the Kirindi Oya project was **8,038** ha (out of the **9452** ha of the cultivable area) giving an overall cropping intensity of 85 percent.

In the first Appraisal Report **(ADB 1977),** the Bank suggested that under the proposed project, a total of **12,934** ha be brought under irrigated agriculture. This includes the existing old area of 4525 ha. The lowland areas would be planted with rice in both the wet and dry seasons. Subsidiary crops such as pulses and cereals would be grown in upland areas in the wet season, while cotton and pulses would be grown in the dry season. The Report estimated a cropping intensity of **189** percent for this cropping pattern based on water availability. A point to be noted is that during both the wet and dry seasons, rice would be grown in the lowland areas.

Subsequently, in its second Appraisal Report (ADB **1982),** the Bank indicated that double cropping of rice in the maha and yala seasons in the lowlands as originally envisaged was reconfirmed to be appropriate for the climatic, topographic and soil conditions of the project area. However, the crops that were envisaged for cultivation in the upland soils were examined in detail with respect to the crop preferences of settler farmers, the experience in the neighboring Walawe Project, the economic returns for the crops, and the crop water requirements in relation to soil characteristics. Rice being the main staple crop in Sri Lanka, it was thought that any cropping pattern proposal which did not include rice would be unacceptable to the farmers and therefore, the Bank introduced upland rice cultivation as part of its revised cropping pattern (ADB **1982).** It should be mentioned that growing upland rice is new to southern Sri Lanka. Neither the farmers nor the officials have much experience in growing upland rice.

The Bank also argued that cotton, in the absence of suitable varieties, organized pests management and adequate price incentives, would not be a suitable crop for the project. The marketing and pricing systems would also need to be improved. Under these conditions, it was considered desirable to omit cotton from the project's cropping pattern. Sugarcane was also considered by the mission as an alternative to cotton. However, in view of the need for a sizeable investment in setting up a sugar factory, this proposal was found to be impractical. Based on the above considerations, the following cropping pattern was suggested:

	Old system	New area		
		Upland	Interm. soils	Lowland
maha	100% rice	upland rice	rice	rice
yala	100% rice	OFC*	OFC	rice

* OFC is non-rice other field crops.

Again in 1986, the Bank revised its cropping pattern as follows (ADB 1986). The revision was with respect to percent of crops grown and not with respect to the crops.

	Old system	New area		
		Upland	Interm. soils	Lowland
maha	100% rice	60% upland rice 20% rice 20% rice	80% rice 20% OFC	100% rice
yala	50% rice 50% OFC	100% OFC	20% rice 80% OFC	50% rice 50% OFC

The water management consultants, based on detailed reservoir simulation and operation studies (Water Management Consultants 1987), state that the cropping pattern suggested by the Asian Development Bank in its 1986 report deals with multiple cropping but is static and not fully adapted to local conditions. Also, this cropping pattern results in a lower irrigation intensity, lower guaranteed rate of irrigation demand satisfaction and lower average yields. Further, presently the farmers irrigate only rice during both the maha and yala seasons. The present practice of cultivating rice during both seasons results in a severe water supply crisis in the yala season. This would require a substantial cut in the area irrigated and a decrease of irrigation intensity. The implementation of this plan would lead to under-developnent of the new area, cause social discrepancies and jeopardize the economic viability of the project. If the aim is to maximize production per unit of land, then the cropping pattern suggested must be dynamic and sufficiently flexible. For maximization of crop production, the cropping pattern must be adapted to the hydrograph of water availability.

Preference should be given to crops with high water utilizationefficiency, high yielding varieties, deep rooted crops, and crops with low sensitivity to water stress especially in the yala season. Based on the above considerations, they have suggested the following cropping pattern:

Old system		New area		
		Lowland	Interm. soils	Upland
maha	100% rice	60% rice 40% OFC	20% rice 80% OFC	20% rice 80% OFC
yala	50% rice 50% OFC	50% rice 50% OFC or 67% rice * 33% OFC	100% OFC	100% OFC

* This depends on water availability.

The water management strategy plan proposed above is a mixture of simultaneous cultivation of rice in lowland areas and subsidiary food crops in the intermediate and upland soils in the new area even during the maha. This cropping pattern appeared to result in the best use of water for the available soils and limited water resources. However, the Irrigation Department raised serious objections to this cropping pattern with regard to scheduling of irrigation water at the field channel level due to mixture of rice and other field crops. The Department also argued that fanners on the upland and intermediate soils may strongly object to this cropping pattern by arguing that while the bulk of water is passing through their fields to supply the lowland rice fields, they are forced to grow only other crops. Farmers on the intermediate and upland soils would like to grow their staple food which is rice at least during one season.

Another scenario suggested by the water management consultants is that all the fanners in the new area will irrigate rice during the maha season and subsidiary food crops in the yala season, irrespective of the soil type of their land. Such a cropping pattern would allow phase I and II areas to be cultivated during the maha one year out of five years, with a reduction in the irrigation intensity had to be reduced. In yala season, phase I and II areas could be fully cultivated in 13 years and partly in 10 years out of 32 years of simulation. In 4 years only part of phase I was irrigable and in 5 years no water remained for the new areas at all. The average annual production area would be 18,740 ha on an annual basis, only 1690 ha less than that suggested for rainfed crops with secured irrigation.

Kirindi Oya presents a special problem not faced in most other Sri Lankan irrigation settlement schemes. It is a severely water short system, which has been justified economically from the beginning on the assumption that farmers would grow a lot of non-rice crops. To date, in spite of the recommendations of the Asian Developnent Bank (ADB 1986) and the Water Management Consultants (May 1989) to grow subsidiary field crops, the Kirindi Oya system continues to be operated as a rice-based system in which only small patches of non-rice crops are grown with special assistance from the Department of Agriculture. One may ask what could be the reasons for such non-compliance. Farmers of the new settlement area argue that rice has a ready market, is less labor intensive, is the staple food in Sri Lanka, can be stored and sold at any time, they know how to cultivate rice, and above all it is risk free compared to other crops. Moreover, they question why they alone should raise other crops even during the maha season, when the old Ellegala system farmers cultivate rice during both the maha and the yala. Thus, we see that there is a continuing "rice bias" or "rice-based thinking" underlying the management of the system. Both farmers and officials share a fundamental and deep rooted bias towards rice. There are strong cultural reasons for this, but this probably has so far prevented farmers and managers from seeing alternatives, such as the one proposed by the water management consultants, as practical, or at least worth a serious test.

Recently a committee consisting of all the line agencies including IIMI was constituted on the recommendation of an Asian Development Bank review mission to prepare an action plan for the introduction of other crops during yala 1990. This committee had decided to grow only two crops, namely greengram and soyabean. The rationale for selecting these two crops is discussed in chapter 6; the planning process is discussed in chapter 7.

The whole exercise of choosing a cropping pattern for the project appears to be based on the availability of water. Annual water availability per hectare is on the order of 2.3 to 2.6 m/ha. Compared to other settlement schemes in Sri Lanka, for example Mahaweli System B with an annual availability of about 3.2 m/ha, this is quite low. Moreover, the present water utilization for rice cultivation in the new area is between 2.0 to 2.6 m/ha which means that with the present water use efficiency, the water in Kirindi Oya project is just sufficient to raise only one rice crop in the whole contemplated project area per year. Under these conditions, the choices left to the planners in increasing the cropping intensity can be listed as follows.

1. One possibility is to go in for rice during the maha and some kind of rotational distribution of water during the yala season in the old Ellegala system and the new area, thereby forcing the farmers to switch over to other field crops or to find additional water through groundwater extraction.

2. The second alternative is to change the cropping pattern between the seasons -- the maha and the yala -- by having rainfed irrigation-secured cropping in the maha. Depending upon the water availability, at the end of maha season, the yala cropping pattern can be decided. In this connection, the following points deserve special consideration. The Kirindi Oya project is a water deficit project, and therefore, the reservoir is likely to be at the minimum drawdown level at the end of the yala season. As such, starting the maha season in time is very much dependent on the inflow into the reservoir. Because of the insufficient reservoir storage, many decisions taken in the cultivation (kanna) meetings are not implementable. During the maha, 75 percent of the annual rainfall occurs in this project area. The effective use of this rainfall is constrained by the water release from the reservoir. If one can go in for rainfed cropping during the maha with supplemental irrigation, then the reservoir water can be saved and effectively used during the yala season. By this change, the uncertainty involved in estimating the reservoir inflow can be minimized to a considerable extent, rainfall can be effectively utilized during the maha, and the planning for the yala can be on a firmer footing since the water availability at the end of **maha** is known.

3. The third alternative is to go in for rotational irrigation in the new area to cultivate non-rice crops during both yala and maha, irrespective of the soils, and in the old system one rice crop in maha and other crops in yala.

The success of the Kirindi Oya project depends to a considerable extent on switching from rice to non-rice crops throughout the project including the old Ellegala system. This can be achieved at least theoretically through rotational water scheduling. Then, is it practicable and politically feasible? This needs a long range innovative strategic plan with committed officials backed by the Government to implement it. One feasible solution that appears attractive is to set up process industries for those crops to be grown in the project area, develop a sustainable market to make growing other crops attractive, and at the same time make water an expensive rather than free input.

MACRO-PLANNING ISSUES

Planning of Water Issues from the Reservoir

The present practice of deciding the area to be irrigated during a season is based on the following procedure. The storage position of the reservoir at the beginning of the season is looked into. The expected inflow into the reservoir at a certain level of probability is estimated using the inflow-duration curve prepared on the basis of past historical records. The reservoir storage in conjunction with the estimated inflow forms the basis to estimate the area that .can be irrigated for the assumed cropping pattern. Generally, the irrigation officials are cautious and conservative in deciding the area to be permitted for irrigation during the season since *any* extra area thrown open for irrigation at the beginning of the season will become their responsibility for supplying water throughout the season. Therefore, they try to convince the fanners and officials during the pre-kanna (pre-season)and kanna meetings the minimum possible area that can be taken up for irrigation at the beginning of the season. Subsequently, the storage position in the reservoir is reviewed periodically and depending on the strength of storage position, additional area is declared for starting the irrigation in that season.

This sequential decision-making procedure has certain advantages in that the possibility of a crop failure in a tract or region due to lack of water is minimized. On the other hand, a sequential decision-making strategy has a number of disadvantages. Because of the uncertainty and communication problems between the farmers and the agency, the farmers are not ready to receive the water and use it immediately when the water is released. Even if the farmers are ready to use the water, lack of an adequate number of tractors for land preparation appears to be a major reason for a prolonged land preparation period, On an average, a farmer has to wait seven to ten days before he can get hold of a tractor. Puddling and land opening (three runs) cost anywhere between 3000 to 3500 rupees (US 5 83 to 5 97 at the 1989 exchange rate of Rs 36 = $ 1.00). In view of the limited credit facilities, it becomes difficult for many fanners to generate this capital to pay in cash to tractor owners for using their tractors. All these constraints prolong the cultivation season and sometimes it encroaches into the next season.

The prolonged season has many disadvantages of which the most important ones are: insufficient time for pre-seasonal maintenance, and interference with water distribution operation of the system for the subsequent season, as has been witnessed during yala 1989. This overlapping of two seasons throws out of gear all operational plans for water distribution in the subsequent season. It also spreads pests and diseases from one season to the other and does not allow effective use of maha rains and drainage water from the upper tracts.

The above discussion raises the important question as to whether the present practice of decision-ding in a sequential way and increasing the irrigated area in installments during the season is the best way of managing the system. Or should decisions be made at the beginning of the season and unless there is a huge shortfall, should that decision be maintained without adding any additional area during the season? The farmers in this case know at the beginning of the season what to expect for the season. Any additional water received during the season should be ear-marked for the subsequent season. In other words, a well- defined policy of water release has to be formulated with regard to allocation between the seasons, the time of release, and the pattern of rotation between the tracts in the case of shortfall. This should be done in consultation with the farmers and must be given wide publicity among the farming community.

Water Allocation Among Old and New Irrigation Systems

Many settlement projects in Sri Lanka with old and new areas have had problems of water sharing among themselves. The old settlers who gain considerable benefits after construction of the project by way of stabilized irrigated agriculture due to a more reliable water supply and increased intensity of irrigation look upon the new settlers as intruders in their domain of influence. The farmers in the old area generally use more than their allotted share of water, complicating anddistorting the allocation of water to different areas.

This can be illustrated with data from the Kirindi Oya project, where the Ellegala old system used to irrigate approximately 130 percent of its service area before the construction of Lunugamvehera reservoir. In the project proposal, an irrigation intensity of 160 percent with some non-rice crops for the old system was assumed (without,unfortunately, consulting the farmers); but the farmers in the old system now irrigate two rice crops (nearly 200 percent intensity), thereby depriving the newly developed areas of their share of water. The concept of riparian right is clearly prevalent in the farmers' minds. In addition, the water supply pattern to this area does not follow any well defined policy. To prove this point, let us look at the source of water supply to the old system and the water utilization pattern during the three seasons of operation as given in Table 2.02.

Table 2.02. Actual sluice water duty in three seasons - Kirindi Oya Project

Season	Area	Ext. of cultivation area (ha)	Requirement as estimat. mcm	Release from reservoir mcm	Rainfall mm	Duty m/ha
Maha 1987/88	Ellegala	3530	40.2	49.4	413	1.40[c]
	RB[a]	2743	31.7	55.7	413	2.03
	LB[b]	1594	20.2	31.3	413	1.95
Maha 1988/89	Ellegala	3710	41.7	16.3	-	0.44[c]
	RE3	2532	33.8	64.3	-	2.54
	LB	1660	21.3	45.7	-	2.75
Yala 1989	Ellegala	3778	42.5	34.2	-	0.91[d]
	RB	1912	23.8	51.8	-	2.71
	LB	-	-	-	-	

a. RB is right bank b. LB is left bank
c. Ellegala system in addition gets run-off water from wewa catchments.

The old Ellegala system receives its water supplies from four sources: 1) water released from Lunugamvehera reservoir; 2) run-off from its own catchments; 3) substantial drainage water from right bank tract 1 and left bank tracts 1 and 2 of the new areas; and 4) rainfall. Presently, the contribution from rainfall and releases from the Lunugamvehera reservoirs are quantifiable while the contributions from the other two components are not quantified clearly. Unless we know these contributions fairly accurately, the release from the Lunugamvehera reservoir to the old system cannot be made more precise. Also as Table 2.02 indicates, in those years when rainfall is above normal as in the case of maha 1988/1989 and the storage position is comfortable, the withdrawal to the old Ellegala system is minimal (0.44 m/ha). On the other hand, in years of low rainfall and insufficient storage position as in maha 1987/1988, the water use in the old system is considerably higher (1.40 m/ha). This is understandable because during heavy rainfall years, the supply from the tank catchments is considerably more and there is less requirement because of the copious supply from the tanks, rainfall and drainage contributions. On the other hand, during dry years, much of the water from the Lunugamvehera reservoir is divertedto the old system allowing very little water to be used for the new settlement areas. This undefined and unplanned allocation of water between the old and new systems creates a lot of problem from the point of water planning and scheduling from season to season.

Therefore, there is a clear need to initiate a detailed water balance study of the old Ellegala system by monitoring the inflows into the tanks and measuring the drainage water emanating from left bank and right bank tracts 1 and 2 of the new settlement area. The allocation of water to these areas has to be fixed considering available water in the reservoir, their requirement, and additional water that can be obtained from other sources such as rainfall and drainage. Such an allocation policy would allow the Irrigation Department to develop scheduling which can be implemented with farmers' assistance and cooperation. The two water sources which are to be effectively used for the success of the Kirindi Oya project are rainfall and drainage water. The scheduling for the old system must give utmost importance to these two components with particular reference to the time of starting cultivation to capture the maximum of drainage water from the upper tracts.

System Parameters for Operational Efficiency

For preparing the irrigation schedules for maha 1987/1988, maha 1988/1989 and yala 1989, the system parameters used are given in Table 2.03.

Based on the assumed parameters, the estimated water requirement and computed duty are given in Table 2.02. Table 2.02 also gives releases from the reservoir and the corresponding duty. One can see from the table that there is a large difference between the estimated and actual duty indicating that there are certain discrepancies either in the assumed parameters of the system or deficiencies in the management and water use of the system. The difference is as much as 100 percent, indicating that by improved management one can reduce the wastage of water as well as the values of some of the loss parameters. Again Table 1 indicates that the total efficiency of the project during maha 1987/1988 was better than that during maha 1988/1989. This appears to be related

Table **2.03.** Parameters used for system irrigation scheduling

Parameter	Old area	New area	Measured values in RB Tract 5, BC2 **
Application Efficiency	80%	70%	
Conveyance Efficiency			
FC	---	93%	
DC	---	93%	71%
P i ,	---	93%	
MC	---	93% (85%)*	
Distribution Efficiency			
Area < 150 ha	80%		
Area > 150 ha	70%		
Percolation loss	3 mm/day	6 mm/day(upland) 3 mm/day(lowland)	10.8mm/day 3.9mm/day

I 85 percent used for right bank tract 5 only
** Measures by IIMI

Source: Water Management Consultants (1987 and 1989).

to the availability of water; the smaller the reservoir storage the better is the use of water resources. Table 2.03 indicates that there exist large differences between the assumed and measured parameters, especially in canal conveyance efficiencies, seepage and percolation (S&P) values, and water used for land preparation.

The values of these parameters are also related to the level of management input and water control adopted in the field. Some of these differences can be minimized by proper management input to the system. For example, consider water conveyance efficiencies: it could be that the channels are not maintained properly; because of the silt and weeds, the conveyance losses are high. By proper maintenance, the losses can be reduced considerably.

The above discussion leads us to conclude that by proper management input and water control, the operational efficiency of the system can be increased considerably. For this a close monitoring of the water distribution system at different subsystem levels is required with proper water measurement. The monitoring of the system would also indicate which one of the parameters is far in excess of the design values and at what places. The reasons for such discrepancies can be investigated and rectified. Presently there is a monitoring cell under the senior irrigation engineer which is not very effective. It is suggested that the monitoring cell should concentrate on getting more reliable data, quick analysis of the data and feedback to the operational division to make use of the information for effective management.

INSTITUTIONS AND MANAGEMENT ISSUES

The Irrigation Department and Irrigation Management Division are the two institutions directly responsible for the operation andmaintenance (O&M) of the system. The Irrigation Department is responsible for system O&M to the field channel level. The water-related activities are directly under the charge of a chief resident engineer. A senior irrigation engineer for water management working under the chief resident engineer is responsible for the operation and maintenance of the new areas of the project including allocations between the new and old areas.

Below the field channels, farmers' groups organized by the Irrigation Management Division are supposed to be responsible for O&M. There are two project managers from the Division, one each for the old and new areas. They are responsible for integrating and coordinating various departmental inputs into the agricultural production process, and for organizing farmers into groups and committees at field channel, distributary and project levels to obtain their cooperation.

Presently, the old system and the new settlement areas act as two independent units and there is not much coordination among either the irrigation officials or the farmers of the two areas. They hold separate kanna meetings and make decisions with regard to starting and closing dates of water releases. It is difficult for the irrigation managers to make a unified decision with regard to water sharing, water scheduling and distribution under the existing division of old and new settlement areas. It is suggested by the officials of the Irrigation Department that the old and new settlement areas can be integrated by dividing the total project area into two divisions under the right bank and left bank canal systems. Each of these two divisions will be manned by a project manager who has the task of integrating both the old and new settlement farmers. Also they feel that the water allocation can be rationalized under this division and the cropping calendar can be selected in one kanna meeting to be held for the whole project to maximize the use of rainfall and drainage water from the upper tracts. Conceptually, the above idea appears attractive and technically sound. However, the farmers in the old Ellegala system are socio-politically much stronger and may not easily agree to this idea. Integrating the farming communities living in the old and the new systems is essential for equitable use of reservoir water. How this can be achieved is a subject for further discussion.

In addition to these two agencies, other departments provide supporting services such as agricultural extension and inputs, land administration, banks and crop insurance, and marketing. The present project management structure is not very conducive for achieving long term goals of the project through effective management. Presently, each department has a set of objectives and specified tasks to perform. For example, the Irrigation Department's job is to deliver water, within the constraints imposed by water availability, finances, the physical condition of the system, etc. It responds to farmers' demands to the extent possible, but since both farmers and the Department are accustomed to irrigate rice crops, that is what they do. Other agencies have their own specified technical functions. But no agency is responsible for achieving the long term objectives of the project. There is therefore a de facto policy of catering to short-term objectives i.e., providing water for rice in a few tracts, on an ad hoc tract-wise rotating basis, depending on the water in the reservoir at any given time, but with old areas always getting sufficient water for growing rice two seasons per year. This satisfies some farmers' short term interests, as they wish to grow rice, and it is easy for the agencies to support their decisions without much exertion since all the line agencies know how to support rice production. New area farmers have not yet organized against the old area fanners, but the latter are organized to demand priority. Further, the various farmers' objectives may be quite at variance with the objectives of the management agencies.

The result is that the system management is unable to get the system as a whole onto a seasonal rotation, i.e., maha-yala-maha. Because rice is raised during both maha and yala, the reservoir gets depleted at the end of the season. For the next season, one has to wait to receive the water in the reservoir and then start with rice in the old area and subsequently add one or two tracts from the new area for rice cultivation. The precedence of short tern objectives reduces the likelihood of achieving long tern objectives as the fanners get used to a certain pattern.

Since the root of this problem is institutional and managerial, the solution would appear also to lie in this realm. It is necessary to establish an overall project management aimed at achieving the long term objective of making best use of the limited water to maximize farmers' income, with the authorityto insure other departments contribute their efforts to achieving this objective. Performance of the overall management would be assessed based on its achievement of the longer term objectives. Assessment of the performance of other departments would be based on their contributions to achieving the overall project objectives. Institutions to facilitate consultation with, and involvement of, legitimate farmer representatives would be a requirement, as would political support from above.

CROP DIVERSIFICATION ISSUES: EXPERIENCE ON OTHER SYSTEMS

An earlier section of this chapter has dwelt on the analysis of the cropping pattern evaluation in the Kirindi Oya Project as proposed in the successive Appraisal Reports of the Asian Development Bank, as well as the Water Management Consultants' report of 1987. Despite the detailed operational plan outlined in the latter report, the project management has not been able to accomplish any measure of crop diversification in the 1988 and 1989 dry seasons. Several factors have been responsible for the management's inability to pilot test crop diversification even within a single tract with a view to getting an understanding of the operational modes for irrigation management for non-rice crops. This section discusses some of the technical issues, drawing on IIMI's analysis of experience in other systems in Sri Lanka. The economic issues related to cropping patterns are elaborated in chapter 6; the planning experience for yala 1990 is discussed in chapter 7.

It would be unrealistic to have expected any major shift to growing of non-rice crops in any of the past yala seasons without having tested the proposed cropping patterns within a single tract or some selected distributary command areas. Experience in Mahaweli System H over a period of ten years commencing in 1978 shows that a slow start in the first year (70 ha of non-rice crops) was followed by a rapid increase from the third year to 1,100 ha, until it reached a peak of 8,600 ha of non-rice crops in the eighth year. A similar sequential increase over a period of years could be postulated for the Kirindi Oya project, except of course with the added problem of more unstable and lower annual water availability per hectare. This would, of necessity, impose a greater strain on planning and management of water deliveries for non-rice crops in the Kirindi Oya system as compared with the Mahaweli System H, and would eventually result in a different growth pattern over a similar span of years.

Despite the very limited accomplishments recorded over the last two yala seasons in respect of crop diversification, a more significant achievement has been the clear demonstration of the potential for growing of non-rice crops during the wet maha season on the well drained soils in farmers' allotments in this southern dry zone environment which receives a lower maha season rainfall than the North Central Province (NCP). This confirms the validity of the recommendations of cropping patterns made in the above mentioned reports in respect of non-rice crops for the upland or well drained soils under irrigation command during the maha season.

The first meaningful step taken towards promoting the growing of non-rice crops in the yala season has been the preparation of the action plan for growing of non-rice crops in yala 1990 by a working group drawn from the respective line agencies presently working in the project, and chaired by the project manager (settlement) of the Land Commissioner's Department. The first draft of the action plan report was discussed on 7 December 1989 in the office of the chief resident engineer, at which a substantial input was made by IIMI drawing on its experience and understandings gathered since yala 1985 from studies on irrigation management for crop diversification conducted in Mahaweli System H and Dewahuwa systems located in the NCP (Panabokke 1989) (see chapter 7).

Arising from the deliberations at this meeting and based on IIMI's own experience and understandings developed at Kirindi Oya over the last 2.5 years, the more important issues concerning crop diversification in this environment can be considered under the three headings of: 1) cropping patterns; 2) cropping calendar and irrigation scheduling; and 3) organization and farmer participation.

CROPPING PATTERNS

Yala - Dry Season

In view of the very tight water situation that will be faced in almost every yala season in the future, the shortest possible planting-to-harvest duration commensurate with economic yield should be the primary aim in selection of crops. Fanners familiarity with growing of such crops even under rainfed conditions should be a further selection criterion.

In the broad group of grain legumes, the Department of Agriculture has been successful in developing short duration (65-70 day) varieties of greengram. In respect of cowpea, soyabean and blackgram, the well known popular varieties fall within a 90 day duration. Almost all farmers in this region are familiar with the cultivation of greengram, cowpea and blackgram mainly under rainfed conditions in maha, while some are familiar with the cultivation of greengram and cowpea under irrigation in yala. There is substantial research information in respect of the frequency and amounts of irrigation for this group of crops. Irrigation intervals can be extended to once in ten days for these crops without seriously depressing yields especially when irrigation water at source become scarce. Irrigation scheduling and delivery is the same for all these crops, and this should be considered a special advantage in systems management. There will also be a ready market for greengram as indicated by Department of Agriculture, and a potential market for soyabean. Cowpea and blackgram will be largely for consumption with limited amounts entering the market.

On the foregoing considerations, the main thrust for non-rice crops during yala should be grain legumes, particularly greengram and cowpea.

The research station at Weerawila should develop the technology for growing a gingelly (sesame) crop in yala by making use of the late March - early April rains for seeding and subsequently a minimum number of irrigations. Gingelly is normally grown as a rainfed crop in the maha season in this region and its sowing-to-harvest duration is around 70 days. It needs a well drained, well aerated seed bed for proper germination and crop establishment, and it is more fastidious in this regard than the grain legumes. It is reported however, that it could manage with two to three irrigations after initial establishment. Since there is a good market for this crop, and because of its short duration it should receive more research attention for being grown as an irrigated yala crop.

While the foregoing crops are best adapted to well drained and imperfectly drained soil conditions, the issue of what crops can be recommended for the poorly drained LHG soils during yala has to be decisively addressed. This has to be viewed together with the nature of the irrigation delivery schedules that will be operative, and will therefore be disoussed in the subsequent section.

Cultivation of chillie is not recommended for the present because the presently available varieties are of 120-140 days duration. In respect of tree crops such as *mango,* citrus and papaw it will be wise to confine these to well drained or imperfectly drained sites that benefit from seepage from irrigation channels, rather than to **grow** them on land developed for rice cultivation.

Maha - Wet Season

In the light of the last two years experience it is almost self evident that any approach to crop diversification should take into consideration opportunities that are available during the maha season, and that are also linked with the subsequent yala season. There is no rationale for considering crop diversification as a solely yala enterprise as in the case of the NCP, both on account of the less wet maha environment in the south and also the very restricted annual water availability of 2.3 to 2.6 m/ha in Kirindi Oya, compared with 3.2 m/ha for Mahaweli System H.

As mentioned earlier, one of the significant achievements has been the demonstration plots of non-rice crops, especially chillie on parts of farmers' allotments in maha 1988/1989 conducted under the guidance of the Department of Agriculture extension staff. There is clearly a limit to the extent of chillie that could be grown to match with the available market. Furthermore most of the coarse grain and grain legume crops are grown as rainfed crops under upland non-irrigated conditions in the maha season throughout the dry zone. Crops that respond to irrigation application during the maha season will therefore have to be considered. The ideal fit will be crops that complete their vegetative phase by late December, and then have their reproductive phase from January to early March which coincides with a period of maximum solar radiation. The former 5 to 5.5 month cotton variety HC **101** would be an excellent choice in this regard. It should be one of the added tasks of the Weerawila research station to test the appropriate maha season supplemental irrigated crops that give a high return per depth of irrigation application discounting rainfall contribution.

CROPPING *CALENDAR* AND **IRRIGATION SCHEDULING**

Selection of optimum dates for land preparation and for sowing or crop establishment, and appropriate scheduling of deliveries for subsequent crop growth with a view to maximizing the use of rainfall and limited irrigation supplies is of crucial importance for the Kirindi Oya system.

Equally important is the issue of appropriate delivery schedules at the heads of distributary and field channel turnouts that would enable a proper allocation of water to both well drained and poorly drained soils which support different kinds of crops with different water requirements; as for example non-rice crops on the well drained soils and rice on the poorly drained soils. Experience gained in Mahaweli System H and Dewahuwa provides us some important guidelines to resolve this hitherto intractable problem which operating engineering staff usually shy away from.

Yala - Dry Season

The optimum time for commencing land preparation for yala crops is between the fourth week of March and the first week of April when there is a high reliability of the afternoon convectional rains. For this to be possible the preceding maha crop should be harvested by the third week of March. When the onset of land preparation for maha is delayed beyond mid-October, the maha harvest gets extended beyond mid-March of the following year and this causes severe problems for timely commencement of yala crops. The 75 percent rainfall expectancy for April is a little over 55 mm, and this has to be captured for timely land preparation and crop establishment.

The foregoing points to the need for pursuing a policy of growing non-rice crops in maha beginning with the October rains and providing supplementary irrigation for such crops between October and January. Rice should therefore be restricted to the lowland LHG soils and that too only if adequate water supply is available at the source. This could be on the basis of selected tracts or distributary command area within a tract.

A practice that should be fostered at Kirindi Oya for yala as developed by farmers at Dewahuwa is to spread the rice straw on the field soon after the maha harvest in late March and burn it in-situ in the field. This enables a weed-free field which could be prepared with subsequent minimum hoeing into which grain legume seed could be dibbled in rows with the initial yala rains. For fanners who wish to till the land with a rotavator in order to prepare a better seed bed, they could avail of both rain and an irrigation issue of 70 mm for land moistening.

Again, based on our experience at Dewahuwa, irrigation deliveries for yala should commence in the first week of April. Two to three deliveries of 70 mm each at the field channel turnout within a period of 14 days is adequate to prepare the seed bed and drill the grain legume crops before the Sinhala New Year which falls in mid-April. In the case of Dewahuwa, land preparation and seeding for non-rice crops was completed in 8 days using 174 mm of delivery in yala 1985; in 15 days using 121 mm of delivery in yala 1986; and in 12 days using 172 mm of rainfall only and no delivery in yala 1987.

Daily evaporation rates increase markedly from June onwards. In order to conserve and maximize use of the limited water resource at some, crop duration in the field should be terminated as early as possible. Crop growth period commencing early April should therefore be limited as far as possible to around 80 days. Irrigation deliveries at seven day intervals with a 70 mm delivery ex-field channel turnout for each delivery is considered adequate for grain legumes.

Maha - Wet Season

Past studies on rainfall confidence limits have shown that the optimum time for sowing of rainfed upland crops in this environment is around the second to third week of October. This is also the traditional practice in the chenas in this region. However, the same land preparation methods practiced for chena crops cannot be implemented on land that is developed for puddled rice cultivation. In order to induce sufficient friability to the upland soil so that it could be easily tilled by conventional tillage implements, the soil has to be moistened to a moisture status close to field capacity. To achieve this around 40 mm of rain is needed to bring the upper 15 cm depth of soil to the moisture status of field capacity. The expectancy of receiving this amount of rain during the month of October is above 75 percent. Land preparation for seeding can therefore be completed by end of October in most years and sowing completed by the first week of November. Among the crops that are known to respond significantlyto supplementary irrigation during the maha season in this environment are chillie, cotton, maize, and soyabean.

In the case of rice on lowland LHG soils, commencement of land preparation will mainly depend on the inflow to the reservoir and the minimum reservoir level that has to be reached before commencement of water issues.

Scheduling Deliveries to Turnouts Commanding both Upland and Lowland Soil

Both distributary and turnout command areas consist of well drained RBE soils on the upland and poorly drained LHG soils in the lowland, with intervening imperfectly drained RBE soils located in the mid-slopes. This is similar to conditions in Mahaweli System H. In situations where non-rice crops are grown on the upland soils and rice is grown on the lowland soils, management problems are encountered in trying to achieve an equitable delivery to the two contrasting cropping systems. In Mahaweli System H the problem is overcome by permitting fanners located on the upland soils and **who** are growing non-rice crops, to use the 1 cusec (28.3 liters per second) discharge in the field channel during the day time for a 6 hour period each, and to permit farms located in the lowland soils to share the 1 cusec flow during the night under an informal arrangement of taking turns.

Since there is no night storage capacity in the irrigation system, and since it will also be impracticable to open and shut turnout gates each morning and evening, the foregoing management method is the most feasible option. This method however, requires a high degree of cooperation among farmers and good communication between agency staff who manage the turnout gates and the farmers who use the water.

It will have to be clearly understood by farmers who grow rice on the lowland that they will receive the same rotational schedule as the upland farmers and not a continuous supply for the duration of the rotation.

In the long term there should be a shift towards using the LHG lowland soils for non-rice crops during the dry yala season. The experience both in System H and Dewahuwa has been that fanners who are located at the tail-end of very long field channels on LHG soils have been able to grow non-rice crops by providing minimal on-farm drainage. It is observed that soyabean is more tolerant to imperfect drainage conditions than most other non-rice crops, and would therefore be the logical choice for lowland soils in yala. This would, however, require a high degree of control and regulation of the field channel water deliveries in a manner that would minimize the build up of a high water table in the lowland area.

ORGANIZATION AND FARMER PARTICIPATION

The Kirindi Oya project is essentially a very new system in which the organizational structure is in its early stages of evolution and where fanners themselves are in the initial **stages** of settling down to a new form of irrigated agriculture apart from puddled rice cultivation and rainfed chena cultivation which they were accustomed to prior to their settlement in this project. Commencing 1986 late yala, there have been only two seasons when all the three tracts on the right bank and the two tracts on the left bank have been able to successfully raise a crop of puddled rice. The experience up to now has therefore been oriented towards managing a rice irrigation system. Similarly farmer participation modes have also been largely conditioned to growing rice.

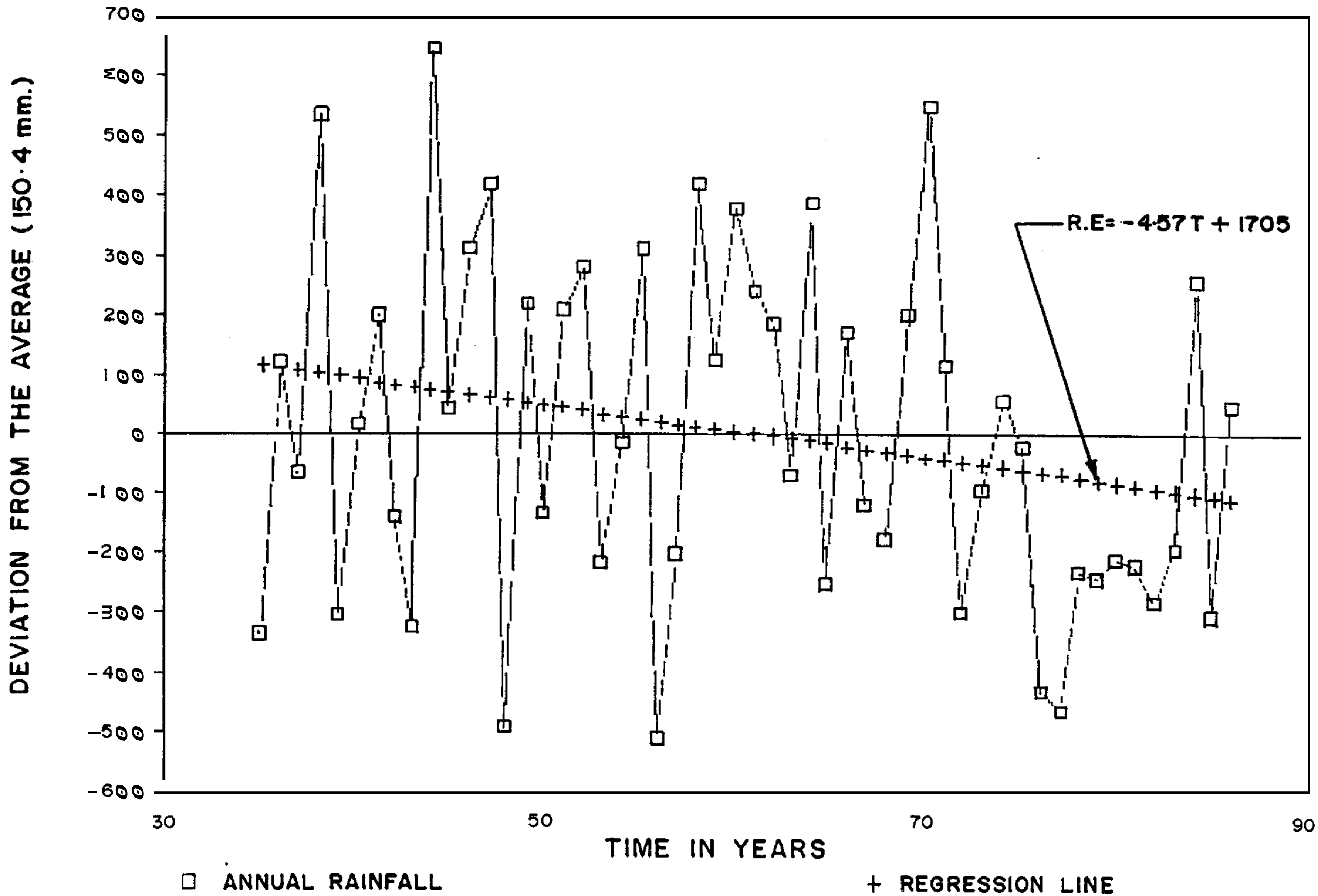
In the light of the foregoing situation it would be unrealistic to expect a major shift in growing of non-rice crops to take place over a short period. At the same time, it is opportune at this stage to set in motion the formation of the institutions and organizational forms that are necessary for farmer - agency cooperation in managing the system for irrigation scheduling and delivery for growing of non-rice crops as in contrast to rice.

IIMI's studies both in Dewahuwa and Mahaweli System H have clearly borne out the fact that in the scheduling and timing of irrigation deliveries below the distributary level there is a big gap between the planned quantity and timing of deliveries and their actual implementation. It is also observed that much of the overrun occurs at the land preparation phase (see chapter 5, below). In the water tight situation encountered in Kirindi Oya the management agency will have to endeavour to minimize this gap as far as possible. This would imply the need for considerable organizational strength and a competent monitoring service which monitors deliveries in a systematic manner and feeds back the information rapidly to the agency water management staff.

As mentioned earlier, scheduling deliveries to turnouts commanding both upland and lowland soils requires a high degree of cooperation among fanners and an effective communication between agency staff and farmers. IIMI's field research in the NCP had identified that the unreliability and inequity recorded at the turnout level is closely linked to the lack of organization and management for sharing water below the secondary level, and also the poor communication between agency staff and farmers in scheduling of water deliveries. These conditions also characterize Kirindi Oya. It is therefore necessary to develop the organization needed for crop diversification from the initial stages, and also to build into it the appropriate management and communication approaches that are required for proper implementation of water deliveries at the turnout level. This problem is discussed further in chapters 3 and 4.

Given the complex nature of the kind of organization that will be needed to support crop diversification and also the important role that will have to be played by farmer participation, the more prudent approach would be to conduct a well planned and properly organized crop diversification activity in a single tract, or else, in a single distributary in each of two or three tracts in the initial phase. This could be treated as a learning process, and could be followed by a gradually expanded program in each subsequent season.

Figure 2.01. VARIATION OF ANNUAL RAINFALL
KIRINDI OYA BASIN FROM 1935 —— 1986



CHAPTER III

IRRIGATION INSTITUTIONS IN KIRINDI OYA

INTRODUCTION

Objectives and Research Questions

As outlined in the Inception Report (IIMI 1988a:17), this component of the research has two broad objectives:

* to document and assess the present functioning, strengths, areas needing further strengthening, and impediments to improvement in the irrigation institutions at the project and farmers' level; and

* to propose structural and management innovations that could be adopted in the short run to improve the project performance, and others that could be tested and adapted over a longer period that would strengthen efforts to achieve the project goals.

With these two broad objectives in mind the research on irrigation institutions was guided by the seven research questions listed in the Inception Report (IIMI 1988a:17-18). We attempt to answer these questions based on our findings on three cultivation seasons (1988 late maha, 1988/1989 maha and 1989 yala) and developnents at the beginning of the 1989/1990 maha season. Further developnents during maha 1989/1990 are described in chapter 7. The seven research questions are summarized here for easy reference.

1. What is the overall organizational structure of the agencies involved in irrigation management at the project/system level, and how has it evolved? Are there structural factors inhibiting management efficiency? How does the organizational structure affect the incentives for various agency personnel to provide efficient irrigation service and for fanners to cooperate in O & M on the system?

2. What are the formal and informal processes of decision-making and information flow both up and down and laterally, and of performance monitoring andevaluation of personnel? Howeffectiveare these processes, and where could improvements be proposed?

3. What are the patterns of communication, cooperation, collaboration, and conflict (if any) among the different agencies for setting and achieving project goals? Is this an area where further improvements could be suggested?

4. What efforts are currently underway to establish water users' groups at the field channel, and above? What methods are being used for organizing them, and how effective are they? What are the task expectations of both the agency officials and the farmers in regard to the farmers' groups? Is the level of resources invested in this area adequate to achieve the objectives? What could be done to further strengthen the groups? What tasks and functions do they perform now, and what others could be contemplated?

5. What are the patterns of communication, cooperation, and collaboration between the key irrigation management agencies and the fanners' groups? Are the agencies effective in encouraging self-reliant, effective farmers' organizations, and if they are not, what are the reasons for this? What could be done to further strengthen the cooperation between farmers and the management agencies?

6. Are the present patterns of cooperation among farmers, or the potential for cooperation with no outside assistance, consistent with the technical requirements and technically feasible options for efficient water distribution of the present turnout/field channel design? What level of effort would be requiredto match cooperative behavior with the technical design?

7. What are the relationships between the institutional factors addressed in this module, and the performance of the system as documented in the module on irrigation system performance? To what extent, if at all, can shortfalls in system performance be attributed to institutional factors? To what extent can irrigation system performance be improved through organizational and management innovations?

Methodology and Definitions

"Institutions" are defined by social scientists as "complexes of norms and behaviors that persist over time by serving collectively valued purposes." They persist because they are valued as well as useful. "Organizations" are "structures of recognized and accepted roles." Organizations, thus, may be institutions, or pot, depending on whether they have continuity because they are valued and useful[1].

The term "irrigation institutions" is defined here as those institutions directly related to the operation and management of the water conveyance, i.e., irrigation, system. For the Kirindi Oya Irrigation and Settlement Project, the Department of Irrigation and the Irrigation Management Division, the two agencies directly involved in the operation and maintenance of the irrigation system, are the major "irrigation institutions." This definition thus excludes such agencies as the Land Commissioner's Department, Agriculture Department, and Department of Agrarian Services. However, since these departments are functionally important to the management system (INMAS) introduced in Kirindi Oya, their roles and functions are briefly discussed when necessary.

As indicated in the Inception Report (IIMI 1988a:19), the data on irrigation institutions has been collected using a combination of participant observation and formal and informal interviews, as well as analysis of documents and files. Participant observation involves attending meetings and other events and observing behavior. Interviews have been carried out with a wide variety of people, including officials at various levels, farmer leaders, and ordinary farmers. These methods result in qualitative data on processes of decision-

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[1]. See Uphoff (1986:chapter 1) and our Interim Report (IIMI 1989a) for a more complete explanation of these terms and their uses.

making, on behavior patterns, and on peoples' explanations and rationalizations for what they do or see others do.

Ideally, these data should be supplemented with quantitative data based on sample surveys to get a more precise picture of the distribution of variation. Unfortunately, for most of the period of study the security and political situation was extremely disturbed. At times it seemed unwise even to try to carry out sample survey interviews. At other times, we discovered that farmers and others were reluctant to respond in ways that would have provided reliable data. Given the extreme situation faced by fanners and officials, it is to their credit that they were able to assist and cooperate with the research at all.

We cannot offer precise data on the extent of variation, and cannot offer quantitative data to substantiate the observations. Nevertheless, we are confident that the observations and generalizations provided in this section, and the conclusions and recommendations derived from them, are valid and reflect social reality in the Kirindi Oya Project.

IRRIGATION ORGANIZATIONS AND THE COMMITTEE SYSTEM

The main organizations involved in the project are the Land Commissioner's Department, Irrigation Department, and the Irrigation Management Division, all within the Ministry of Lands, Irrigation, and Mahaweli Development; and the Departments of Agriculture and Agrarian Services, under the Ministry of Agriculture, Food and Cooperatives. A number of other departments and semi-government agencies, such as the banks and the Crop Insurance Board, are also involved in the project activities.

The Land Commissioner's Department, Irrigation Department, and Irrigation Management Division are headed at the project level by no less than four "project managers." These arc the project manager (land and settlement), the project manager (irrigation) or chief resident engineer of the Irrigation Department, and the two project managers from the Irrigation Management Division, respectively. One Irrigation Management Division project manger is in charge of the new area while the other is in charge of the Ellegala and Badagiriya old systems.

The Department of Agriculture functions in the project under an agricultural officer who has responsibilities toward both the new and old systems as well as to areas beyond the project boundaries. He is under the assistant director (extension) for Hambantota District. The activities of the Agrarian Services Department are handled by an assistant commissioner for Hambantota District.

We see, thus, a rather large proliferation of departments, and a rather surprising number of positions called "project manager." As will become clear, this proliferation reflects a serious fragmentation and dilution of authority, limiting the ability of project management to make coherent plans and implement plans effectively. The project management structure has evolved rapidly over time. See Merrey and Somaratne (1989) for a detailed description as of 1981, and Stanbury (1989) and IIMI (1988b) for more recent developments.

The Project Officers and their Responsibilities

The project manager (settlement). The project manager (settlement) is responsible for the custody, alienation and settlement of state lands, providing infrastructure and associated facilities to settlers, and administration of the aid under the World Food Program. He is assisted by an assistant project manager. His field staff includes colonization officers and field instructors to handle settlement activities. Colonization officers have been appointed on the basis of one for each tract while field instructors are deployed on the basis of one for each hamlet in the new system. The project manager (settlement)has a separate construction cadre engaged in development of non-irrigation infrastructure.

The project manager (settlement)also has responsibilities for coordination of project activities on behalf of the Government Agent. Since the project has been implemented in two phases, he needs to play an important role until the completion of phase II activities. His involvement in the completed phase I area continues because the land administration in the phase I area has not yet been handed over to the Government Agent.

The project manager (irrigation)/chief resident engineer. The chief resident engineer was initially responsible for the implementation of irrigation construction work under the project. However, when the irrigation system in phase I area began functioning, he became responsible for both operation and maintenance activities in phase I and the construction work in phase II. Until very recently he employed his construction cadre for both operation and maintenance (O&M) activities as well as construction work. We analyze the O&M organization below. His construction cadre includes four resident engineers in charge of right bank, left bank, headworks, and a number of design engineers attached to his office, as well as irrigation engineers, technical assistants, work supervisors, and skilled and unskilled laborers.

The project managers (Irrigation Management Division). Two project mangers under the Integrated Management of Major Irrigation Schemes (INMAS) program were appointed in 1986, just before the first water issues for the new area of the project. Their main functions are development of linkages for coordination among the various agencies involved in agricultural planning and implementation, and promotion of farmer participation in both the decision-making on agricultural planning and the operation and maintenance of the irrigation system.

The two project mangers have established their project offices and necessary committee systems for coordination based on a division between the "new" and the "old" areas of the project. We paid primary attention to the organizational activities in the new area of the project (right and left bank canal systems). The organizational structure of the Irrigation Management Division in the new area is described in detail below.

Officers of the Department of Agriculture. Hambantota District has been divided into three segments for administrative and other functional purposes of the Department of Agriculture. The project comes under the agriculture officer in charge of segment III. These segments are further divided into agrarian services divisions[2] under the charge of agricultural instructors. There are five agrarian services divisions, four of which fall within the project area, Weerawila, Pallemalala (Badagiriya), Yodawewa, and Meegahajadura. The first four cover the new and old areas of the project. The agricultural officer with the assistance of agricultural instructors is responsible for agricultural extension work in the project. The agricultural instructors are normally assisted by Krushi Viyapthi Sevakas (KVS), the grass roots level extension officers until early 1989. They have now been absorbed to the Poverty Alleviation Program as grama sevakas (local level officers) and receive instructions from the assistant government agent.

Officers of the Department of Agrarian Services. The Agrarian Services Department in the project area functions under an assistant commissioner for Hambantota District. There are four divisional officers assigned to the four agrarian service centers in the project to assist the assistant commissioner in his functions. The field level officers are cultivation officers, who are supposed to provide a wide variety of services to fanners in the established irrigation systems. However, they too have been absorbed into the Poverty Alleviation Program as grama sevakas. The major functions of the Agrarian Services Department is settlement of disputes between landlords and tenants, maintenance of land holders registers, collection of acre levy from farmers, issue of identity cards to fanners, estimation of damage to crops by stray cattle and settlement of disputes among farmers on such damages, taking legal action against those who do not clean and maintain their field channels, and supply of inputs such as weedicide, pesticide and fertilizer.

THE IRRIGATION DEPARTMENT

The O&M Organization

As discussed in previous reports (IIMI 1988b; 1989a; 1989b), the O&M organization of the Irrigation Department has evolved through several development stages. Initially, the O&M activities in the phase I area of the project were handled by the left and right bank resident engineers, from the yala 1986 season to the end of maha 1986/1987. The resident engineers simultaneously managed some construction work in the phase I area and other construction-related activities in phase II. With the assistance of an irrigation engineer in charge of construction, the resident engineers prepared water issue schedules and were in charge of operation. The field level operational activities were handled by technical assistants who also supervised construction work, and they were assisted by work supervisors and irrigation laborers. The resident engineers had the authority to instruct the resident engineer (headworks) for the operation of main sluices and were responsible for distribution and monitoring of water down to the field channel turnouts.

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2. At this level, the divisional boundaries of the Departments of Agrarian Services and Agriculture are the same and the officers are together in the Agrarian Services Centres.

There was a severe drought in the 1986/1987 maha, which was the first season for many farmers in the new system. More than 60 percent of the cultivation in the new area failed due to the drought and created serious problems for the settlers in the new area. The settlers blamed the Irrigation Department, and accused it of advocating cultivation in the entire command area with a very low reservoir (Merrey and Somaratne 1989).

The second stage of developnent was introduced in maha 1987/1988 with the appointment of a senior irrigation engineer in the office of the chief resident engineer to prepare water issue schedules. He was also given authority to control the issues from the main sluices. The resident engineers now had to contact the senior irrigation engineer whenever they wanted to increase the discharges in the main canals, as their previous authority to instruct the resident engineer (headworks) for such purposes had been withdrawn.

However, the resident engineers remained responsible for the operation and maintenance of the system below the main sluices, and monitoring of discharges. They appointed irrigation engineers (O&M) with some subordinate staff to attend. to these duties while also attending to construction work in the area as well. The technical assistants and work supervisors were appointed on the basis of one for each tract, with seven to eight irrigation laborers to assist them. The senior irrigation engineer was given formal authority to give instructions to the resident engineers on operational matters towards the end of the season.

As described below in chapter 5, our observations on the irrigation water delivery performance in the 1987/1988 maha season revealed:

* inequity of irrigation supply to the field channels under DC2 (FCs 9 to 15) in the sample area and to DCs 8, 2 and 5 located in the BC2 in tract 5;

* oversupply of water to the sample area during the season; and

* failure to implement rotational water issues after land preparation.

The first two problems are clearly associated with the ineffectiveness of the O&M organization, as further discussed below. The third problem relates more to the weakness of farmers' organizations, and other community-level problems.

Problems Associated with the O&M Organization

Our observation on the problems with the O&M organization, as discussed in the <u>Progress Report</u> (IIMI 1988b:71-72), revealed the following:

* The priority given to construction over O&M by the resident engineers and irrigation engineers in charge of operation. This is mainly due to the fact that Irrigation Department evaluations are based primarily on the achievement of construction targets, as well as a natural tendency of civil engineers to prefer construction work. Solid skills and experience in construction is an essential requirement for fresh graduate engineers to get their professional qualifications and become chartered civil engineers. Young engineers thus naturally favor construction over O&M to achieve their professional qualifications as early as possible, as this will affect their seniority and increments in the Department.

* Lack of incentives for the O&M staff, and the non-existence of clear indicators to measure their performance.

* Division of authority over the operation of the system among resident engineers and the senior irrigation engineer.

* Lack of understanding and awareness of the role assigned to the senior irrigation engineer by some officers engaged in O&M.

* Inadequate communication system for irrigation system operation by the senior irrigation engineer via the resident engineer (headworks) and resident engineers for the left and right banks.

* Lack of communication among the technical assistants in charge of operational activities in different tracts (upstream and downstream) of the system.

* Non-existence of a communication feedback system from the field to the resident engineers, other than requests by fanner representatives for increasing the discharges at times of shortage. This is mainly because the channeling of information from the irrigators (lowest level Department employees) to the technical assistants and irrigation engineers via work supervisors does not occur.

* System operation remained entirely in the hands of unskilled-f laborers temporarily hired for this purpose; there was no guidance or supervision by senior 'field-level staff.

* Irregular field visits by engineers, technical assistants, and work supervisors in charge of system operation.

* Lack of a proper system for monitoring discharges.

These research findings demonstrated that institutional factors were affecting irrigation system performance. Therefore, attempts were made by the chief resident engineer on instructions from the Director of Irrigation to reorganize the O&M organization, effective from January 1989. The proposed reorganization included the following features, as reported in the Interim Report (IIMI 1989a:31).

1. Establishment of a separate O&M organization under the senior irrigation engineer, who has been delegated complete responsibility over O&M matters, including administrative and financial control. He reports to the chief resident engineer, whom he is to keep informed on his work.

2. Appointment of an irrigation engineer (O&M) for each of the two new sub-systems (left bank and right bank). The O&M engineer receives his instructions directly from the senior irrigation engineer for O&M work, and exercises financial and other authority for all O&M matters in his respective area.

3. Appointment of one technical assistant and one work supervisor for each tract to be responsible for supervising the O&M work under the supervision of the O&M engineer. Turnout attendants (irrigators) have also been appointed on the basis of one for approximately 200 ha, to be supervised by the work supervisors.

4. Allocation of specific vehicles, machinery, and other equipment to the O&M section.

The O&M engineers were to continue to work out of the resident engineers' offices, and to remain under the resident engineers for certain administrative purposes. They were required to keep the resident engineers informed of their work. However, the proposed reorganization did not come into effect as expected and there were conflicts and contradictions over the question of the financial autonomy of the O&M section. At one instance the senior irrigation engineer and one resident engineer came into conflict over assigning some residual construction work in phase I by the resident engineer to technical assistants for O&M on the system. The senior irrigation engineer viewed this as an attempt by the resident engineer to divert them from O&M work. The resident engineer, on the other hand, explained that his intention in assigning the improvement work in the phase I area to the O&M technical assistants was to insure the work is completed satisfactorily as they are the people who know the problems and their implications as system operators.

These conflicts and contradictions manifested in themselves a kind of underground, i.e., unstated, resistance to change of the dominant construction-oriented Irrigation Department structure at the project level. Finally the O&M section was not given financial autonomy on the understanding that the delegation of financial autonomy for certification of payments to more than one officer assigned to the same office is contrary to the rules and financial regulations. As a result, the senior irrigation engineer had neither financial control over O&M funds nor administrative control over the O&M engineers operating from the resident engineers' offices. However, the senior irrigation engineer could issue direct instructions to the O&M engineers and their staff regarding the operation of the system.

The new O&M organization, with these changes, started functioning in yala 1989. Though the organization was not fully autonomous, and its operational activities were interrupted by the unsettled political and social disturbances, it showed some definite improvements in its performance (IIMI 1989b). The following observations on water delivery performance substantiate the improvements.

* The overall water supply from the system to the fanners during the season was not adequate. This was because the Irrigation Department attempted to save water towards the end of the season as the water level in the reservoir was very low. However, farmers managed to obtain adequate water because of rains and re-use of drainage water by some tail-end allotments.

* There was no serious inequity in water deliveries in the sample area except for FCs 10 and 13. The problems on FC13 at the tail are related to upstream farmers' interventions at field channel turnouts.

However, the rotations again could not be initiated in time, and therefore could not be implemented, because of delays in land preparation by farmers, farmers' interventions at field channel offtakes, and disturbances in the area. But the Irrigation Department did attempt to communicate with farmer representatives by holding meetings with them to make them realize the impact of water scarcity and the necessity of finding ways to manage with the available water supply.

These slight improvements, however, cannot be explained solely in terms of the organizational changes. In the right bank system where we conducted our research, the resident engineer and O&M engineer worked cooperatively, and the O&M engineer was more or less under the resident engineer for administrative, financial and other practical purposes. In addition, the previous senior irrigation engineer who had conflicts with the resident engineers over their role and interference in O&M matters went on transfer and a new officer took over. The new senior irrigation engineer tried to avoid conflicts and adjust to the situation. The improvements are thus clearly associated with personalities and personal relationships as well as with the organizational changes. The new structure did focus responsibilities for O&M on particular individuals, rather than spread them *among* officers also doing construction. But the present O&M structure, from an organizational point of view, still appears to have several problems.

The division of O&M authority among *so* many officers (chief resident engineer, senior irrigation engineer, three resident engineers, two O&M engineers) seriously affects the performance of the staff. In the case of the senior irrigation engineer, he functions without financial authority over O&M. He is supposed to supervise the work conducted using O&M funds without having financial authority. The O&M engineers execute work funded by O&M funds, but the financial controls are exerted by the chief resident engineer or resident engineers. It is difficult to hold an officer responsible for executing O&M functions effectively without delegating him sufficient authority over the control of O&M funds. As a result, the senior irrigation engineer's activities are limited to instructing the O&M engineers on operational matters; he has no involvement in maintenance work other than some paper work such as allocation of O&M funds to the resident engineers on the sanction of the chief resident engineer. This division of authority hinders his ability to exercise direct authority over O&M.

The O&M engineers are administratively under the resident engineers, and the O&M organization under the main canals actually functions under the resident engineers and not under the senior irrigation engineer. No job descriptions with details on who is responsible to whom and for what and how he is supposed to do it have been issued to the O&M staff. As a result, there is a great possibility for the O&M engineers to be assigned other duties by the resident engineer. It is no secret that construction carries better rewards than O&M work, and there is no surprise if O&M engineers willingly take such responsibilities in addition to their O&M work.

Clear definition of roles through specific job descriptions is also required for technical assistants, work supervisors, and irrigation laborers. Though we observed technical assistants attending to their job by making regular field visits, we have strong doubts about the work supervisors' involvement. Effective system operation requires their participation for supervising irrigation laborers and giving instructions on certain operational matters, as well as being a liaison with farmers and fanner representatives.

There is no incentive for the officials of the O&M organization to motivate them to attend to their duties as required by the operational assumptions. Proper incentives cannot be offered without some policy decisions at the national level. The major constraints for offering such incentives are:

* the lack of financial resources for O&M work; and

* the non-existence of indicators to measure the performance of O&M staff.

These constraints particularly affect the performance of the middle- and lower-level field staff who are the "kingpins of water management from the agency side" (Raby and Merrey 1989:77).

Conclusions and Recommendations on the O&M Organization

1. The organizational structure. Based on our finding over several seasons of research and recent developments in the project, we have concluded that a weak O&M organization in the project cannot compete with the dominant construction-oriented culture of the Department at the project level. Further, given the serious water supply constraints faced by the system, a strong O&M organization is essential. We therefore propose that management responsibility for the completed areas of the Kirindi Oya Project be handed over to the Range Deputy Director, Hambantota, without any further delay. Under the range deputy director, we suggest that an experienced chief irrigation engineer be appointed as the overall irrigation manager of the irrigation system. The positions of the chief resident engineer and three resident engineers are temporary, until construction is completed; these positions will be phased out as the construction is completed. Until that time, we suggest the chief resident engineer's and resident engineers' activities be confined to the construction work in the phase II area of the project. Our proposed organizational set-up for the O&M division of the entire Kirindi Oya Irrigation System, including the new areas and Ellegala and Badagiriya systems, is given in Figure 3.01.

The proposed organizational structure provides for a senior engineer having overall authority, and O&M engineers for the three hydrological subsystems and the head works. It also provides for the Hydrology Division working in the catchment to report directly to the chief irrigation engineer rather than to the deputy director of the Hydrology Division in Colombo, as recommended in chapter 2. Finally, it provides for a monitoring and evaluation unit to be responsible for collecting data and using it to evaluation performance, and providing timely feed back.

The density of personnel deployed could be as follows: one technical assistant per 2000 ha; one work supervisor per 1000 ha; and one irrigator per 200 ha. It is assumed that Badagiriya will continue to receive water from the main system (right bank canal); hence its inclusion under the right bank subsystem is justified (this is based on the new development in the project described under the organization structure of the Irrigation Management Division). The Ellegala system includes Gamunupura area, Tissawewa, Yodawewa, Debarawewa and Weerawila Tanks.

Several steps have to be taken before handing the system over to the deputy director, Hambantota. These include completion of residual work in phase I area; lot improvement and many other minor works reported by farmer organizations remain undone according to the minutes of meetings of the Project Committee.

A number of construction defects are still to be observed in the system. Even in the case of DC 2, the canal cannot convey the design discharge in certain reaches. The identification of such defects in consultation with the farmers, and taking remedial action is necessary prior to the handing over, as the O&M organization is weak in resources.

Rehabilitation of broken field turnouts and other structures is also required. We have observed many broken field turnout structures and other regulating structures in many field channels in the sample area. Strict rotations cannot be implemented without these repairs. This will have a serious impact on the proposed crop diversification program for yala.

2. Professionalize irrigation management. At present Irrigation Department personnel conceive of themselves primarily as civil engineers, not irrigation managers. The Department's own values and incentive system reinforce this attitude. But nationally, not only in Kirindi Oya, the role expected from the Department places greater emphasis on irrigation management, and less on construction. It is time for the Department to begin adjusting to these changing needs.

The Department should take a clear position that emphasizes and values professional irrigation management as an important role of its employees. The senior Department staff should be given clear and full responsibility matched by appropriate authority for improved management of irrigation systems. Both in-service and on-the-job training, and a system of incentives for high professional performance, are required. Incentives could include non-monetary ones, such as selection of good system managers for valued overseas training opportunities, and letters of commendation from the Director for a job well done.

The middle and field-level O&M staff should be issued clear job descriptions (the Irrigation Department manual defines the roles of irrigation engineers and technical assistants in a general way, but these are rarely consulted). The guidelines in the final draft of the O&M Manual prepared by the water management consultants (Water Management Consultancy 1989) can be followed in their preparation. Recruitment and training should be based on the skills required for carrying out the jobs.

3. Performance monitoring. Introduction of clear job descriptions will provide a basis for developing measures of performance of O&M staff. In addition, effective management of irrigation water deliveries will require an

effective timely system for ascertaining real time demand as against available supply; changing delivery patterns to meet the demand; monitoring delivery performance in relation to targets; and making further adjustments based on performance.

4. Working committee in the Irrigation **Department.** The Irrigation Department is at the early stage of a major transformation from a construction agency to an agency with primary technical responsibility for management of irrigation systems. The management function will require new skills and procedures for participatory and joint management with farmers. The above recommendations also point in this direction. To facilitate the process of transformation from a "bureaucratic technical-engineering" approach to a "strategic organization" with a participatory approach, we propose that the Irrigation Department establish a "working committee" modeled on the one that has guided the transformation of the National Irrigation Administration in the Philippines (Korten and Siy 1989). This would be an advisory committee, including both Department officials and some outside expertise, to assist the Department in learning from its experiences and adapt itself to work more effectively in the new mode.

THE IRRIGATION MANAGEMENT DIVISION

Formal Organizational Structure and Objectives

Kirindi Oya is one of about 35 major schemes on which the Irrigation Management Division is implementing its program for Integrated Management of Major Irrigation Schemes (INMAS). The Division itself is quite small, with minimal staff and very little authority or funds. In Kirindi Oya it is represent-ed by two project managers (one each for the old and new areas), who are each assisted by an institutional developnent officer. Until recently, they had a number of institutional organizers to work at the field level.

The general guidelines for INMAS advocate the establishment of a pyramidal committee structure operating on three tiers: field channel groups, distributary channel organizations, and the project committee. The structures and the functions of the committees at each level are conceived as follows (see IMD Handbook 1985).

1. Field channel groups. All the fanners under a field channel are members of the field channel group and are expected to appoint a "farmer representative," preferably by consensus, to represent its members at higher levels of the committee structure. Before the formation of field channel groups, the institutional organizer is supposed to work in the community and explain the program. He is supposed to play the role of a "change agent" to bring about an attitudinal change in the community in order for them to adjust to the new requirements such as cooperation for sharing water and channel maintenance demanded by the irrigation system. The major function of the field channel group is to organize water distribution and maintenance of field channels and drains in the turnout area. The group is supposed to meet regularly to discuss issues and problems relating to water distribution maintenance and take timely action. Problems that the field channel group cannot solve can

either be referred to the distributary organization or to the appropriate line agency. Field channel representatives are supposed to have close contacts with the field level irrigation staff to find solutions to irrigation problems at field level.

2. Distributary organizations. The field channel representatives appointed by fanners under one normal distributary channel (or several adjacent small ones) form the distributary channel organization. It is a formal organization with a constitution and a secretary, a president, a treasurer, and other office bearers appointed by the fanner representative members. This organizational meeting is also supposed to be initiated by the institutional organizer (if any) with the participation of the project manager. Meetings of the distributary organization are supposed to be attended by field level officers of line agencies to discuss problems and find solution to those problems that can be solved at this level. The responsibilities of distributary organizations are to (IMD Handbook 1985):

a. organize activities relating to water distribution and maintenance of field channels;

b. arrange for the equitable distribution and rotation of water along field channels;

c. encourage fanners to improve on-farm water management;

d. facilitate fanners' participation in decision-making, planning and implementation of all matters concerned with agriculture and irrigation;

e. identify areas needing improvements and rehabilitation;

f. organize collective work that can be handled by farmers under the supervision of the officers;

g. keep the authorities informed of irrigation offenses, pest attacks, disease outbreaks, and crop damage caused by animals; and

h. encourage farmers to pay O&M fees.

3. The Irrigation Management Division-Project Committee. The project committee convened by the project manager is at the apex of the committee structure implemented under the INMAS program. The members of the committee include farmer representatives on the basis of one from each distributary organization, technical assistants of the Irrigation Department, colonization officers of the Land Commissioner's Department, agricultural instructors of the Department of Agriculture, and divisional officers of the Agrarian Services Department. The O&M engineers of the respective canal systems also attend meetings though they are not members of the committee. Officers of other line agencies are invited to committee meetings, which are held regularly once a month. The functions of the project committee are (Perera 1986):

a. formulating and implementing the seasonal agricultural program;

b. holding pre-kanna meetings and making arrangements for holding of timely **kanna** (pre-season cultivation) meetings;

c. coordinating the provision of credit and other inputs in time;

d. making arrangements for operation and maintenance of all capital assets and approval of items to be handled under the maintenance program for the irrigation system;

e. reviewing the agricultural program during the season in order to take any necessary corrective action;

f. attending to problems connected with water distribution reported to the committee by farmer representatives;

g. promoting farmer participation in the project through formation of farmer organizations;

h. organizing farmer and officer training; and

i. reporting to the District Agricultural Subcommittee on the problems that cannot be solved at the project committee level.

The project committee is linked to the district level through the District Agricultural Subcommittee which is the main implementing body at district level for the management of INMAS projects. The District Agricultural Subcommittee is linked to the national level through a central coordinating committee which reviews policy and provides guidelines for implementation.

The Irrigation Management Division Committee Structure in Kirindi Oya

Two project committees have been established in the project, one for the old area and one for the new area. Our main concentration was on the Committee structure in the new area of the project. The Irrigation Management Division project manager for the new area has attempted to form the three tier committee structure following the INMAS guidelines. Though the committees reflect the pattern advocated in the program, they have not yet developed to take responsibilities as anticipated.

Field channel groups. Field channel groups were initiated at the beginning by the project manager without the assistance of a field staff. It is not surprising, then, that he could not explain clearly to all the farmers and farmer representatives the objectives of the program. Therefore, the farmers were not aware of their roles or those of the farmer representatives in the program.

Though the institutional organizers were fielded in 1988, their stay in the project was limited to a period of one year in many cases. They did not leave any significant imprint on the farming community during this short period. As a result, the majority of the farmers are still unaware of the objectives of the program.

A majority of the farmers were temporarily settled in the project at the beginning. After the crop failure in 1986/1987 maha, the majority moved out of the settlement for economic reasons. They lost confidence in the system (Merrey and Somaratne 1989). Though the situation has improved now, a significant number (20 percent in our sample) are still not permanently settled. This is a major problem in organizing farmer groups.

Irrigated agriculture was not the main concern of the fanners stricken with severe hardships. It was very difficult to organize them for such purposes at the beginning. When the cultivation started, many fanners found that they could not irrigate their lands without some improvements in the canals and levelling work in allotments. On such occasions they rallied round the organization to find solutions to such problems but lost interest when the work was over.

The field channel representatives who were appointed by the farmers at the beginning did not have the leadership qualities demanded by the program. There was no training for them. Therefore many did not have a commitment to the program. Even those who were committed to some extent lost interest in the program, because of other farmers' lack of cooperation. The farmers attributed the traditional role of "water headmen" (vel vidane) to field channel leaders and wanted them to take the responsibility for doing much of the required work.

For all these reasons, there was no active involvement of fanners or field channel representatives in canal cleaning and other maintenance activities. Since there were no rotational issues and water was in abundance, there was no perceived necessity for them to participate in water distribution.

Distributary organizations. The field channel groups are conceived by the Irrigation Management Division as informal "groups", not formal organizations; but the distributary organizations are expected to develop into formal organizations. More recent thinking is that these organizations will be legalized and asked to take formal authority and responsibility for system O&M from the distributary level down. However, the evolution of these organizations at Kirindi Oya has not been very promising so far. There are several reasons.

1. The farmer organizations at Kirindi Oya were initially formed as hamlet-based organizations. This was because the people living in different hamlets located four to six kilometers apart had, in principle, been allocated lands to share water from one or more common distributaries (Stanbury 1989). Therefore people getting water from different distributaries but living in the same hamlet were included in the hamlet level organization (Merrey and Somaratne 1989 provides an example; see chapter 7 for another). This is a common problem in all the hamlets of the right bank system; out of the seven distributaries under BC2, three fall into this category. Though attempts were made to base the

organizations on distributaries, the settlement pattern has reduced the participation of field channel representatives living in other hamlets.

2. Distributary organization meetings were not regularly attended by farmer representatives. In the case of the Hamlet 11 organization comprising of 22 field channel representatives, the number attending meetings never exceeded 12. The problems of fanners on some field channels could not be discussed at the meetings because of this.

3. The leaders of distributary organizations tried to find solutions to irrigation problems and other community level problems through the involvement of the Irrigation Department and other relevant organizations. For example, after the loan funds for phase I construction had been used up, the farmer representatives were successful in getting the remaining land, irrigation and drainage construction work completed by using phase II funds. Recently lining of a portion of DC5 in right bank tract 1 was done through the project committee and subcommittee of the project coordinating committee.

   But the organizations failed to issue invitations for meetings to the officers concerned on many occasions. Some officers did not attend even when they were invited. As a result either the distributary representatives or project manager had to take the problems to the relevant organizations for solutions. There were no attempts by distributary organizations to solve problems by community participation or by the participation of field-level line agency officials.

4. Fanner representatives took decisions about seasonal cultivation programs that were biased towards farmers' views as there were no line agency officials to influence their views and decisions at distributary organization meetings. This sometimes has led to inappropriate decisions; the issue of first water before harvesting was completed, lack of time allocated for canal maintenance at the start of yala 1989, and the decisions to cultivate rice in both 1988 and 1989 yala seasons are examples.

5. The Irrigation Management Division and the Land Commissioner's Department representatives had conflicts over certain issues; these came out for example during discussions of community problems at distributary organization meetings. On some occasions there were criticisms against some field level officers of the Land Commissioner's Department. In a previous publication we had documented attempts to undermine each others' programs (Merrey and Somaratne 1989). The Land Commissioner's Department had no effective program at that stage to solve these problems. This led to conflicts between its field level officials and the leaders of distributary organizations. Many fanner leaders became discouraged as a result of these conflicts. The conflicts between the two departments are no longer predominant, but many of the community level problems still remain unsolved. Because of the tensions associated with the transition from the settlement stage to the agricultural production stage, and the ineffective organizational strategies adopted, the Irrigation Management Division could not address the on-farm water management issues at this

stage. This remains a serious problem. The distributary organizations almost everywhere in the project have inherited these problems. In many cases the organization rests on one or two leaders who liaise with the Irrigation Management Division project manager to solve their problems.

The project committee. The Irrigation Management Division project committee for the new areas of Kirindi Oya is comprised of the divisional level officers of the Departments of Irrigation, Agriculture, Agrarian Services, and Land Commissioner, and the distributary organization leaders. Though O&M engineers are not members of the committee, they attend meetings regularly. However, the management capacity of the committee is still not developed for the formulation and implementation of agricultural programs for a number of reasons.

1. The District Agricultural (DAC) Subcommittee did not function for a long period, hence the project committees in the entire district had been paralysed. The INMAS program requires an effective DAC subcommittee in order for the lower level committees to function. Even when the subcommittee started functioning, the project level officers did not attend the meetings. The farmer representatives of the new area who attended the committee were frustrated, because there were no higher officers of the important agencies like the Irrigation and Land Commissioner's Departments at the subcommittee meetings. Therefore, they came to prefer attending the subcommittee of the project coordinating committee established in the project (see below). However, the farmer representatives of the old area attend the DAC subcommittee meetings but avoid the subcommittee of the project coordinating committee because line agency officers involved in the old area attended these meetings. This situation has now improved and the project level officers also participate in the meetings held once every three months. However, this situation weakened the functioning of the project committee in the area until mid-1989.

2. The project committee received less attention because of the existence of a more powerful "project coordinating committee" established for implementation of the project activities. However, its major function was to oversee construction and settlement in the project and not agricultural plan implementation. Higher level project officers of other line agencies did not attempt to develop the management capacity of the Irrigation Management Division project committee, for example by attending meetings regularly and using it as a forum for consultation with farmers on agricultural planning. The conflict between the Land Commissioner's Department and the Irrigation Management Division further reduced the development of the management capacity of the project committee and also seriously affected the launching of crop diversification programs in yala 1988 and 1989. This situation improved with the arrival of a new project manager for land and settlement activities. The participation of the chief resident engineer at a recent (late 1989) project committee meeting also shows the recent change in the Irrigation Department attitude towards the program.

3. Achieving the objectives of the INMAS program demands a bureaucratic reorientation. However, because the Irrigation Management Division has failed to give the necessary training to the officers of other departments, the objectives of the program and their responsibilities toward it are not clear to them. Therefore, the officers tend to work primarily for the narrower objectives of their agencies without involving themselves much in the INMAS program activities. For example, an agricultural officer once refused to give the assistance of his field level staff to the project manager (Irrigation Management Division) for data collection to prepare the seasonal agricultural program because they themselves prepared a program for the entire district. This is in spite of clear directives from the center ordering cooperation in seasonal planning.

Conclusions and Recommendations on the Irrigation Management Division

Conclusions. Our findings in the three seasons covered in this study clearly demonstrate the structural weakness of the Irrigation Management Division organization at every level of the committee structure. The following are our observations in this context.

1. Though the field channel representatives and distributary organization leaders generally propose the cultivation calendar, they make no serious effort to clean canals on time, as agreed at cultivation meetings. This reflects the weakness of the organization to a great extent, though some settlement issues such as temporary residence of settlers are also important factors. But in our experience in Kirindi Oya even those who are permanently settled attend to canal cleaning only after the water issues are made. They never clean field channel roads or de-silt the channels; they only clean weeds from the canal.

2. The rotations could not be commenced in time (and thus were not implemented) during any of the observed seasons because of the delay in land preparation. The delay in land preparation is attributed by farmers and officials to delays in the supply of inputs, for which better arrangements could be made through coordination. However, the line agency support for the Irrigation Management Division's attempts to solve these problems remains unsatisfactory, especially in the case of credit and tractors.

3 One of the main responsibilities of the Irrigation Management Division is to formulate and implement the agricultural program and monitor its progress. However, the Division has failed to attend to these functions because of lack of line agency cooperation and because its main focus has been on irrigation problem solving. It could be seen that the cultivation calendar agreed upon was not adhered to in any of the seasons and as a result water issues had to be extended.

Overall, then, we find that despite rhetoric in support of turning over authority to farmers and gaining farmers' participation, the government agencies have in fact consistently given very low levels of support to building institutions through which fanners could participate effectively. This is reflected in the low level of resources and central support provided to the Irrigation Management Division, and the minimal interest and support for the Division's efforts provided by other departments. We find that the actual impact so far has been to confirm and encourage fanners' dependency on the bureaucracy, rather than creation of self-reliant farmers' organizations, or true joint management. The Irrigation Management Division and the committee system it has tried to create are not effective. Farmers' groups and organizations exist to some degree, but are not being "institutionalized," i.e., infused with a value and usefulness that would lead to strong and continued sustainability.

Recommendations. The government policy regarding the management of major irrigation schemes demands the proper functioning of the project committee system proposed under INMAS. Though alternative management innovations could be proposed for the Kirindi Oya Project, our focus here is to develop the management capacity of the project committees to handle the irrigation and agriculture-related activities in the project.

1. The Irrigation Management Division should take the initiative to train the project- and field-level officers to enable them to understand the program better. They are not very knowledgeable about the program at present.

2. The Irrigation Management Division should identify training needs of the farmers and farmer representatives, through a formal participatory "training needs assessment" process. The training should emphasize on-farm water management and crop diversification issues as these are key areas for the success of the project.

3. The project committees should be formally recognized as the mechanism for policy decisions. As part of this recognition, we suggest re-naming them as "Project Management Committees" to emphasize their role. They should focus on formulating, implementing and monitoring the agricultural. program. Agreement on a realistic cultivation calendar, and adherence to this calendar, will be essential in order to use the limited water supply effectively.

4. We recommend forming three project management committees, one each for the right bank, left bank, and Ellegala subsystems. Under the overall project management structure we are proposing (see below), it will be at this level that project management committees can be most effective.

5. The project level higher officers need to participate at project management committee meetings when decisions on seasonal agricultural program are taken, to influence fanners to take rational decisions.

6. The responsibilities of the field level officers of line agencies towards the INMAS program, and their relationship to the Irrigation Management Division, should be included in their job descriptions and the heads of line agencies need to take action to insure adherence. We believe the Irrigation Management Division could increase the Rs 250/= allowance paid to members of the committee to motivate more active participation.

7. The problems that the project management committee cannot solve should be attended to by field level officers of line agencies, in consultation with their superiors, and the results should be reported to the committee at subsequent meetings.

8. The DAC subcommittee needs to evaluate the performance of project management committees in the district periodically, and attempt to strengthen their management capacity.

Conclusions on the Other Committees in the Project

Our previous three reports discussed a number of other committees functioning in the project. They are:

1. The project coordinating committee

2. The subcommittee of the project coordinating comittee

3. The committee for crop diversification.

The project coordinating committee is required to function in the project until the completion of Phase 11. However, its functions need to be limited to construction and new settlement issues in order to pave the way for the project management committees to develop their management capacities. It is necessary to take a policy decision at the central coordinating committee to limit its functions and allow the project management committees to function through the DAC subcommittee.

The subcommittee of the project coordinating committee, established in part as a result of observations in an earlier IIMI report, was useful as a forum for the project, manager (Irrigation Management Division) because the DAC subcommittee was not functioning, and later higher level project officers did not attend DAC subcommittee meetings. Now the situation has changed. Therefore, we recommend the abolition of the sub-committee of the project coordinating committee.

However, the committee formed to address crop diversification issues needs to be retained for a longer period because the project management committee is still not developed sufficiently to take this responsibility. The committee had prepared an agricultural program for yala 1990. All the line agencies were involved in the preparation of the program and worked as a team to realize its objectives. This is the first such group attempt we have observed in the project for crop diversification. The Irrigation Management. Division has contributed to the program through primary data collection with the involvement of distributary organizations in the project.

DECISION-MAKING, INFORMATION FLOW AND PERFORMANCE MONITORING

Decision Making

Making decisions regarding the cultivation season is very important in irrigated agricultural schemes. It requires information on the availability of water, data on the inflow and rainfall assumed for a particular season, the extent of area to be cultivated, the crop varieties to be cultivated, the availability of seed and other inputs, marketability of the products, and other information. Therefore, decision-making involves information and data collection for the formulation of a program for the season.

The project committee is supposed to prepare this program before the commencement of a season. However, for various reasons discussed above, it has not succeeded in preparing such a program. The decisions for the previous three seasons were taken at the cultivation (kanna) meetings without having any such program. The procedure followed in the previous three seasons was as follows.

1. The project manager (Irrigation Management Division) arranged distributary organization meetings with farmer representatives and arrived at decisions regarding the cultivation season. Since the meetings were not attended by officers of other line agencies, they had no influence on the decisions. For yala 1989, the project manager could not discuss plans with the farmers at distributary organization meetings since the meetings could not be held for security reasons. Plans were discussed only at the project committee level.

2. The farmer representatives then proposed dates for the cultivation season at the project committee meetings. These meetings are attended by field level officers, but they did not know much about the program of their own department for the season and therefore, could not influence the fanners' thinking.

3. The project manager then arranged pre-kanna meetings with line agency officials and fanner representatives. By this stage the fanner representatives had a program agreed upon by them at the project committee. They attempted to maintain their own decisions. The officers were forced to accept these decisions.

4. The decision of the pre-kanna meeting was ratified at the kanna meeting.

There were attempts by other project level officers to influence this decision-making process on three occasions. In maha 1988/1989, the sub-committee of the project coordinating committee, with the participation of project level higher officers, was formed to guide this decision-making process. The last two seasons (maha 1989/1990 and yala 1990) the decisions taken at the project committee have changed, and the dates proposed for the cultivation season postponed after discussions with the farmer representatives, and ultimately changed completely.

In yala 1989, the project committee decided to cultivate rice in the right hank tract 1 and left bank tracts 1 and 2 even though the project authorities intended to cultivate only non-rice other field crops. The project manager (Irrigation Management Division) was accused of taking farmer-biased decisions against the project plans for cultivating non-rice crops in yala. Similarly, in yala 1989, the farmer representatives and project committee decided to cultivate rice. The project authorities failed to change this decision because they had no solutions to farmers' problems such as credit, marketing and crop insurance. Neither the project committee nor the project coordinating committee had made any plans before the commencement of the season. Instead, officers attempted to launch programs without any prior preparation to study and address the constraints involved.

A recent development in the project has complicated the seasonal decision-making. A pre-kanna meeting for the entire project was held recently with the participation of farmer representatives from both the new and old areas of the project. It was initiated by the chief resident engineer to present a technical solution to the water crisis in the scheme. The solution was, basically, to provide tanks in the old area with drainage water, especially from tracts 1 and 2 on the right and left bank systems.

Though the Irrigation Department officers claim that they had no intention to deprive the old area farmers of priority rights over water by the proposed plan for water issues, the old area fanners as well as the Irrigation Management Division project manager for the old area were suspicious. The old area farmers generally hold negative attitudes towards the whole development project. Their attitude might have been very different if the Asian Developnent Bank-funded rehabilitation work in the old areas had been carried out in consultation with farmers or existing fanner organizations. From the farmers' point of view the rehabilitation program has not led to any significant improvement in their irrigation systems. In addition they fear that the drainage water from the new area would tend to cause salinity in their rice fields without sufficient drainage.

As a result, the farmers in the old area attempted to retain their priority water rights and they were successful at the meeting. The priority claimed includes priority water rights in both yala and maha for 200 percent cropping intensity. More recently, Badagiriya farmers have also claimed some priority over water from the main system. If these priorities remain, the new area fanners will face serious shortages, even for cultivation of non-rice crops, and even if phase II is not completed. This is a very complicated situation which should receive attention at central coordinating committee level and at the political level (see chapter 2).

Recommendations on Seasonal Decision-Making

1. The project committees should prepare a tentative cultivation program for the season at least three months prior to the commencement of the season, with at least two scenarios for "water abundant" and "water short" seasons, respectively, in collaboration with senior Irrigation and Agriculture Department officials.

2. The proposed plan should be discussed with farmer representatives at distributary organization meetings, attended by other line agency officials to influence the decision making.

3. A final decision on the seasonal program needs to be agreed upon at a project committee meeting when the water level in the reservoir is sufficient to commence the cultivation. The project committee can hold a special session in case it has already held its monthly meeting. The participation of the senior irrigation engineer and other high level project officers is required to explain the reasons for changes to the program, if any, such as the curtailment of the cultivation area due to scarcity.

4. Then, either a meeting of the DAC subcommittee attended by farmer representatives of both systems, or a pre-kanna meeting restricted to farmer representatives with the participation of key officials is needed to discuss common issues and confirm the decision.

5. Finally, the government agent should hold kanna meetings based on tracts or tanks to explain and ratify the decisions taken at the pre-kanna meetings.

Information Flow

Information is required not only to take decisions on the seasonal agricultural program, but also for monitoring the implementation of the agreed upon program. The Irrigation Department has to make water issues for the season. The Irrigation Management Division has to attend to water management activities in the turnout areas and arrange the necessary inputs. All these activities involve information sharing and decision-making at various levels.

In the case of the Department of Irrigation, the senior irrigation engineer has to prepare a water issues schedule, including information on the discharge quantities at various offtakes and duration and timings of rotations. He requires from the field information such as:

1. discharges made to various offtakes in the system;

2. progress of land preparation in the command area;

3. rainfall and other climatic data from weather stations located in various places in the system; and

4. data on inflow and water availability in the reservoir.

Our observation on the various aspects of information sharing demonstrate that the information is not received in time by the senior irrigation engineer and even if it is received it lacks accuracy. The following are our observations with regard to the information flows in the Irrigation Department.

The discharges at offtakes of the system. Measuring discharges at various offtakes is necessary to know whether the farmers receive adequate amount of water in time and in an equitable manner and also for the monitoring of system performance. The Department did not succeed in collecting these data in the first two seasons but was successful in yala 1989. However, the data could not be used for any practical purpose. The normal practice of the Department is to use theoretical rating curves of the measuring structures for calibrating discharges, but this does not reflect reality. In many cases the measuring structures are defective and some theoretical rating curves have never been checked in the field. As a result there is no possibility to know whether the distributary structures are delivering the design discharges.

The progress of land preparation. The water issue schedules assume three staggers in the season with 20 percent progress in land preparation in the first three weeks, and 60 percent and 20 percent respectively in the subsequent three weeks. The land preparation period is assumed to be five weeks. However, land preparation takes a longer time than assumed for various reasons discussed elsewhere. The Irrigation Department is forced to change the schedule based on the progress of land preparation to avoid wastage of water. The Department could not collect systematic timely data on the progress of land preparation in the two previous seasons; in yala 1989 the Department adjusted discharges based on data being collected during the land preparation.

Rainfall and other climatic data. Rainfall data are very important in a water short scheme like Kirindi oya. Though weather stations with instruments are available in the project we find that the data collected are not accurate, apparently because of the lack of experienced personnel. Other climatic data, such as evaporation, humidity, and speed of wind, are required to prepare schedules based on more realistic values instead of theoretical or assumed ones.

Data on inflow and water availability. Though the data on water availability in the reservoir can be obtained from the headworks resident engineer, there is a strong doubt about the accuracy of the inflow data received because the Irrigation Department officers cannot closely supervise the measurement activities done at a station located in a distant. place in the catchment.

Information Flows within the Irrigation Department. Our findings show clearly that the collection of information in the field is not satisfactory. However, channelling of information from the senior irrigation engineer to the field, and communication within the higher level of the organization, have improved since the reorganization of the O&M section. Certain communication problems such as channeling of information to the O&M engineers and technical assistants from the senior irrigation engineer have been avoided by regular field visits by the senior engineer and other O&M staff. As a result the following improvements can be observed now:

1. The unusual fluctuations in the right bank main canal have been avoided by establishing communication between tracts through daily visits along the canal by technical assistants assigned to the O&M section.

2. Regular field visits by the senior irrigation engineer and his staff have given them an opportunity to communicate and share information with the field level staff.

However, we observed that the O&M section does not have any formal meetings to discuss and evaluate the performance of the irrigation system or to identify operational and distribution problems.

Though the situation at higher levels of the system shows some improvement, there is a serious lapse in communication and information sharing in the field. This is largely due to the ineffectiveness of fanner level institutions in the project. The Irrigation Department attempted to solve *some* field level problems by arranging weekly meetings with fanner representatives and farmers at unit offices, and through a complaint book kept at the unit offices for fanners to lodge complaints. But the farmers have preferred to find temporary solutions to the shortage of water in canals through irrigation laborers who can offer immediate solutions by increasing the discharges to a particular field channel. This kind of problem solving mechanism could be observed throughout these seasons in our sample distributary.

To further elaborate on this issue, the tail-end field channel (FC 13) of DC2 is water short throughout the season. The scarcity is grave during the land preparation period because the canal cannot convey the design discharge due to defects in the design. Since this is not brought to the notice of the higher level officers, the problem remains unsolved. In some instances the canal design assumes that all the allotments under a particular canal are poorly drained soils though the situation is entirely different. In such cases water shortages are unavoidable. However, due to the lack of feedback, these problems do not receive due attention.

Information flow within the Irrigation Management Division *end* with Fanners

The Irrigation Management Division is supposed to communicate and share information through the three tier committee structure established in the project. As we have pointed out above, some organizations are defunct, hence two way communication does not occur. In hamlets where the organizations are active, various kinds of irrigation problems and other field level information are brought to the project committee and solutions are intimated to the fanners concerned through distributary leaders. The Irrigation Management Division has been successful in solving irrigation and other agricultural problems in this way.

In tract 5, the organizations were defunct and as a result communication flow upwards and downwards did not occur. Because of this serious lapse in communication, the Irrigation Department took a decision for an early water issue for yala 1989 when many rice fields in tract 5 were still not ready for harvesting. The following are our observations on communication lapses in tract 5:

1. Both distributary organizations and field channel groups are defunct, though the leaders of the distributary organization attend the project committee meetings. As a result the Irrigation Management Division cannot effectively share information with the fanning community.

2. The most vital information such as the dates of pre-kanna and kanna meetings are often intimated to the community by posters and leaflets rather than through the farmer representatives.

3. The agricultural data are collected in many cases by distributary leaders themselves who, as field channel leaders, are ineffective. This leads to unnecessary delays in the collection of some vital information necessary for formulating agricultural programs. For example, the Irrigation Management Division tried to collect information through the distributary organizations in previous seasons on farmers' willingness to grow other field crops, and this led to delays in obtaining the data. In the preparation of maintenance programs, the Division expects the project committee leaders to collect information on broken structures in the field and distributary channels. But the field channel representatives are ineffective, so only a few of the distributary leaders do this. Since they cannot meet all the farmers, their data are incomplete.

Conclusions and Recommendations on Information Flows

A good management information system does not develop on its own. It results from serious attempts at monitoring and evaluating of system performance to fill real management needs. The monitoring and evaluation of system performance leads to communication with farmers and the field level staff and finally to the development of a good information system. Therefore, our recommendations emphasize evaluating the performance of the irrigation system.

1. The Irrigation Department needs to shift its attention to evaluating system performance by monitoring discharges at distributaries instead of the present practice of evaluating only ex sluice duty. This involves construction of more effective measuring structures as the existing ones are defective in many cases. In addition, the theoretical rating curves for distributaries and field channels in the entire command area need to be re-calibrated in the field. This may require a lot of money and energy, but is necessary for developing an information system. It may be most practical to start with a few key measuring points scattered along the main canals, and add other points slowly as management capacity and resources allow. The measuring structures king constructed using phase II funds must be calibrated.

2. The Irrigation Department needs to train its field staff to enable them to collect data with accuracy. Senior field staff should supervise and guide them in order to enable them to be more accurate.

3. Irrigation Department field staff need to establish rapport with fanners and try to identify problems associated with construction and design defects instead of offering temporary solutions and blaming the farmers for their present irrigation practices. This would also enable them to collect more accurate information.

4. The senior irrigation engineer needs to attend farmer organization meetings, project committee meetings, etc., to collect information on the irrigation system from the users' perspectives.

5. The Irrigation Management Division needs to strengthen the farmer organizations in order to have an effective communication mechanism which can be used for information sharing. Recently, under an Institutional

Strengthening Activity supported by the Asian Development Bank, the consultants recommended a set of simple, appropriate irrigation performance indicators, and a methodology for collecting these through fanners' organizations (Uphoff n.d.). We strongly recommend that this approach be pilot-tested in Kirindi Oya, both as a way of improving information flows, and as an activity that could strengthen farmers' organizations.

6. The Irrigation Department should hold regular monthly meetings with its O&M staff and discuss ways to improve irrigation system performance.

Performance Monitoring and. Evaluation of Personnel

In almost every government department, the performance of personnel is evaluated annually in terms of the conditions laid down in the Administrative Regulations. The normal practice, however, is to grant annual salary increments to an officer if he has not committed a serious offence. This allows the officers to do the minimum and still get their annual increments. On the other hand if an officer works hard or has a high level of commitment, he cannot get any formal reward other than the usual annual increment granted to others whose actual performance is minimal.

Therefore, performance monitoring and evaluation of personnel is a strange idea in the Sri Lankan context. Even promotions are granted on seniority and in many cases are based on examinations and not on the commitment or work performance of the officer. Though commendations and recommendations by higher level officers are important, they are perceived as personally biased and are not an encouragement for better performance.

The performance monitoring of personnel can be done based on the task expectations in the job descriptions issued to employees. If we take the job descriptions proposed by the water management consultants in the operation and maintenance manual for Kirindi Oya, the O&M staff is supposed to prepare and submit various reports, collect field data, and attend to specific operational functions as and when required by the Department. In addition they are supposed to attend project level and farmer level meetings and attend to complaints made by farmers in the complaints books kept at unit offices. Therefore immediate supervisors can prepare evaluation reports on staff performance on a monthly basis to use in their annual evaluations. The monthly reports can be kept in the personnel file of the particular employee.

Though the employees can be evaluated based on their performance as per the job description, it is very difficult to recognize and reward them for good performance in the present context. As we have pointed out earlier, a revision of present administrative and financial regulations is required for granting monetary recognition of better performance. In the case of middle and field level officers, the most effective incentive is monetary recognition, since they are poorly paid in comparison with their task expectations. Therefore we suggest paying the field staff an additional allowance based on performance.

Irrigators now hired on a temporary basis should be extended based on their performance as evaluated at the end of every season by a board comprising of technical assistants, work supervisors, and O&M engineers, chaired by the senior irrigation engineer. In the case of irrigation engineers engaged in operation and maintenance, the Department should arrange valued oversees training on O&M both as an incentive and for further improvement of skills.

PATTERNS OF COMMUNICATION, COOPERATION AND CONFLICT AMONG AGENCIES

In previous reports we had documented conflicts between the Land Commissioner's Department and Irrigation Management Division at the project level. It seriously affected the launching of a successful crop diversification program in the project. At the same time we observed a general lack of effective cooperation among the Irrigation Department, Irrigation Management Division, and the Agriculture Department.

But recent developments in the project show much greater cooperation, communication and collaboration among key management agencies. All the agencies were actively involved in planning the crop diversification program for the yala 1990 season. The new project manager (settlement) who is responsible for the overall coordination of this committee has been able to bring the agencies together and they mesh very well for this purpose.

Improved cooperative and collaborative attempts to realize project goals and objectives could be seen in other committees as well. Even the project coordinating committee shows improvement by its attempts to solve various problems. Recent examples include the efforts of the new project manager (settlement) to solve encroachment problems, and the implementation of a land survey in the new areas to settle land questions.

The project manager (settlement), chief resident engineer and other line agency officials attend meetings organized with farmers by the project manager (Irrigation Management Division) in the new area and extend their cooperation to Division activities. The change of attitude of field level officers to the Irrigation Management Division is also noteworthy. The field level officers attend Division meetings more regularly and the chief resident engineer also recently attended a project committee meeting to discuss irrigation problems with farmer representatives. We believe that this cooperative attitude will continue and would enhance the project committee's capacity to handle agricultural plan implementation in the new areas independently when the lower level field channel groups and distributary organizations are strengthened.

While the trends in the new area of the project show some improvement in collaborative and cooperative attempts to realize project goals and objectives, a different trend is observed in the old area. The farmer representatives in the old area as well as the project manager (Irrigation Management Division) for the area feel that the Ellegala system is independent and autonomous from the new project and that it should have priority water rights in both yala and maha seasons for rice cultivation. They prefer that their way of life should remain undisturbed by the various activities and programs in the new area. In chapter 2, we have discussed the serious problem of allocation of water among the subsystems.

Some officials suggest hat the priority issue arises because the project committees have been established on the basis of "old" and "new" areas of the project, and therefore the project managers have a natural tendency to become spokesmen for the farmers in their respective areas. One solution suggested by some Irrigation Department officials is to reorganize the Irrigation Management Division activities based on the **banks** of the Kirindi River and not on "old" and "new" systems in order for the two project managers to be responsible for both types of systems (Weerawila, Pannegamuwa and Badagiriya tanks are located in the right bank of Kirindi Oya while Tissa, Ycda and Debara tanks are in the left bank).

However, this proposal contradicts the basic organizational principles of the Irrigation Management Division committee structure which advocates the establishment of committees based on hydrological boundaries. Field channel and distributary organizations as well as project committees have been formed on this basis. Though the Weerawila and Pannegamuwa tanks are located on the right bank of Kirindi Oya geographically, they have no hydrological relationship with the right bank main canal system. Weerawila and Pannegama tanks as well as Ycda, Debara, and Tissa tanks on the left bank of Kirindi Oya are supplied with water from Ellegala Anicut which is linked to the left bank main canal by a feeder canal. The Ellegala system consisting of these five tanks is a separate hydrological unit depending on the Lunugamvehera reservoir. In addition, at present the O&M and financial responsibilities of the Ellegala and Badagiriya systems lie with the irrigation engineer (Tissamaharama) who is directly under the range deputy director of irrigation in Hambantota.

Further, this proposal does not take account of the human aspects of organizations. The two communities in question have great differences in interests, problems, and needs. Ellegala farmers are an established community with certain norms and practices regarding irrigation water. They attend to canal cleaning and related work without much influence from outside. Their problems are associated with sharecropping and rehabilitation, while the settlers in the new area have many problems such as encroachments, lack of credit and other inputs, lack of participation for canal cleaning without some outside influence, lack of solidarity and sense of community, and lack of water. Therefore the project managers have to prepare training programs and committees based on these field problems. It is easier to deal with organizations based on the system structure, i.e., Ellegala, right bank, and left bank. If the project were divided following the Irrigation Department officers' proposal, it would overburden the project managers with coordination work. Both would have to interact with agency officials in both systems and would have to include the officers of both in their project committees. This would create many difficulties in organizational activities.

Therefore, we do not *see* any rationality behind the proposal to divide the project. into two areas based on banks as far as the Ellegala system is concerned. Badagiriya needs a separate treatment. Even in the case of

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[3]. But since these tanks get drainage water from the right bank, this proposal may be the Department's way of achieving its objective of reallocating priorities.

"administered" rigidly, should be perceived as "fair", and must have high level political support. Much negotiation would be required to come to an acceptable definition of "fair" given the serious conflicting views at present.

Within each of the subsystems, as recommended above, there would be a project management committee at the apex of a structure of farmers' organizations, to decide on the policies for each season given the allocation for that subsystem. At this level there would be flexible, responsive, participatory "entrepreneurial" management of the system.

Therefore, for overall project management, we recommend that the Government of Sri Lanka appoint a senior person as "resident project director" at the rank of an additional government agent. This person would be responsible for overseeing the establishment of decision rules for water allocations among the subsystems in future, setting up the mechanism for making and implementing these decisions, developing plans for achieving the long term objectives of the Kirindi Oya project, and insuring the effective cooperation among the supporting departments and agencies for their full contributions to planning and plan implementation. In order to be effective, the resident project manager must have full political and administrative support. The position of resident project director need not be permanent: we recommend phasing out the position after four to five years, when the project policies should be stabilized.

We also recommend that the Government establish a "water allocation panel" consisting of high-level representatives of the concerned government departments and political interests. This panel, modeled after the Mahaweli Water Management Panel, would be responsible for validating and legitimizing major water allocation decision rules, and the implementation of the agreed water allocation policies each season. Reaching agreement among the various interests will be a political process supported by technical data and advice on possible scenarios. Political support will be required subsequently to institutionalize and implement the agreed policies.

Under this structure, then, two contrasting management principles will be explicitly recognized. At the highest level, there will be strict adherence to administrative rules agreed upon as being fair to all parties given the water resource constraints. At the subsystem levels, there would be flexible management in response to fanners' needs, with a high degree of farmer participation through the project management, distributary, and field channel committees.

WATER USERS' GROUPS

The fourth research question identified in the Inception Report is a series of questions relating to the program to form water users' groups at field channel and above. We have discussed in detail the field channel groups and distributary organizations under the section on the organizational structure of the Irrigation Management Division at project level when answering the first research question. Our three previous reports also focussed much attention on this aspect.

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There have been attempts to form water users' group since the commencement of the first agricultural season in the project. The Kirindi Oya irrigation system, with its design for rotational water issues within field channels, demands such groups for efficient water management. In spite of these attempts we find that both the field channel groups and the distributary organizations are still weak, ineffective and not valued by their members. We suggested in earlier reports that this is mainly due to the problems associated with the strategies adopted by the Irrigation Management Division at the beginning, as well as the serious settlement problems experienced by the farmers at the initial stages of the project, development.

As we have already pointed out in our previous reports, the Irrigation Management Division's initial approach to farmers' organizations in Kirindi Oya had been from the "top and not the bottom," i.e., the distributary level had been organized without.adequate attention to the foundation at the field channel level. This could have been avoided if the Division had taken the initiative to send institutional organizers to the project as soon as the project managers were appointed. However, the project manager had to try to organize farmers without adequate financial. resources, and had no other alternative but to approach members through developing a distributary (or rather hamlet) organization. As a result the objectives of the program could not be explained clearly to farmers and farmer leaders.

Though institutional organizers were appointed later, they left to take up permanent appointments as teachers after a period of one year. Their short stay in the project left no significant imprint on the farming community. The majority of institutional organizers lacked the commitment to work with farmer groups and were highly pessimistic of any possible change in the ideology of peasantry, whom they viewed as a "corrupted lot", i.e., people who are unable and unwilling to adopt "modern" ideas. The pattern of losing institutional organizers before the end of their two year contract is a major problem even in the other projects under INMAS and cannot be avoided without a change in recruitment policy. Their pessimism about a possible change in the community raises fundamental questions about the past recruitment of institutional organizers, which we are unable to answer. However, more recent recruits are GCE A Level-educated, not university graduates, and are from the community, not outside. Their initial work is discussed in chapter 7.

The Irrigation Management Division has thus not yet been able to bring about necessary changes in the farm community to work with other farmers and farmer groups as required by the INMAS program. Instead, the way the program was introduced has tended to promote dependency thinking in the farming community. For instance, the project manager (Irrigation Management Division) tried to solve irrigation problems of the farmers through creating distributary organizations and the project committee. These problems were channeled to the organization by one or two leading farmer representatives. The problems identified were actually those which needed the direct involvement of the Irrigation Department, i.e., things to be done by outside agents. Those problems were directed to the relevant organizations by farmer representatives or by the project manager himself.

There were no activities to encourage farmers to do things by themselves. Though the distributary organizations have been successful in solving irrigation problems and various other community problems this way, the farmer community does not have a high regard for the organization which has contributed so much to solving their problems. Their view is that it is the responsibility of the farmer leaders and distributary organizations to solve their problems without their involvement in the organizational activities. In other words, farmers seem to view the organizations not as farmers' organizations, but as extensions of the government.

In addition, the farmers' perception of the program is that the distributary organizations and project committee should take action to solve all the problems of the community, such as poverty alleviation, providing free rations, and other issues not related to water. This kind of dependency is not strange in the Kirindi Oya farmer community because they have been depending too long on the aid of various agencies even for subsistence. The farmer representatives and distributary leaders who did not have training for guiding people to achieve the objectives of the program tended to play the role of patrons, further encouraging the farmers to depend on them.

The Tasks and Functions of Farmers' Organizations

There are said to be 306 field channel groups and 19 distributary organizations established in the new areas of the Kirindi Oya scheme. They have been formed from the "top and not the bottom" as described above. Some of these organizations, especially those in tract 5, are defunct, though some distributary leaders attend project committee meetings and discuss various problems of the community with the field level officers representing the line agencies concerned.

The major function of the farmers organizations at present is irrigation problem solving through the involvement of the Irrigation Department. In addition they act as pressure groups in the decision-making process for cultivation seasons. However, their involvement in water distribution and maintenance work at field channel level is very unsatisfactory. The on-farm water management practices adopted by farmers results in wastage of water and inequity in water distribution. The rotational issues could not be practiced in any of the seasons observed. The fanners' behavior reflects a highly individualistic pattern and an absence of a sense of community.

Task expectations of farmer organizations by farmers and officials. The task expectations of the water users' groups by fanners are mainly problem solving by the leading men of their organizations. In their view the farmer leaders shouldwork to solve their problems. They should distribute water among the farmers under field channels and organize canal cleaning activities. In this respect they attribute the traditional role of vel vidane (water headmen) to the farmer leaders. The "failure" of the leaders to fulfill these expectations leads to serious criticism of them by farmers. All the seven farmer representatives in tK2 are waiting to resign because of this attitude of farmers, and their lack of cooperation for canal cleaning and water distribution. Though farmers are well aware that they have to clean and maintain field channels, their work in this respect is limited to cutting weeds and excludes desilting and minor repairs to canal bunds and structures under the field channel.

The officers of the Irrigation Department expect farmer organizations to clean and maintain field channels, adhere to the cultivation calendar, inform them of irrigation difficulties and problems associated with irrigation water, and distribute water equally within field channels. From their point of view the organizations have so far failed to attend to these functions, especially to distribute water equally. Their contributions to O&M of the system are also not satisfactory. However, the organizations have been effective in channeling irrigation difficulties to the Department from the engineers' point of view.

The Irrigation Management Division has high expectations of the organizations. It expects farmers to handle O&M activities at the field channel level at present, and take responsibility at the distributary level in the immediate future, and participate actively in planning and implementation of agricultural programs in the project. However, farmers, farmer lenders, as well as the officers of the other government departments view the organizations as still too weak to carry out many of these functions. Since the farmer groups are still not in a position to attend to O&M work under field channels independently, handing over additional responsibilities would create many more problems in their view.

Are the Resources Adequate to Achieve the Objectives?

As we have emphasized in our previous reports, the problem of promoting farmer organizations is seen as peripheral to the overall project objectives, and as something only the Irrigation Management Division is responsible for -- as a marginal agency without power and authority dealing with a peripheral problem. In Kirindi Oya the organizational activities rest on the project manager who had neither office nor staff at the initial stage. The institutional organizers were sent some two years later to assist him. They left after one year. The program still suffers from lack of resourceful personnel to organize farmer groups in an effective way. Instead of appointing graduates without any organizational skills, action should have been taken to try alternatives such as using officers in the government service with such talents and skills, on secondment to the Division, or using less-educated personnel such as Agriculture Diploma holders or even, as now being tried, A-Level people. Lack of financial resources to hire more qualified personnel by offering better salaries has been mentioned as an important constraint.

It is also evident that the financial resources invested for the promotion of farmer organizations is inadequate. The funds allocated to train farmers and farmer leaders in this year suffice only to train a very insignificant number of them. The entire amount allocated for training is less than Rs 75,000/-, i.e. under US$ 2,000., for 1989 in the new area of the project. In addition the training program suffers due to lack of resource persons to conduct them. This also illustrates the position of the Irrigation Management Division without sufficient financial. resources to hire experienced personnel to conduct such training programs.

Conclusions and Recommendations on Farmers' Organizations

Many of the impediments to organizing effective fanners' organizations are beyond the control of local project officials. The security situation is one obvious example. Another is the continuing lack of a legal framework for legitimizing farmers' organizations for irrigation management. This section focuses on things we think are actionable by the Irrigation Management Division and other agencies involved in Kirindi Oya.

1. It was evident from our interviews with fanners and fanner representatives that they are not aware of the objectives of the program and their responsibilities towards it. Therefore, the Irrigation Management Division needs to field effective institutional organizers and guide them to work with farmers to explain the objectives of the program. By December 1989 some A-Level people had been recruited and were under training in Polonnaruwa, though we question whether two weeks' training is sufficient. The Division must monitor their performance closely and guide them to establish rapport with fanners and organize farmers effectively. As discussed in chapter 7, these organizers were not very effective in the first half of 1990.

2. The institutional organizers should guide farmers to solve the problems within field channels with community participation instead of directing even minor difficulties to the Irrigation Department. Field channel cleaning and maintenance activities should be encouraged on a group basis instead of the present practice of individuals doing assigned sections as and when they prefer. This would encourage them to participate in group work and contribute to developing solidarity.

3. The Irrigation Management Division should avoid the present practice of problem solving by becoming directly involved with the Irrigation Department and other line agencies. Instead, the members of the field channel groups should be encouraged to discuss their problems and develop solutions themselves. Only serious problems needing the attention of higher level officers should be taken to the distributary organizations. The line agency officials should be encouraged to participate at those meetings to discuss these problems and assist farmers in finding solutions. The farmer representatives in turn should be encouraged to inform the other farmers about the decisions taken at distributary organization meetings.

4. Related to the previous point, project managers of the Irrigation Management Division must be encouraged to stop acting as the farmers' spokesmen. We have documented in previous reports the perception of other officers that fanners need not be invited to some committee meetings as the project manager could speak for them. This perception has been encouraged to some degree by project managers, since it is the only source they have for claiming any authority in the absence of control over budgetary or other resources, This tends to continue the dependency syndrome characteristic of Sri Lankan settlement schemes.

5. The farmer representatives are not entitled to claim any payments for the work they do for the community. It is therefore necessary to encourage the farming community to consider whether some compensation ought to be offered. Perhaps appointing them under the Agrarian Services Act would provide some incentive, since they would then he entitled to compensation from farmers.

6. The farmer leaders should be encouraged to study various alternative methods for water distribution within field channels during the land preparation period and to find solutions to problems by discussing them with group members. They should be trained in on-farm water management practices and informed on the practical implications of the design of the irrigation system and the necessity for rotational issues. Other farmers should also be trained on these aspects eventually.

7. The Irrigation Management Division project managers should encourage the institutional. organizers to organize farmer groups independently, i.e., without the direct intervention of the project manager; and he should focus more on the supervision and performance evaluation of institutional organizers. Weekly meetings with institutional organizers, and periodic in-service training to understand their problems and provide guidance would help.

8. The Irrigation Management Division should provide sufficient financial assistance and experienced personnel to strengthen the training program at the project level. The training program needs to be prepared in consultation with project managers in order to address field level problems specific to the project.

9. Irrigation Management Division officials from head office need to supervise and evaluate the performance of the project managers by holding regular meeting with them in the field.

10 The Irrigation Management Division should proceed very slowly with the handing over of responsibilities for distributary management to farmers' groups until they exhibit the management capacity to manage the system below the field channel turnout. Handing over these responsibilities prematurely would further discourage the farmers and farmer groups. An intermediate step might be to implement the proposed participatory performance monitoring system (LBI 1989: chapter 4; see above).

COOPERATION AND COMMUNICATION AMONG AGENCIES AND FARMER GROUPS

In previous reports, we have documented a pattern of resistance to the Irrigation Management Division-formed farmer groups among some officials, and resistance to farmer representatives participating in project level committees. However, with the appointment of a new project manger to handle settlement- and land-related activities, the situation shows a change for the better. Our recent, observations substantiate that there is a more cooperative attitude towards farmers' organizations by the major agencies involved i.n the project. There is a genuine attempt by the Land Commissioner's and Irrigation Departments to solve farmers' problems in consultation with farmer representatives attending the subcommittee of project coordinating committee.

However, the fanner organizations are still weak. One of the main problems documented is the existence of a vast communication gap between the farmers and farmer representatives as well as between the officers and farmers. The reasons for this include the lack of participation at distributary organization meetings by the field level officers, and the lack of initiative by farmers to hold regular field channel group meetings.

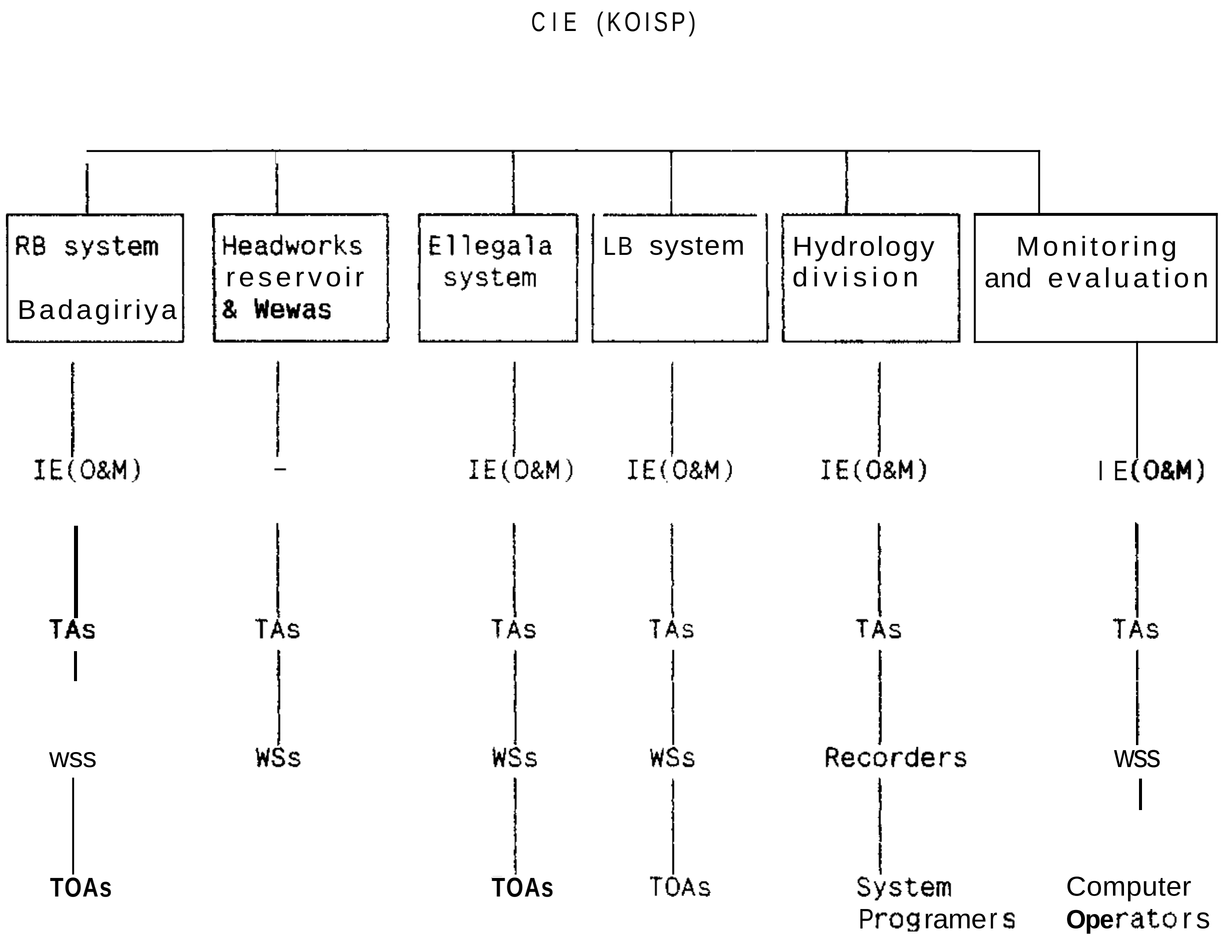
Previously, the lack of participation by some officials at distributary organization meetings was mainly due to conflicts that some line agencies had with the Irrigation Management Division. This problem has been resolved now. Rut in many cases the field level officers still do not participate at these meetings because they do not receive regular invitations indicating the date and time of meetings, and agenda. We recommend that the Irrigation Management Division should take the initiative to guide distributary leaders to invite the field level officers to such meetings through the heads of agencies. This is vital to build up a cooperative attitude, communication and mutual trust between the farmer groups and officials.

In addition we have recommended above that the responsibilities of the line agency officials to the program for promoting farmer organizations be written into their job descriptions, and payment of some allowances be made for their active participation in the program. We further recommend that project level higher officers and field level officers of line agencies be given some training in order to assist them to adjust to the requirements of the program as this work involves a considerable bureaucratic reorientation, which does not happen automatically. Finally, we recommend that field channel groups be encouraged to hold regular meetings to reduce the communicntion gap 'between farmers and farmer representatives.

Beyond these points, a fundamental weakness remains in the overall project management structure. This is that there is no overall authority with a mandate to achieve the overall. long-term objectives of the project, in terms of balanced socio-economic development, and supporting the development of an implementable and profitable cropping pattern. Officials of each department focus on achieving the objectives defined for that department, which may or may not completely support the longer term objectives. A more integrated, authoritative, politically supported management structure is required.

We have therefore strongly recommended above the appointment of a senior overall "Resident Project Director" (the term "manager" is already over-used in Kirindi Oya) with full authority to insure the integration of each department's contribution to the overall objectives. This Director should have budgetary authority over line department heads in the project area. He would also administer the water allocation rules, and chair the water allocation panel meetings recommended above.

Figure 3.01. The proposed organizational structure for O & M organization in Kirindi Oya



Kev to abbreviations
CIE is chief irrigation engineer
KOISP is kirindi Oya Irrigation and Settlement Project
IE is irrigation engineer
RB and LB are right bank and left bank, respectively
TA is technical assistant
WS is work supervisor
TOA is turnout attendant (irrigator)

CHAPTER IV

DESIGN-MANAGEMENT INTERACTIONS

I

Research conducted in many parts of the world reveals that there is a gap between the levels of potential and actual performance of irrigation projects. This gap can be attributed to various physical, social, institutional and managerial factors. One important factor is the inadequate attention being paid in planning and design of irrigation infrastructure to ensure a high degree of conformity between the design and actual operation. It is often evident that the design of the physical system embodies a set of fundamental operational and institutional assumptions, upon which the degree of success and quality of operation depend. In most instances, there is a high degree of interdependency between the technical, operational and institutional assumptions and requirements. In some cases, the technical and operational assumptions are either not realistic or difficult to realize within the institutional environment under which the irrigation system operates. Therefore, in a new irrigation settlement project like Kirindi Oya it is useful to review the design-management interactions within the institutional environment.

Research Questions

As outlined in the <u>Inception Report</u> (IIMI 1988a:15), this research component assesses and compares potential and actual performance, management options, andorganizational requirements of the fieldchannel and turnout designs and suggests alternative water distribution methods that will improve performance and manageability.

With these broad objectives in mind, the research on design-management interactions was guided by the five research questions listed in the Inception Report (IIMI 1988a:15). Those research questions are summarized here for easy reference.

1. What were the operational and institutional assumptions made in designing the turnouts and field channels?

2. What are the feasible options for water distribution among fanners? What is the flexibility in operation that fanners can utilize particularly when there is a mix of rice and other diversified crops under the turnout?

3. What are the levels of cooperation among farmers and types of organizations of farmers required for operating the rotations and sharing water under different conditions of resource availability --when water supply is adequate, and when there is shortage of water supply compared to the demand?

4. What is the impact of the field channel and turnout design and operation on the operation of the distributary canal? How frequently does the flow vary in the distributary and field canals?

5. What are alternative water distribution methods and practices that can lead to improved performance at the tertiary level in terms of equity of water distribution and water use efficiency? What are the management implications of adopting them?

Objectives of Irrigation-Settlement Projects

The choice of the basic elements of design and the size and scale of the project components are largely determined by the basic objectives of the project. The size and scale of the basic physical project components emerge from a complex interaction of the objectives of the project along with physical factors such as hydrology, topography and climate, and social, economic, and agronomic considerations.

The objectives of a typical irrigation settlement project can be viewed from different perspectives: the levels of farmers, agency personnel operating the system, and the nation. The objectives at these different levels show differences in interests and some degree of incompatibility among objectives. It is the planner's responsibility to blend these differences in interests and objectives at different levels in order to have an optimal choice of design elements.

At the national level, the objectives are to increase the food and fibre production, provide land and shelter for a maximum number of poor landless families, generate employment, and achieve self sufficiency. At this level the investment for a settlement project is partially an economic venture which brings economic returns to the national income in the long term. This objective interacts with the available resources of land and water to determine the area to be developed for a pre-determined cropping pattern which enable the settlement of the maximum possible number of landless families.

The objectives of the agency responsible for the operation of the system narrow down from the national objectives to a concern with allocating the available seasonal quantum of water among the maximum possible farmers in compliance with the basic water allocation and distribution scenarios as agreed with the farmers at the cultivation meeting and in conformity to the design and operational rules adopted by the agency. Implicit within this objective, the agency is concerned with providing reliable and equitable supply of water with simplicity of operation. These concerns with the interactions of institutional factors have given rise to the choice of the size of turnout area, field canal, capacity, size of farm turnout, etc.

The objectives of each individual farmer are somewhat in conflict with the objectives at the other levels. The individual farmer is concerned with the production of enough food for his subsistence and to maximize his income in the short run while trying to upgrade his quality and standard of living in the long run. Ideally the individual farmer prefers the most profitable crops that fit into his capability, with either a continuous delivery of water or a delivery on demand. This is a major area of conflict in objectives at his level with the other two levels. In particular the preferences of each individual farmer are not necessarily in harmony with the betterment of the entire fanning community. Therefore this influences the choice of water distribution which has to ensure an equitable supply to the farming community at large.

Kirindi Oya Project: Background

The Kirindi Oya Irrigation and Settlement Project can basically be characterized by 1) the existence of an old irrigation settlement before the new reservoir project was commissioned, and **2)** the limited availability of water for double cropping in the newly developed command area. These two basic characteristics have influenced the selection of cropping patterns, and apportionment of priority for water in the planning of the project. Though the irrigation system has been designed to cater for rice irrigation in both yala and maha seasons, the seasonal operation of the system is confronted with two basic challenges in order to conform with the basic project objectives. These are:

1. selection and implementation of an appropriate cropping pattern to make use of the limited supply of water to best achieve the objective of the project; and

2. selection of appropriate operational scenarios which do not jeopardize the water rights of the old system settlers and the equitable benefits to the new settlers, while achieving reliability and adequacy of water supply.

The second Appraisal Report prepared for the project (ADB:1982) envisaged a 200 percent cropping intensity with a mixture of rice and non-rice crops. The third Appraisal Report prepared for Phase II (ADB: **1986)** envisaged through a simulation study a 170 percent cropping intensity (100 percent in maha and 70 percent on an average during yala) with a mixture of rice and other field crops. More recently, the water management consultants have proposed as the "most feasible" scenario a mixture of rice and other field crops on lowland areas, and irrigated and rainfed crops on upland areas (Water Management Consultants **1987**: volume 1).

The Irrigation Department recently proposed a 'cluster system' for allocation of water. In this proposal water is to be issued first to head-end tracts of the new area and the drainage water coming from the new tracts has to be utilized to fill the tanks of the old Ellegala system, to enable the old settlers to make the best use of drainage water from upper areas of the new system. This, on paper, appears to be a feasible and appropriate strategy in order to ensure the overall water use efficiency of the water-short Kirindi Oya system. However, the old settlers collectively resisted the proposal and rejected it on the grounds that the new proposal would jeopardize their traditional water use rights.

The degree of success in canal operation depends upon the reliability, adequacy and equity of water supply. Examining these parameters involves many issues which can be broadly divided into two categories: technical and non-technical. The technical issues address the basic design assumptions made at planning and designing of the project as well as the subsequent operation of the system. The non-technical issues embrace the operational, institutional and organizational assumptions and procedures which are complementary to the technical issues.

The treatment of design-management interactions in Kirindi Oya should address one fundamental question: whether the irrigation system design has enough capability to meet the crop water requirements at the farm level with a reliable, adequate and equitable supply. This is considered the number one requirement that must be satisfied to certify that the irrigation system is capable of functioning satisfactorily. If not, one can investigate the technical reasons why such a conformity between the design and operational capacity does not exist. If the system is capable of delivering the supplies as planned or designed, and in actual practice this does not happen, then one can look into the operational procedures and organizational structures and their implications to identify the constraints, and possible improvements necessary to close the gap between actual and intended performance.

PROCEDURES FOR ESTIMATION OF WATER DEMAND

Technical Note no. 6 of the Irrigation Department (Irrigation Department 1981) describes the procedures to be adopted in determining the crop water requirements for rice and subsidiary food crops. The basic elements of the computational procedures and the assumed parameters are presented below.

1. The evapotranspiration (ET) of the reference crop is computed by the Modified Penman's method for the climatic variables at Mahailluppallama. This is considered to be representative for projects in the dry zone and intermediate zones of Sri Lanka. The 75 percent exceedence probability evapotranspiration values at Mahailluppallama are recommended and adopted for the design. These reference ET values are compared with the values computed by modified Penman's method on the basis of meteorological data from Hambantota and pan evaporation observations at Tissamaharama. The 75 percent probability evapotranspiration values at Angunukolapellessa are used for the preparation of water delivery schedules of the Irrigation Department. The pan-evaporation data at Weerawila monitored by IIMI, is provided in Table 4.01.

A summary of the seasonal total reference crop evapotranspiration deducted from Table 4.01 is as follows:

	Reference crop ET (mm)	
	Maha season	Yala season
Mahailluppallama	786	1060
Hambantota	1033	1083
Angunukolapellessa	856	982
Weerawila (tract 5)	905	1252

This table indicates that the crop water requirements during any typical yala season can be higher than the assumed values by 27 percent for the operational schedules, implying the importance of monitoring climatic variables in the project area.

Table 4.01. Comparison of monthly reference crop ET values at Mahailluppallama, Hambantota and Weerawila* (* project area right bank tract 5)

Month	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
	Maha season (Oct - March)						Yala season (April - August)					
M. Illuppallama												
mm	157	109	117	119	127	157	150	162	175	190	193	190
mm/day	5.1	3.6	3.8	3.8	4.8	5.1	5.0	5.2	5.8	6.1	6.2	6.3
Hambantota [a]												
mm	173	154	150	177	180	200	183	183	174	185	181	177
mm/day	5.5	5.1	4.8	5.7	6.4	6.4	6.1	5.2	5.8	5.9	6.2	5.9
Angunukolapellesa [b]												
mm	149	103	116	149	155	184	149	160	155	175	165	178
mm/day	4.8	3.4	3.8	4.8	5.5	5.9	5.0	5.2	5.2	5.6	5.3	5.9
Weerawila [c]												
mm	216	165	161	93	134	136	168	201	234	186	229	234
mm/day	6.0	5.5	5.2	3.0	4.8	4.4	5.6	6.5	7.8	6.0	7.4	7.5

a. Based on the meteorological data at Hambantota and pan evapration observation at Tissamaharama for a time series of 26 years.

b. Based on the meteorological data at Angunukolapellessa agriculture research station.

c. Based on pan-evaporation observations in right bank Tract 5 by IIMI for one year.

2. The growth of the crop from sowing to maturity is considered in four stages, namely initial (sowing and seedling growth), development (vegetative growth), mid (reproductive growth) and late (ripening). The evapotranspiration of the crop differs for each crop growth stage and this difference is accounted for by multiplying the reference crop ET by a crop factor (Kc) for each growth stage. The growth stages and their respective Kc values for the crops common in Sri Lanka are shown in Annex 4.01.

3. The irrigation requirement is the amount of water to be delivered to the farm for land prepration and crop growth, when the effective rainfall is insufficient to meet such requirements.

4. The amount of water and the number of applications required for land soaking and land tillage (land preparation) which typically includes first ploughing, second ploughing and puddling vary considerably with the type of soils. For rice in the clay or heavy soils generally encountered in the lowland forms (LHG soils), the design procedure recommends two applications of water: first application of 100 mm in 5 days (2.31 l/s per ha) for land soaking and 75 mm in 10 days (0.87 l/s per ha) for land tillage, totalling 175 mm spread out over 15 days (1.35 l/s per ha). When transplanting is done instead of broadcasting it is further recommended that the land tillage requirement may be provided in two applications of 45 mm for land tillage and 30 mm prior to transplanting. These recommendations implicitly assume a land preparation period of 2 weeks for a typical farm allotment, which allows 5 days for land soaking and 10 days for land tillage. However, when rice is cultivated on upland soils consisting of well-drained Reddish Brown Earth (RBE), the corresponding land soaking and land tillage requirements are obviously high. The design procedures for the estimation of irrigation requirements do not recommend any corresponding values for RBE soils.

The Operation and Maintenance Manual (O&M Manual) prepared by the Water Management Consultants (1989) recommends that 50 mm is sufficient for land soaking if the land soaking is performed in a week. This would mean a requirement of 7 mm/day (0.81 l/s per ha). It also recommends that puddling can be performed with a layer of approximately 50 mm of water on the field. This would mean a land tillage requirement of 7 mm/day (0.81 l/s per ha), if land preparation is performed in one week, or 3.5 mm/day (0.40 l/s per ha) if the land preparation is spread out over two weeks (Water Management Consultants; 1989: Section IV4, pp.22-23).

The values recommended by the design guidelines and the values recommended by the water management consultants for the operation of the system are compared with the observed values in Distributary Canal 2 (DC2) of Branch Canal No. 2 (BC2) of right bank tract 5 in yala 1989 season in Table 4.02.

Table 4.02. Land soaking and land preparation periods, and irrigation water requirements in Kirindi Oya

	Design Guideline	Operation Guideline	Observed Values DC 2*
Land Soaking			
Period (days)	5	7	8
Requirement (mm)	100	50	400
(mm/day)	20	7	50
(l/s per ha)	2.31	0.81	5.78
Land Preparation			
Period (days)	10	14	30
Requirement (mm)	75	50	430
(mm/day)	7.5	3.5	16.0
(l/s per ha)	0.87	0.40	01.85
Total			
Period (days)	15	21	38
Requirement (mm)	175	100	880
(mm/day)	11.7	4.76	23.2
(l/s per ha)	01.35	0.55	02.68

* These figures indicate the actual water use, not the requirement.

The table shows the large difference between the assumed land preparation requirements and the actual water used by a typical farmer in Kirindi Oya (in DC2 of right bank tract 5). This indicates that what is actually happening in the field is different from what has been assumed in the design and operation models. A rough estimate of the amount of water being used by the farmer for the land soaking and preparation can be computed as follows:

a. Land soaking water (in week 1)

1 m depth of soil with porosity 35 percent with antecedent moisture content of 25 percent at the time land soaking begins.

Hence additional water required for completed saturation	=	100 mm
Topping up (ponding) water	=	100 mm
Seepage and Percolation losses in a week 7 x 10 mm/day	=	70 mm
Evaporation losses 7 x 5 mm/day	=	35 mm
Total	=	305 mm

b. Land preparation (in week 2 and 3)

The requirement is only to allow for S&P losses = 140 mm

Thus the total water requirement for land prepration of a typical farm can be as high as 445 mm spread over a period of three weeks.

When non-rice crops are cultivated on RBE soils, land soaking is not separately provided for. The Irrigation Department design recommends one combined application of about 40 mm for land tillage at any pre-determined time in the land preparation period of 15 days. Some research conducted elsewhere recommends 40 to 70 mm (Dimantha, S. 1987).

5. The seepage and percolation losses (S&P) are assumed as 3 mm/day for maha and 5 mm/day for yala for lowland farms typically consisting of LHG soils. When rice is cultivated on upland farms consisting of RBE and intermediate soils, the corresponding S&P values should be higher than that of LHG soils. However, no recommended values are found in the design procedures and guidelines. When non-rice crops are cultivated for the purpose of computing the irrigation water requirements at farm level, the land soaking and preparation activities are assumed to commence in staggers. The design guidelines recommend three staggers in such a way that water issues and farm operations are to be carried out on 1/3 of the command area at any given time. This means that the cropped area is divided into three equal staggers with a time lag of two weeks between the commencement of each successive stagger.

For the purpose of scheduling irrigation, the O&M manual recommends a somewhat different stagger. It suggests a distribution of 20, 60 and 20 percent of the command area for staggers 1 to 3 respectively with a time lag of only one week between each successive stagger.

6. Technical note No. 6 recommends the following values to be considered as effective rainfall (Re) in the estimation of irrigation water requirements for design purposes.

For rice: Re = 0.67 (R-25.4) subject to a maximum value of 225 mm and zero when actual rainfall (R) is 25 mm or lower.

For non-rice crops: Re = 0.67 (R-0.25) subject to a maximum value of 75 mm or zero when R is 6 mm or lower.

The actual rainfall to be considered for estimating the effective rainfall is the 75 percent exceedence probability rainfall at the required location. However, the operation and maintenance manual recommends the adoption of the 70 percent of the 80 percent probability of exceedence rainfall as the effective rainfall in the preparation of water delivery schedules and planning water deliveries.

Based on the 80 percent probability rainfall at Tissamaharama, deduced from the data from more than 50 years, the two recommendations on effective rainfall compare as shown in Table 4.03.

Table 4.03. Comparison of effective rainfall suggested by design guide lines and O&M Manual

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Monthly rainfall R(mm)	77	135	66	26	6	24	56	11	4	0	0	0
ER												
Design (mm)	34	73	27	0	0	0	20	0	0	0	0	0
O&M manual (mm)	54	94	46	18	4	16	35	8	0	0	0	0

Table 4.03 indicates that the effective rainfall estimated by the Water Management Consultants' (1989) O&M manual is higher than the design values. These values are useful in preparing water delivery schedules before any cultivation season but their practical significance in actual operation is somewhat limited. What is more important in real operation is not only the amount of rainfall, but the temporal and spatial distribution of any rainfall event. Though effective rainfall is very difficult to estimate in the actual operation, what is required is for the Irrigation Department to prepare some guide-lines on how the irrigation deliveries should be adjusted to take the best use of rainfall for a given rainfall event. In other words, the Department should know for how long the irrigation can be temporarily withdrawn for a known rainfall event.

7. The loss from seepage and percolation and evaporation in conveying the water from the reservoir to the farm is provided for in the conveyance efficiency (Ec) of the distribution system. The values assumed in the design and the values recommended by the operation and maintenance manual for irrigation scheduling are provided in Table 4.04. The various efficiency parameters adopted for the design and the preparation of water issue schedules are also indicated in Table 4.04.

The preceding paragraphs describe the data, assumptions and parameters adopted by two different models to estimate the irrigation water requirements at farm level as well as at the higher levels of the distribution and conveyance system. These data and assumptions have inherent uncertainties and inaccuracies to a degree that they *can* influence the estimated values of irrigation water requirements at various levels of the irrigation distribution system.

Assuming the first water issue for land soaking commencing from 1 October and 15 April respectively for typical maha and yala seasons, the peak irrigation water requirements computed by the two models are as indicated in Tables 4.05 and 4.06.

Table 4.04. Comparison of efficiency parameters in new area of Kirindi Oya

	Design Guidelines	O&M Manual	Remarks
Application Efficiency			
for LHG farms	0.60	0.70	0.50 for OFCs
for RBE farms	0.55	0.70	(O&M manual)
Conveyance Efficiency			
Main Canals	0.65	0.95	A conveyance
Branch Canals	0.65	0.95	efficiency of 0.7
Distributary Canal	0.75	0.95	computed in DC2 of
Field Canals	0.80	0.95	RB Tracts in yala 1988 season
Overall Irrigation Efficiency	Rice	OFC	
LB Tract 1, 2	0.65	0.50	
LB Tract 3, 4	0.60	0.45	
RB Tract 1, 2	0.65	0.50	
RB Tract 3, 4	0.60	0.45	
RB Tract 5, 6, 7	0.60	0.45	

Table 4.05. Daily peak irrigation water requirements as per O&M manual

	Maha		Yala	
Rice	RBE	LHG	RBE	LHG
FIR[a]	13.8 mm 01.50 l/s ha	11.4 mm 01.32 l/s ha	13.8 mm 01.60 l/s ha	11.4 mm 01.32 l/s ha
AT FTO[b]	19.7 mm 02.28 l/s ha	16.3 mm 01.88 l/s ha	19.7 mm 02.28 l/s ha	16.3 mm 01.88 l/s ha
AT FC[c] head	21.2 mm 02.45 l/s ha	17.5 mm 02.03 l/s ha	21.2 mm 02.45 l/s ha	17.5 mm 02.03 l/s ha

Table 4.06. Daily peak Irrigation water requirements as per design guidelines

	Maha		Vala	
Rice	IBE	LHG	RBE	LHG
FIR	.3 mm .96 l/s ha	8.3 mm 0.96 l/s ha	12.6 mm 1.44 l/s ha	12.6 mm 1.43 l/s ha
AT FTO	5.0 mm .74 l/s ha	13.0 mm 1.60 l/s ha	22.6 mm 2.26 l/s ha	20.8 mm 2.4 l/s ha
AT FC head	8.8 mm .18 l/s ha	17.3 mm 2.00 l/s ha	28.0 mm 3.27 l/s ha	25.7 mm 2.48 l/s ha
	Ipland rice		150 day Chillies	
FIR		6.8 mm 0.78 l/s ha		12.6 mm 1.46 l/s ha
AT FTO		12.4 mm 1.43 l/s ha		22.8 mm 2.64 l/s ha
AT FC head		15.6 mm 1.79 l/s ha		28.5 mm 3.3 l/s ha
	Ipland rice		Soyabeans	
FIR		6.8 mm 0.78 l/s ha		12.6 mm 1.45 l/s ha
AT FTO		12.4 mm 1.43 l/s ha		22.8 rnm 2.64 l/s ha
AT FC head		15.6 mm 1.79 l/s ha		28.6 mm 3.3 l/s ha

[a) FIR - Field Irrigation Requirement
(b) FTO - Farm Turnout
(c) FC - Field Canal

DESIGN OF IRRIGATION DISTRIBUTION SYSTEM AND TURNOUT AREAS

Design Canal Duties for Field Channels

The canal duty, which is required to determine the canal capacities, is deduced from the computation of the peak irrigation water requirement for any derived cropping pattern. The trial computations for alternative cropping patterns indicate that the field canal duty is not very sensitive to the selected cropping pattern. The design duty for a field canal serving 100 percent LHG farms and 100 percent RBE farms are 1.78 l/s per ha and 3.61 l/s per ha respectively (regardless of crop). The field canal duty of 3.61 l/s per ha is derived on the assumption that when upland farms (RBE soils) are cultivated with a combined cropping pattern of upland rice with non-rice crops, the irrigation is restricted to daylight hours, i.e., 12 hours per day. In contrast, the duty for lowland farms (LHG soils) is arrived at on the assumption of round the clock (24 hours per day) irrigation.

These design duties have a direct relationship with the design capacity of a field canal and the size of the turnout area served by it. The implicit assumption underlying the design capacity of a field canal and the size of the turnout area is that a stream size of about 14-15 l/s (half a cusec) is the best stream size manageable by a typical farmer for a 1 ha allotment. The layout of farms under a field canal is such that a single farm turnout structure can typically deliver water to a maximum of 2 farms at a time. The structural design of the farm turnout does not provide for control arrangements at the farm inlets to regulate the flow from the field canal to the farms; it is designed for the delivery of 14 l/s to the farm when it is fully opened and zero delivery when it is closed by the farmers. Thus, to ensure equity of water delivery, the design of the field canal is such that it serves only two. This is the rationale for standardizing the capacity of a typical field canal at 28-30 l/s or one cusec.

There exist direct relationships among: 1) the design duties of the field channel; 2) the design capacity of a field channel; 3) the size of the turnout area served by any field canal; and 4) the proportion of RBE soils and LHG soils in that turnout area. It was earlier mentioned that the design duties of a typical field canal are 1.78 l/s per ha and 3.61 l/s per ha for LHG and RBE soils respectively. This design duty is rather independent of the cropping pattern considered for the deduction of those values. This means, if the above duties are adopted for the determination of the size of the turnout area served by any given field canal, with due consideration to the respective areas of LHG and RBE soils in the command, the standard field canal of 28 l/s capacity should theoretically provide flexibility in meeting the peak irrigation water requirements for any cropping pattern adopted by the farmers in that field canal. This flexibility has been provided in the design by limiting the size of the turnout areas to a maximum of 18 ha (30/1.78 ha) for 100 percent LHG farms and 8 ha (30/3.61 ha) for 100 percent RBE farms. However it should be noted that the duty for RBE soils (3.61 l/s per ha) used for the determination of the maximum size of the turnout area (8 ha) assumed only 12 hours of irrigation per day. This means, if the irrigation is provided round the clock instead of day light hours, the turnout area serving 100 percent RBE soils can be larger than this maximum size.

Table 4.07. Comparison of the design capacities (existing) with the required capacities of distributaries (Dcs) in Kirindi Oya

DC	Area (ha)	Design)ischarge (l/s)	Design Duty (l/s/ha)	Length of DC (m)	No of F s served tandard	No of F s served lon standard	Sum of FC's Capacity (l/s)	um Fc capacitier
RB tract 1								
DC 2	49	120	2.4	550	4	–	113	1.06
Dc 3	297	600	2.0	–	14	7	666	0.90
DC 4	158	480	3.0	3637	13	–	370	1.30
DC 5	190	300	1.6	2286	6	6	385	0.78
RB tract 2								
DC 1	82	120	1.5	1172	3	2	158	0.76
DC 2	268	480	1.8	8242	16	3	574	0.84
Dc 3	78	120	1.5	3492	8	–	226	0.53
Dc 4	38	90	2.4	216	3	–	85	1.06
DC 5	83	120	1.4	1365	7	1	257	0.47
DC 6	169	300	1.9	3680	12	1	377	0.80
Dc 7	70	120	1.7	2016	6	1	170	0.71
DC 8	47	120	2.6	82	3	1	115	1.04
DC 9	58	120	2.1	1682	7	–	198	0.61
RB tract 5								
Dc 18	30	30	1.0	1030	1	1	58	0.52
DC 1	22	60	2.7	40	2	–	56	1.07
Dc 1A	17	60	3.5	60	2	–	56	1.07
DC 9	60	120	2.4	840	4	–	113	1.06
DC 11	127	270	2.1	2020	6	3	262	1.03
Dc 12	29	60	2.1	300	3	–	85	0.71
DC 13	139	240	1.7	2660	11	–	311	0.77
RB tract 5	**C2 – San**	**e sub-sy**	**em**					
DC 8	57	170	2.9	–	6	–	170	1.00
DC 2	90	170	1.0	1036	7	–	198	0.86
DC 3	75	150	2.0	1350	4	2	169	0.89
DC 4	37	90	2.4	196	3	–	85	1.06
DC 5	71	–	–	1350	3	2	150	–
DC 6	50	180	3.6	120	[illegible]	1	145	1.24
DC 7	90	190	2.1	1020	[illegible]	1	207	0.92

Table 4.07. Comparison of the design capacities (existing) with the required capacities of distributaries (DCs) in Kirindi Oya

Continued

DC	Area (ha)	Design Discharge (l/s)	Design Duty (l/s/ha)	Length of Dc (m)	No of FCs served Standard	No of FCs served Non standard	Sum of FC's Capacity (l/s)	Design discharge /Sum Fc capacities
LB tract 1								
DC 1	230	-	-	4940	8	7	441	-
Dc 2	50	90	1.8	280	1	2	88	1.02
Dc 3	94	210	2.2	1250	4	2	188	1.12
DC 4	89	180	2.0	890	7	1	235	0.77
Dc 5	49	120	2.4	430	4	-	113	1.06
DC 6	35	90	2.6	240	3	-	85	1.06
Dc 7	191	360	1.9	3190	18	-	509	0.71
LB tract 2								
DC 1	65	120	1.8	470	2	2	114	1.05
DC 2	138	510	3.7	1500	5	3	240	2.13
DC 3	39	90	2.3	560	3	-	85	1.06
DC 4	80	180	2.3	400	3	2	-	-
DC 5	188	360	1.9	2280	13	-	368	0.98
DC 6	65	150	2.3	960	2	2	136	1.10
DC 7	51	120	2.4	430	4	-	113	1.06
DC 8	25	60	2.4	-	2	-	60	1.00
DC 9	186	360	1.9	2190	7	5	377	0.95
DC 10	38	90	2.4	230	1	2	60	1.50

Though 12 hour or daylight irrigation has been assumed for RBE soils, the design does not indicate what happens to the flow in the canals during the remaining 12 hours at night. In a system where night storage facilities are not available and alternative opening and closing of canal turnout gates leads to fluctuation of water levels in the canals, the operating agency is compelled to operate the system around the clock for both rice and non rice crops. This is an important drawback in the system design.

Table 4.07 indicates the turnout areas served by each distributary canal of the right bank tracts 1, 2, 5 and left bank tracts 1 and 2, and the proportions of RBE and LHG soils in each turnout area. It is seen that in general, the turnout areas are within the limits of the design, offering theoretical operational flexibility for a variety of cropping patterns, from 100 percent rice in both RBE and LHG soils to a mixture of rice with non-rice crops or upland rice. Turnout areas occasionally exceed the design limits and are as large as 24 ha.

Design of Canals

The design dimensions of a canal are determined to provide permissible velocities in the canal that would theoretically prevent silting and scouring, for a design bed gradient and the assumed value of Manning's rugosity coefficient(n) for the nature and roughness of the canal bed. The rugosity coefficient is usually assumed as 0.025 for earthen excavated canals. The permissible velocity that would limit either silting or scouring is adopted as 0.46 meters per second (m/s) for earthen canals up to a capacity of 700 l/s (0.7 cusecs) and 0.76 m/s for earthen canals of the capacity range 700 l/s to 8500 l/s (8.5 cusecs).

The design bed gradient for a canal is usually selected considering the limitations of maximum permissible velocity, relative loss of command (steeper the slope, more the loss), increase in seepage loss (milder the slope, more the seepage), etc. These consideration have led to design gradients of 0.00040 for field canals and distributary canals and 0.00035 for branch and main canals.

Table 4.08 gives the standard field and distributary canal sections adopted by the Irrigation Department.

Table 4.08. Standard field and distributary canals.

The standard field canal and distributary canal are designed according to

$$V = \frac{1.486 \times r^{2/3} \times S^{0.5}}{n}$$

The side slopes are 1:1 or 1:1 and 1/2 and the free board is 0.45 m. The free board may be encroached by 5 percent and 10 percent respectively in field canals and distributaries. The standard sections are marked with asterisk in the Table 4.08.

Table 4.08. **Standard field** and **distributary canal sections**

Standard Discharge in cusecs	BW in ft	FSD in ft	A in sq.ft	V in fps	Actual Discharge in cusecs	Vc in fps	CVR	Permissible increase from STD discharge
Field Canal								
	1.00	0.74	1.59	0.68	1.07	0.70	0.97	
1.0*	1.00	0.80	1.76	0.70	1.23	0.73	0.96	
	1.00	0.87	2.00	0.73	1.46	0.77	0.95	16%
Distributary Canal								
2 - 3*	1.50	0.90	2.57	0.79	2.02	0.79	1.00	
	1.50	1.05	3.23	0.86	2.76	0.87	1.01	38%
3 - 4*	2.00	1.00	3.50	0.87	3.04	0.84	1.04	
	2.00	1.15	4.28	0.93	4.00	0.92	1.01	33%
4 - 5*	2.50	1.20	5.16	0.99	5.09	0.94	1.05	
	2.50	1.35	6.11	1.05	6.41	1.03	1.02	60 - 28%
6 - 7*	3.00	1.40	7.14	1.10	7.84	1.04	1.06	
	3.00	1.55	8.25	1.16	9.56	1.11	1.05	59 - 36%
8 - 10*	3.50	1.50	8.63	1.16	10.04	1.09	1.06	
	3.50	1.65	9.86	1.22	12.07	1.00	1.05	51 - 21%
11 - 13*	4.00	1.70	11.14	1.27	14.11	1.18	1.08	
	4.00	1.85	12.53	1.32	16.60	1.25	1.06	51 - 28%
14 - 16*	4.50	1.80	12.96	1.33	17.22	1.22	1.09	
	4.50	1.95	14.48	1.39	20.06	1.29	1.08	43 - 25%
17 - 20*	5.00	1.90	14.92	1.39	20.70	1.27	1.09	
	5.00	2.05	16.55	1.44	23.90	1.33	1.08	41 - 20%
20 - 25*	5.50	2.10	18.17	1.48	26.94	1.35	1.10	
	5.50	2.25	19.97	1.54	30.70	1.41	1.09	54 - 23%

BW - **Bed Width**
FSD - **Full Supply Depth**
A - Cross **Sectional Area**
V - **Velocity in the canal**
Vc - **Critical Velocity**
CVR - **Critical Velocity Ratio** (CVR=V/Vc)

Conversion factors

1 ft = 0.3047111
1 **fps** = 0.3047111 **per second**
1 cusec = 28 l/s
1 cusec = 0.0283 Cumecs
1 **Sq ft** = 0.093 **Sq** m

Turnout areas exceeding the design limits are usually served by field canals of non-standard cross sections, i.e., different from the standard cross sections indicated in Table 4.08. In such circumstances the design depth of water in the field canal, when it is running full (full supply depth), is slightly increased to have the required discharge, without exceeding the permissible velocities in the field canal. In other words, the difference in cross section is usually accommodated only by a higher full supply depth, with the water level at design discharge (maximum 41 l/s) encroaching into the freeboard provided it is within the acceptable limits and without exceeding the permissible velocities. Therefore the field canals serving turnout areas larger than the design sizes do not have any operational constraints built into the design. The design has allowed for deliberate overloading of the standard field canal capacity of 28 l/s to run up to a maximum discharge of 41 l/s, when the turnout area is larger. This sanctioned overloading of the standard field canal would allow turnout areas of 23 ha (41/1.78 ha) for 100 percent LHG farms and 11.5 ha (41/3.61 ha) for 100 percent RBE farms. When 24 hour irrigation is adopted for the irrigation of RBE soils, the occasional maximum size of the turnout area consisting of 100 percent RBE soils can theoretically be increased to 23 ha. The turnout areas of Kirindi Oya lie well within these theoretical limits as shown in Table 4.07.

Design of Distributary Canals

The design capacity of a distributary canal is determined on the basis of the number of field canals served by that distributary. Under normal circumstances, when a distributary canal serves a given number of standard field canals of 28 l/s capacity, its design capacity is the sum of field canal capacities served by it. When a distributary canal serves some occasional turnout areas larger than the standard sizes, the discharge capacity of the distributary canal should still be the sum of the discharge capacities of the field canals. Such increases in the design capacities are usually achieved by the depth of water in the canal encroaching into the normal free board of the standard cross sections indicated in Table 4.08, but keeping the velocity of flow within the permissible limits to prevent silting or scouring.

Table 4.07 gives the design discharges of distributary canals in right bank tracts 1, 2 and 5 and in left bank tracts 1 and 2. It indicates that most of the distributaries in the new Kirindi Oya system have been designed for varying canal duties ranging from 1.0 l/s per ha to 3.7 l/s per ha, with most of the distributary canals having a duty of 2.0-2.4 l/s per ha. However, it is also seen that in most cases, the design capacity of the canal is not the same as the sum of the discharge capacities of the field canals.

Table 4.07 indicates that the ratio between the design discharge and the sum of field canal capacities served by some distributaries is below 1, indicating inadequate canal capacity at least in the head reaches of the distributary canal. For example, DC5 canal of right bank tract 1 serves 6 field channels of standard 28 l/s capacity and 6 whose capacities are more than 28 l/s. This means that DC5 should deliver a design discharge of 385 l/s (without accounting for distributary canal losses) at the head in order to meet the peak irrigation requirements under the field channels served by it. But the ratio between the design discharge and the sum of design discharges of field channels is only 0.78, implying a capacity constraint. Thus DC5 has to be run bank-full in order to meet the irrigation requirements as observed in the previous seasons. In the maha 1989/1990 season, it was observed that the tail-end field canals in this distributary canal suffered severe water shortages during the land preparation period even when the distributary was run at its bank full discharge. This distributary was taken over by the farmers for operation from this season. Discussions with the farmers and the farmer leaders reveal that they took over this canal for operation because of the serious difficulties encountered by them in water distribution and conveyance in the previous seasons. Thus the design capacity has been a constraint for the successful operation of this canal. Similar capacity constraints can be observed in some other distributary canals too. The case of DC 5 during maha 1988/1990 is discussed in detail in chapter 7.

Design of Drainage Canals

The capacity of the main drainage canals in Kirindi Oya has been determined on the basis of carrying 1 cusec (28l/s) for every 10 ha. This is the standard duty adopted for the design of drainage canals for major irrigation schemes. Experience indicates that this capacity is adequate to drain off the excess rain water from the command area without causing yield loss due to prolonged inundation of crops.

Land Preparation

The method of water delivery adopted for the design and operation of the irrigation distribution system is continuous delivery during land preparation, end rotational delivery in the subsequent crop growth period. In other words, the canals would be operated to run continuously during the land preparation phase and the mode of water distribution would be changed from continuous delivery to a system of rotation after sowing is completed. In this system of rotation the field canals are opened and closed according to a pre-determined schedule, while the flow in the distributaries is maintained continuously. In this mode of operation, field canals may be operated to run at design discharge or at a slightly higher discharge when required, while the distributary canals may be operated to run continuously, but at regulated discharges to suit the discharges requiredby the field canals during any given period of the rotation.

However, though the delivery is said to be continuous during the land preparation period, this statement reflects the perspective of the agency operating the system. Field canals are run continuously during land preparation period, but at the farmer's level, the water for the land preparation has to be shared by a systematic rotation. The design of the field canal and the structural design of the farm turnouts are such that two fanners are expected to share the entire flow in the field canal at one time, for an agreed duration.

The design model allocates 100 mm in 5 days and 75 mm in 10 days, to meet the land soaking and land tillage requirements respectively, amounting to a total of **175 mm** in **15** days for the land preparation of a typical 1 ha allotment. The operation model recommends a somewhat restricted allocation of 50 mm in 7 days and **50 mm** in **14** days for land soaking and land tillage respectively. In the first instance there is a remarkable difference in the assumptions on land preparation water requirements in the design and operation models, though the design is more conservative than the operation. Second, the actual requirements of the farmers for land soaking and the land tillage as observed in the previous seasons appear to have been underestimated by both models. Third, time periods allocated for land soaking and land tillage and for the total land preparation period appear to be more optimistic than the reality.

The land soaking requirement is necessary to bring the soil to saturation to facilitate the mechanical operations in land tillage. It depends on the type of soil and the antecedent moisture conditions of the soil. In a typical maha season, where the cultivation begins after one or two rains, the land soaking requirements assumed in the models may be sufficient for LHG soils but may need revision for RBE soils. But for a typical yala season, where the rainfall is limited, the antecedent moisture percentage can be very low and more irrigation water is required to soak the land, particularly for RBE soils. In yala 1989 season, the farmers in DC2 of BC2 of right hank tract 5 used about 400 mm on average for the land soaking (IIMI 1989b). A rough estimate of water requirements for land soaking as presented in a previous section (305 mm) indicates that the assumptions made in respect of the land soaking requirements need further investigation.

The research conducted in yala 1989 season in Kirindi Oya indicates that on an average a farmer uses 6 to 8 days between the receipt of water and first ploughing, 10 to 18 days between the first and second ploughings, 7 to 10 days between second ploughing and puddling, and 1 to 3 days between puddling and sowing (IIMI 1989b). This means that the land soaking is allowed for about 6 to 8 days and the subsequent land tillage operations take about 18 to 30 days till sowing, thus extending the land preparation in a typical 1 ha allotment over 3 to 5 weeks from the commencement of water issues. Thus there exists a discrepancy between the theory and the reality of the land preparation period for a typical 1 ha allotment. *As* a result, the operation of the whole system virtually slips out of the control of the operating personnel during this phase of the cultivation.

The land preparation phase for irrigated rice cultivation is very complex in terms of the period, water requirements, and systems of sharing water among farmers. This complexity arises not only due to water but also due to various socio-economic constraints faced by the fanning community. Let us review the sequence of activities that follow from the first release of water in a typical field canal, in order to understand the complex interactions of water, socio-economic factors, and water sharing practices in the land preparation phase.

When the field canal turnout gate is first opened for the season, the operating agency implicitly assumes that one cusec (28.32 l/s) will flow in the canal and the farmers will immediately respond to water issues by beginning to share water to soak their farms. The premise here is that the field canal would be kept open €or 7 days per week and 24 hours per day so that two farmers would share the discharge in the field canal at a time. It is theoretically possible to deliver the land soaking requirement of 100 mm per one hectare allotment in 1.1 days (1 day and 2 1/2 hours), if pairs of farmers resort to sharing the field canal flow at a time, at a rate of 14 l/s through farm turnouts, assuming a 70 percent application efficiency. If the application efficiency is ignored this period reduces to 18 hours. If this rotational sharing continues among the farmers without losing any time in between switching from one field turn out to the next, the continuous flow in the field canal can theoretically deliver the land soaking requirement to about 12-18 ha in a 7 day period, if there are no application losses. If the application losses are accounted for then the area is limited to 12 ha. If the land soaking requirement is only 50 mm, as assumed in the operation, then the area that can be served with the land soaking requirement within a week increases to 24-36 ha.

The above computations pinpoint a part of the operational constraints faced by rice farmers in the land preparation phase. Table 4.07 shows that in the Kirindi Oya irrigation system, there are some turnouts serving about 20 ha of 100 percent RBE soils. If the land soaking requirement exceeds the design limits (100mm), the standard one cusec flow in the field *canal* fails to serve the land soaking requirement of larger turnout areas within a rotation period of one week. This compels the operating agency to overload the field canals to have an increased flow. If the flow is increased to a limiting discharge of 41 l/s, then the land soaking requirement of 100 mm can be delivered to only about 17 ha within a week, if the application losses are accounted for, leaving another 3-4 ha not served. Thus the design has imposed an operational constraint in the land preparation phase by laying out turnout areas as high as 20-24 ha consisting of 100 percent RBE soils. This constraint is very significant in yala season, when the rainfall is scarce.

On the other hand let us assume that the farmers in a typical field canal resort to the ideal mode of water sharing for land preparation. When the first two farmers receive their share for soaking after a day or two, they are compelled to begin the first ploughing within the next two or three **days**, before the moisture condition in their allotments is depleted below saturation. This means the first two farmers should have farm power at their disposal in order to commence the first ploughing without losing any time for the depletion of wetness in their allotments. The same argument applies to the other farmers too, who complete the land soaking in succession in the ideal mode of water sharing. This is where the main socio-economic constraints interact with the water as well as the mode of water sharing to disrupt the whole process.

Our research, observations and discussions with fanners reveal that inadequacy of farm power and initial capital to pay tractor hire are a major constraint which inhibits the operation and in turn the overall performance of the water delivery system. Inadequacy of farm power has become a grave problem for the new settlers, particularly when the cultivation in both the new area and old Ellegala system commences almost at the same time. Though tractors had been provided to the farmers under the project on easy payment conditions, most of the tractors are not presently available in the project area to facilitate land preparation activities. Shortage of farm power is the number one constraint that affects land preparation activities.

On the other hand, when a farmer finds a tractor for hire, in most instances he lacks the initial capital to pay the tractor owner. This is another constraint. The collective impact of these constraints are reflected in the command area **by** way of delayed land preparation activities. This leads the operating agency to adopt ad hoc and trial and error methods in system operation during the land prepration. In the environment of these socio-economic constraints the water use efficiency by the farmers goes down, leading to over-use of water.

The socio-economic constraints impose an informal stagger of land preparation activities in turnout areas. This stagger may or may not be identical with the staggers assumed for the preparation of water schedules. However, the informal stagger is a blessing for the operating agency to deliver a continuous delivery within the capacity constraints of certain distributaries in Kirindi Oya. It was earlier seen that the capacities of some distributaries are less than the aggregate sum of the capacities of field canals served by them. If there were no socio-economic constraints so that all the farmers could commence land preparation simultaneously, then the Irrigation Department would be compelled to maintain continuous design discharges in all the field canals at the same time. This would not be possible in some distributary canals due to capacity constraints. Though it is not realistic to expect simultaneous land preparation to take place, this shows that in some distributary canals, capacity is a potential constraint to deliver continuous supply to the field canals.

The foregoing paragraphs analyze the ideal mode of water sharing during land preparation in order to recognize the design as well as operational constraints and their inter-relationships with the socio-economic environment within which land preparation takes place. It is now worthwhile to review how the farmers in a turnout area adjust to the constraints imposed by both the design and the socio-economic environment, in order to have a basis for identifying more realistic scenarios of water distribution and allocation during the land preparation phase.

When a field canal turnout gate is opened for the first time to issue water for land preparation, the farmers compete with each other to soak their allotments. The ideal mode of water sharing between two fanners at a time rarely takes place. Instead, water sharing takes place in highly informal ways which is different from turnout to turnout and therefore difficult to model. One or a few farmers who have the capability to hire tractors and are ready to plough, come to an agreement with the rest of the farmers to use the first or first few turns of water to soak their allotments, and then subsequently to commence ploughing. Once they finish diverting the entire flow in the field canal, another group of farmers gets its turn to divert water from the field canal. There are various informal arrangements and eventually decisions on the commencement of land soaking and other activities are taken by each individual fanner on a day-to-day basis. This situation is a direct consequence of the socio-economic constraints typical of the new areas of the project. Thus it is difficult to predict in advance when a typical farmer needs water to soak his allotment and when he will commence ploughing and the subsequent agricultural activities.

The land preparation phase of rice cultivation is complicated by the fact that the land preparation period is influenced by socio-economic variables and in turn by the multiplicity of decisions, on the commencement and the period of each agricultural activity, taken exclusively by each individual farmer each day. Tt is often the case that the land preparation period stretches substantially over a longer period than anticipated by the design or agreed at the cultivation meetings. The total water use by farmers is excessively high; it was 1400 mm per ha in Dc8 of Chandrikawewa Branch Canal in Walawe and about 800 mm per ha in DC2 of right bank tract 1 in Kirindi Oya (IIMI 1989b). The land preparation in a typical farm allotment stretched over 4.5 to 5 weeks in both Kirindi Oya and Walawe (IIMI 1989b). This suggests the problems characteristic of matured as well as new schemes. The important question that emerges out of this situation is that if the land preparation phase cannot be accurately modelled or predicted in terms of the water requirements, quantity, point of time, and duration, and in terms of time required by each fanner to begin and complete the various activities, how can the operating agency maintain a balance between the adequacy of supply and the prevention of over-use of water during land preparation?

The option available to the operating agency is to monitor the day-to-day land preparation activities very closely, if it is interested in ensuring high water use efficiency. On any given day, only one farmer may need water and on some other days three to four farmers may need water. If there is a close system of monitoring by the irrigators, the actual requirement can be closely matched with the supply by decreasing or increasing the field canal turnout gate opening almost daily during the land preparation period. The irrigator has to inspect the turnout areas very frequently, assess the progress of land preparation, communicate with the farm leaders or individual farmers to identify their cultivation plans for the day and during the subsequent days, and then adjust the field canal flow to approximately match the supply with the field requirement. This daily and intensive monitoring is anyway required to assess the land preparation progress and the informal staggers of cultivation occurring in each individual turnout area and then at the delivery points higher up of the system in order to adjust the irrigation schedules and canal deliveries during the subsequent crop growth period.

Water Delivery Options

The options available to the operating agency for the distribution of water can be categorized as follows:

1. Continuous but variable flows in the canals including field canals, the rate of flow being regulated and adjusted to match the field and crop water requirements.

2. Pre-determined rotation among field canals while distributary canals, branch canals and the main canal run continuously but with variable flows. Three methods are possible under this system.

   a. The field canals are run continuously with constant design flows for the predetermined periods of rotations, the period being variable depending on the growth stage of the crop. This can be termed as "fixed discharge-variable period'' delivery.

   b. The field canals are run continuously with variable flows for the pre-determined periods of rotation, the period being constant throughout the growing season of the crop. This can be termed as "variable discharge-fixed period" delivery.

c. The field canals are run continuously with variable flows for the pre-determined periods of rotation, the periods too being variable depending on the growth stage of the crop. This can be termed as "variable discharge-variable period" delivery.

3. Demand system which may again use any of the above options.

The selection of an appropriate option of water delivery up to the field canal turnout in Kirindi Oya depends on the interaction of a multiplicity of factors, including a wide variety of time-related factors such as crop requirements,,climatic conditions and water availability and the design of the system. In the first instance it should complement and facilitate the capability and manageability of the farmers in sharing water below the field canal turnout, within the facilities, flexibility limits, and constraints of the design and construction of the canals, and appurtenant control, regulation and measurement devices. Second, the option of water distribution should ensure the minimum of interventions by the operating personnel in adjustment and regulation of flows. Third, the method of distribution should facilitate irrigation of the selected cropping pattern in the turnout areas, whether it is rice, non-rice crops, or a combination of rice with other crops. Finally the distribution should ensure the predictability, reliability, adequacy and equity of distribution both of the main and tertiary systems within the specific set of design, construction, management, and institutional facilities and constraints prevailing in the environment.

The design of the tertiary system below the field canal turnout offers limited options for water sharing among the fanners. A typical field canal below the field canal turnout would usually consist of a number of farm turnouts designed and located along the field canal in such a way that, when the flashboard is inserted in the farm turnout across the field canal, the entire flow in the field canal would head upstream of the board to deliver equal amounts of water amounting to a flow of about 14 l/s through the two 150 mm diameter uncontrolled openings incorporated in a single structure. The uncontrolled pipe openings lack the facilities for either measurement or control, and therefore the delivery to any individual farm allotment has to be maintained either at zero or 14 l/s flow at any given time. Thus the design of the tertiary system limits the flexibility of water sharing among farmers to a degree at which two farmers in the turnout area served by a typical farm turnout must simultaneously share the entire flow in the field canal at a time for the period ascribed to them, during a pre-determined rotation interval. This limited flexibility in the design of turnout facilities influences the choice of the water distribution method, and limits the options available to the operating agency to adopt either the "fixed discharge-variable period'' or "variable discharge-fixed period" delivery of water.

The selection of an appropriate water distribution method depends on the relative merits and demerits of each of the above two alternatives. In the mid-season 1988 (maha 1987/1988 commenced in January 1988 therefore it is called a mid-season), the "variable discharge-fixed period'' delivery was adopted for the rotation among the field canals. In other words, each field canal of the system was scheduled to receive a variable supply but for a pre-determined period which was constant throughout the growing season. The constant period was determined on the basis of the period required to supply the peak daily irrigation requirements (which occurred in week 8 after the commencement of season) when the field canal discharge is maintained at the design discharge. The field channel discharge was scheduled to be reduced during the rest of the season in proportion of the daily irrigation requirement of any given week to the peak daily irrigation requirement.

The variable discharges were converted into equivalent heights of water above the crest level of the measuring weirs constructed immediately downstream of the field canal turnout structures and the irrigators were provided with the water depths to be maintained in each week of the growing period. This mode of scheduling was based on the premise that it would be convenient for the farmers to share the delivery of the field canal for the same constant duration throughout the growing season, two farmers sharing the flow at any given duration. This method implicitly assumed that in the Kirindi Oya environment where the fanners were not yet fully organized, the adoption of the constant irrigation period would be more convenient than a variable irrigation period.

However, in the subsystems studied in our research, it was observed that the farmers very rarely followed the intended internal rotations and instead resorted to various informal ways of water sharing throughout the season. This compelled the turnout attendants to deviate from strict adherence to the schedules preparedby the Department for the rotation among the field canals and to respond to the needs of each individual field canal in an ad hoc manner. The variable discharge-fixed period mode of delivery demands very frequent and accurate interventions at the field canal turnout gates in order to maintain the required variable flows in the field canals and in turn at the distributary canal turnout gates in order to maintain the design discharges. The broad crested measuring weirs constructed at distributary canal and field canal turnouts have not been location-calibrated; instead the required discharge has to be released on the basis of the calculated height of water over the weir, which may or may not be accurate. Thus the 'variable discharge - fixed period' method of delivery appears to be cumbersome for Kirindi Oya.

The next alternative, "fixed discharge - variable period'' has certain merits over the other, from a management point of view. It is basically a schedule which delivers a constant design discharge in the field canal for variable periods depending on the stage of growth. Though the farmers are required to share the water for variable periods, it offers certain other advantages. The discharge in the field canal is constant and any reduction in the flow is easily noticeable to the farmers and provides them clear evidence to demand more water from the turnout attendants. On the other hand, it makes the turnout attendants more responsible and accountable to maintain the design discharge in the field canal throughout the season. It offers minimum gate interventions and less water level fluctuation in the canals. The discharge in the distributary canals can be maintained almost at steady levels. The main advantage of this method is that the scheduling within the field canal is done with two extreme stream flows in the field canal: gate open with the design discharge (28 l/s) and gate closed with zero discharge, making the actual operation less complex than the other alternatives.

The forgoing review shows that the "fixed discharge-variable period" mode of water distribution requires more organizational capabilities of the farmers and less intervention by the operating agency. The "variable discharge fixed period" mode is the other way around -- it requires more effort from the agency, less from farmers. Theoretically, in an environment like Kirindi Oya, where farmer organizations are still very young and not strong, the "variable discharge-fixed period" mode of water distribution appears to be cumbersome more convenient for the farmers, but less convenient to the operating agency. But in the long run, when the farmers are better organized to take over more operation and maintenance responsibilities, the fixed discharge-variable period would be the best method of water distribution.

VARIABILITY OF FLOW IN DISTRIBUTARIES

As discussed in previous sections, the field canal and turnout design is such that, the discharge in the field canal has to be maintained either at design discharge (typically 28 l/s) or zero. This design limits the flexibility of water delivery schedules to a certain degree.

Annex 4.02 is the rotational delivery plan prepared for DC2 of right bank tract 5 in maha 1987/1988 (mid) season by the Irrigation Department. This schedule was intended to be implemented during the periods of peak irrigation water requirements. It shows that field canals under DC2 were planned to be operated at design discharge on specific days of the week, while the distributary canal was planned to be operated continuously throughout the week, but at different delivery rates. In this specific example DC2 was to be operated at design discharge (170 l/s) on 5 and 1/2 days of the week, while at a higher discharge (195 l/s) during the remaining 1 and 1/2 days. The rotation schedules for other distributary canals indicate a similar pattern of continuous delivery throughout the week at different design discharges.

Thus, the design of the field canal and the operation schedules introduce a variable flow at the head of a distributary canal in any given rotation week. This variability is inevitable in most of the distributary canals where the design capacity is less than the sum of the design discharges of the field canals served, as documented in Table 4.07. For example, in DC5 of right bank tract 1, the design discharges of the distributary canal is 300 l/s, whereas the sum of the design discharges of the operating field canals is also about 385 l/s. Thus on certain days of any rotation week, the discharge at the head of the distributary canal has theoretically to be maintained at about 400 l/s if losses are accounted for.

Figures 4.01 and 4.02 show the discharge measured at half hourly intervals at the head of DC2 and all field canals served by it during a seven day period of the yala 1989 season. Close observation of these discharge hydrographs indicates that the variability of flow at the head of a field canal increases from head to tail and there is a considerable flow variation at the head of the DC2. The results of findings from the set of hydrographs are given in Table 4.09. This table indicates that the flow in a typical distributary varies considerably and the degree of flow variation amplifies when one goes down from head to tail field canals served by a typical distributary canal.

Table 4.09. Variability of flow in Dc2 of BC2 of right bank tract 5, Kirindi Oya Project

Canal	Design Discharge l/s	Maximum Flow l/s	Minimum Flow l/s	Average range of flow l/s	Maximum flow / Minim flow
Dc2	180	225	90	125–170	2.50
FC 9	30	32	10	30–34	3.20
FC 10*	30	14	8	8–12	1.75
FC 15	30	30	20	20–28	1.50
FC 11	30	65	12	30–50	5.42
FC 12	30	52	10	20–50	5.20
FC 14	30	58	10	10–50	5.80
FC 13	42	40	2	2–20	20.00

* Supply was deliberately reduced because farmers had access to drainage water.

OPERATION FOR OTHER FIELD CROPS AND FOR A MIX OF RICE AND OTHER CROPS

It was earlier stated that the design criteria for canals, turnout areas and other structures in the irrigation and drainage infrastructure were based on criteria to serve rice. However the irrigation water requirements for other field crops are lower than for rice and therefore in principle, the design capacities of the irrigation infrastructure should not impose constraints to serving other field crops in the same command.

However, the irrigation layout designed for rice imposes a major impediment to adopting irrigation methods based on furrow irrigation, which may be one of the most efficient irrigation methods for non-rice crops. This drawback stems from the difficulties and high costs involved in transforming the soils and paddy basins into furrows, in the process of switching over from rice cultivation in maha season to cultivation of other crops in yala season. The absence of a secondary and tertiary network of drainage canals further limits the choice of furrow-based irrigation methods. Thus the irrigation layout designed for rice limits the choice of irrigation methods either to controlled flooding for the well-drained and upper parts of the intermediately drained soils or to raised bed methods for the poorly drained soils. The most appropriate irrigation methods have yet to be decided on the basis of the experiences of fanners and research results.

Unlike rice which tolerates excess moisture for a considerable period of inundation, other crops are very sensitive to both deficit and excess moisture in the soil, demanding a narrow range of moisture content for irrigation and hence operation of the system. This in turn demands the exercise of more attention and care in both scheduling and operating the canals and turnouts to implement the schedules. The major management questions that emerge from this requirement are whether the present O&M resources and skills, and the present level of farmer organizations and their management capacity would be sufficient to deal with more precise operation for large scale cultivation of other crops in the Kirindi Oya system. This question remains to be tested in yala 1990 season, during which non-rice crops are to be grown in the system on a wide scale with the active participation of all line agencies responsible for agricultural implementation and activities.

However, the design of the field canals and canal turnouts and the farm turnouts imposes two major constraints which limits the flexibility to select a wide range of irrigation rates for other crops. As mentioned earlier, the field canals have been typically designed for a standard design discharge of 28 l/s. Also the regulation of flow in the field canal to have a reliable discharge in the range between zero and 28 l/s requires a high degree of intervention by the operating staff, but even then the reliability of achieving a required flow accurately is questionable. The economic considerations in the design of farm turnouts have resulted in a limited flexibility to maintain accurately any intermediate discharges between zero and 14 l/s through the 150 mm farm pipes. For rice cultivation farmers presently regulate the stream size to the farms by partially clogging up the farm pipes with stones, straw and earth, with no or little concern for the rate of flow. Though planking arrangements have been provided in the farm turnout to regulate the flow between the two extreme rates of flow, they are hardly used. These wooden planks are not designed to regulate the stream flow to the farm at any discharge other than the two extreme values. Thus the scheduling of irrigation for other field crops has to be done within the design constraints imposed by the field canal turnout and the farm turnout. When there is a mix of rice with other field crops in the same allotment, as a few farmers attempted during yala 1989 season under the demonstration trials of the Agricultural Department, the design constraints of the field canal turnout and the farm turnout are more significant. When this mixed cropping is adopted on a wider scale, scheduling becomes more complex.

The lack of facilities to regulate precisely the stream flow at both the field canal and farm turnout levels limits the free choice of cropping patterns that each individual farmers may prefer to adopt in this system. In the short run, the fanners would not select a wide range of crops due to marketing and other socio-economic constraints, and would limit the choice to such crops as chillies, legumes, onions and a few vegetables. However, in the long run if the cultivation of other field crops turns out to be an attractive venture, there will likely be more demand for a wider range of crops. But there would be limitations on the free choice of crops within the scheduling constraints imposed by the system as it is now designed. This means that the farmers have to come to a common consensus to grow one or a combination of a few crops, before each season, as they presently do with respect to the variety of rice to be grown in each season. Therefore it is necessary to adopta uniform cropping pattern with strict adherence to the cultivation calendar.

The system-wide cultivation of other field crops demands other managerial and institutional requirements. The operating agency will be compelled to adhere somewhat strictly to the implementation of the pre-determined schedules, based on "fixed discharge - variable period" mode of water distribution. The farmers will be required to share the water without defaulting within the irrigation interval dictated by the schedule prepared by the operating agency. The observations during the previous cultivation season revealed that neither the irrigators nor the farmers demonstrated the skill, leadership and dedication to follow the schedules as envisaged. Though the Irrigation Department demonstrated some improvements in ensuring a better quality of operation in yala 1989 season, the management below the field canal turnout remained unsatisfactory in levels and standards. Under these circumstances, the Irrigation Management Division has to play a vital role in training and motivating the fanners to adhere to the mode of water sharing imposed by the turnout design and its inherent constraints.

CONCLUSIONS

Operational and Institutional Assumptions

The design of field canals and turnouts in the Kirindi Oya irrigation project embodies a set of technical, operational and institutional assumptions. The field canals are designed for a typical design discharge of 28 l/s (one cusec) and the turnout areas are sized to serve the peak irrigation water requirements for rice, depending on the total percentage of well. drained (RBEs) and poorly-drained (LHGs) allotment areas served by the field canal.

The climatic and soil variables, efficiency parameters, and the irrigation water requirements for land soaking and preparation used for the estimation of peak irrigation water requirements both for the design of turnout areas and for the water delivery schedules show an underestimation of the reality. As a result, some turnout areas serving 20-24 ha of well drained soils will have operationaldifficulties,as the design discharge in the field canal cannot meet the irrigation needs of all the farmers within the typical irrigation intervals of seven days, if rotation is implemented. This situation emphasizes the need for continuous monitoring of the climatic and soil variables, efficiency parameters etc. in the project area, in order to assess the irrigation requirements more accurately and confidently.

Most of the distributaries in the Kirindi Oya system have design discharges which are less than the aggregate sum of the design discharges of all the field canals served by them. This imposes a potentialcapacityconstraintparticularly during the land preparation period during which all the field canals are operated simultaneously with continuous flow. When such a distributary has excessive conveyance losses above the assumed values (for example, DC5 canal of right bank tract 1) and large turnout areas served by one or more field canal (for example, field canal *49* in DC5 in right bank tract 1 which consists of 24 ha), the distributary canal capacity can be a severe constraint in ensuring an adequate and equitable supply to the farmers.

The design of the farm turnouts in Kirindi Oya assumes that **14-15** l/s (half cusec) is the best manageable stream size for an individual fanner and two farmers below the field canal turnout will share the entire 28 l/s (one cusec) flow in the field canal simultaneously. The institutional assumption here is that the Irrigation Department can communicate well with the farmers about the water delivery schedules, rainfall adjustment rules, etc. well in advance of **any** cultivation season, and farmer organizations can manage the water distribution below the field canal turnouts to suit the schedules prepared by the Irrigation Department.

Water Delivery Options

The design of the tertiary system below the field canal turnout limits the water distribution options due to lack of control and measurement facilities incorporated in the design of farm turnouts. Thus, the water distribution below the field canal turnouts has to be in such a way that two fanners at a time irrigate their allotments with a stream size of 14-15 l/s (half cusec) within a predetermined irrigation interval, dictated by the water delivery schedules prepared by the Irrigation Department. With this limited flexibility, the Irrigation Department and the farmers have options for either 'fixed discharge-variable period' or 'variable discharge-fixed period' modes of water distribution.

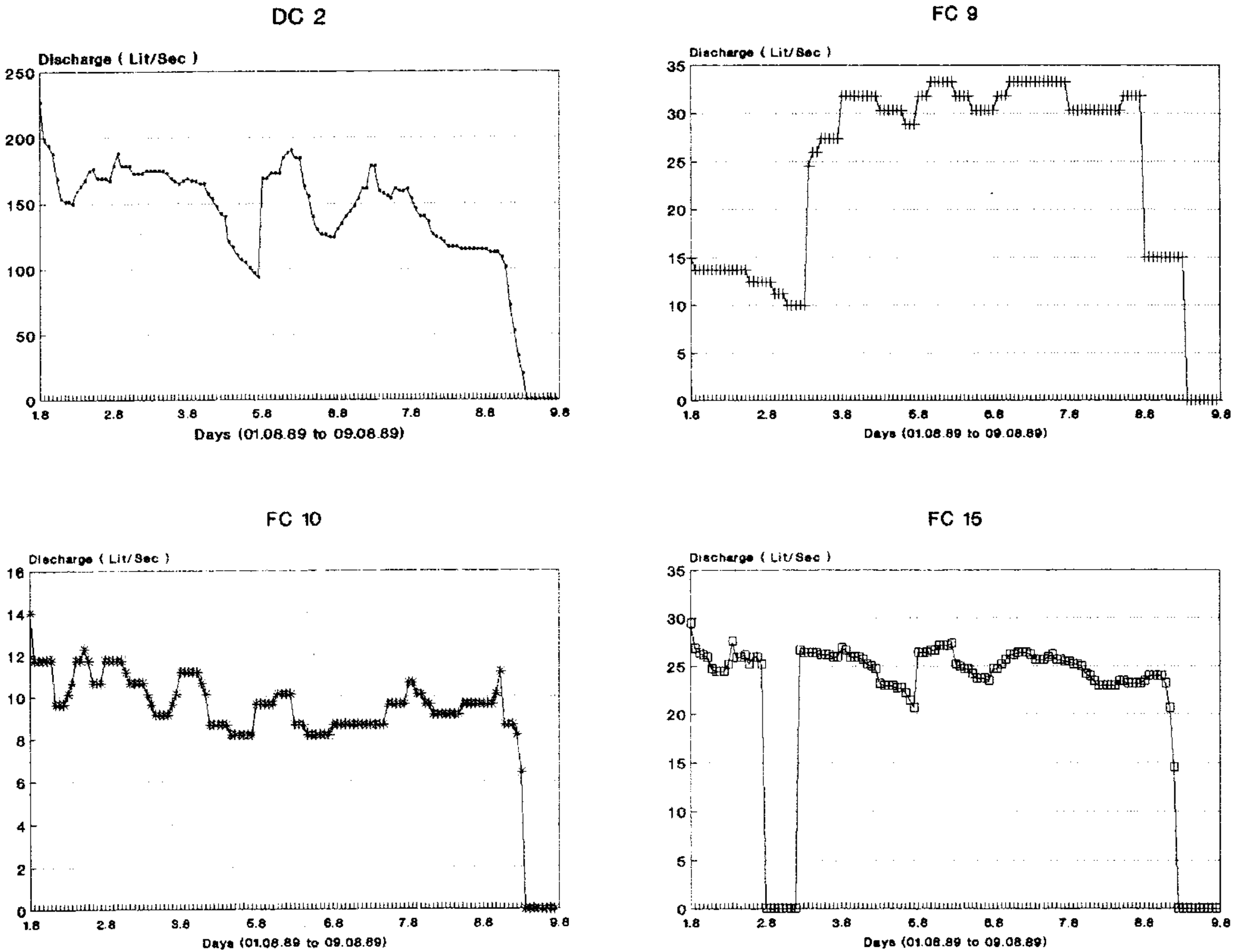
The former option requires more organizational capacity and capability of fanner organizations and less from the operation and maintenance unit of the Irrigation Department and the latter the other way around. Presently the farmer organizations are not well geared to adopt the 'fixed discharge-variable period' mode of delivery and hence in the short run, the Department has to play a major role in implementing 'variable discharge-fixed period' mode of delivery, if it intends to assist farmers to smoothly accomplish water distribution below the field canal turnout. However, the difficulties in regulating variable discharges in the field canal due to the lack of accurately calibrated measurement facilities hinders the implementation of such schedules precisely. Thus the establishment of fanner organizations and enhancing their capacities and capabilities to adopt the limited options of 'fixed discharge-variable period' mode of water distribution are absolutely essential even at the early stages of the project.

Variability of Flow

The design of the field canal and the limited option of 'fixed discharge-variable period' water distribution available to the Irrigation Department, make it difficult to maintain a steady and fixed design discharge at distributary canal heads during the rotation periods. In certain instances, where some distributaries suffer from capacity constraints, variability of flow at the head is inevitable due to deliberate overloading of the canal beyond the sanctioned limits. Also, sometimes there is a fluctuation in discharge at the head of a distributary as a result of fluctuations in the upper levels of the system. This fluctuation propagates to the tail of the distributary with tail-end field canals suffering from larger variability and fluctuations in the discharge than head-end field canals.

Alternative Water Distribution Methods to Improve Performance

The complex interactions of socio-economic factors with water and soil properties make it difficult to model the land preparation in terms of the period and water requirements and designation of daily quantum of water into the field canals. Thus systematic and predetermined water schedules are difficult to prepare for the land preparation period. What is necessary to adopt is very intensive monitoring of land preparation activities and progress during this phase on a day-to-day basis, and adjustment of the field canal flows daily to suit the land preparation activities that are likely to take place under the command of each field canal on any given day.. This requires strong dedication by the irrigators who are required to inspect all the field canals under their supervision, to meet the fanner representatives daily, and to adjust the canal flows on a daily basis. This practice combined with farmer training to adopt proper on-farm practices will reduce the water use in the land preparation phase.



4.01. Half hourly flow variations at the heads of DC2 and FC9, FC10 and FC15 in DC2 under BC2

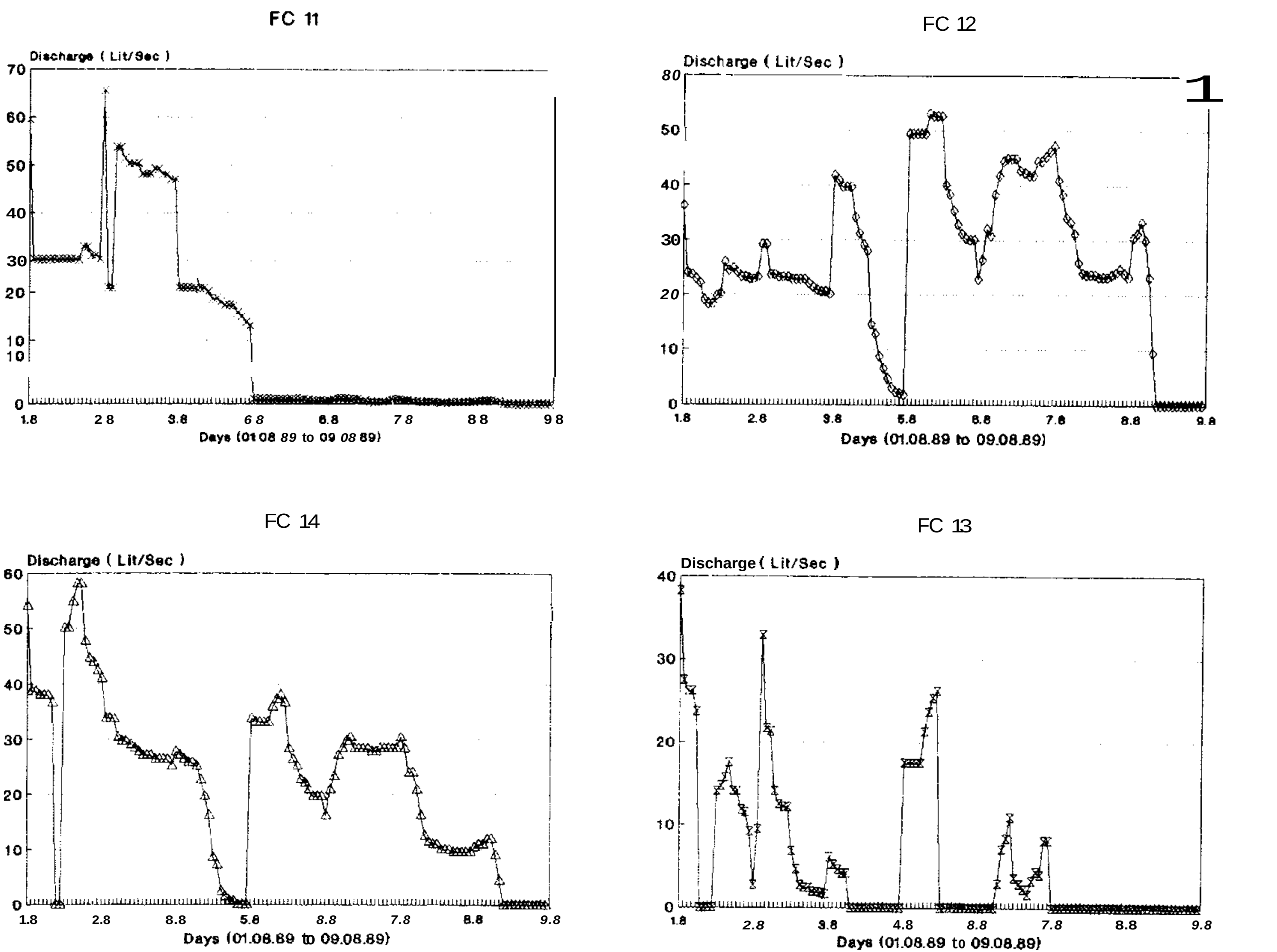


Figure 4.02. Half hourly flow variation at the heads of FC11, FC12, FC14 and FC13 in DC2 under EC2

Annex 4.01

GROWTH STAGES AND CROP FACTORS

Growth Stages

		Initial	Development	Mid	Late	Total
Lowland paddy (135 day)	Days	30	40	45	20	135
	k_c	1.00	1.15	1.20	0.30	
Lowland paddy (105 day)	Days	20	30	30	25	105
	k_c	1.00	1.15	1.20	0.90	
Upland paddy (135 day)	Days	30	40	45	20	135
	k_c	0.90	1.00	1.05	0.90	
Upland paddy (105 day)	Days	20	30	30	25	105
	k_c	0.90	1.00	1.05	0.90	
Soya beans	Days	15	20	50	20	105
	k_c	11.65	3.85	1.05	0.75	
Ground Nuts	Days	20	30	40	20	110
	k_c	0.65	0.80	1.00	0.80	
Green Gram	Days	15	20	25	15	75
	k_c	0.50	0.80	1.05	0.70	
Cowpea	Days	15	25	35	15	90
	k_c	0.70	0.00	1.10	1.00	
Pulses	Days	15	25	35	15	90
	k_c	0.50	0.80	1.05	0.50	
Chillies (180 day)	Days	30	30	90	30	180
	k_c	0.65	0.85	1.00	0.90	
Chillies (150 day)	Days	25	25	75	25	150
	k_c	0.65	0.85	1.00	0.90	
Cotton	Days	25	35	45	30	135
	k_c	0.65	0.90	1.05	0.90	

Annex4.02

The rotational delivery schedule of ID for DC 2 in BC 2, tract 5 in right bank for mid maha 1987/88 season.

C No	Area (ha)			Peak equirement	elivery Rate	Design ischarge	Delivery Duration	Weekly schedule						
	BE	LHG	Total	(l/s/ha)	(l/s)	(l/s)	(Days)	Mon	Tue	Wed	Thu	Fr	sat	Sun
9	*6.0*	-	*6.0*	2.1	30	28.32	3.16	****	*****	*****	**			
10	-	15.0	15.0	1.6	30	28.32	6.02	****	*****	*****	****	■■■■	.**	■■■■■
11	-	10.0	10.0	1.6	30	20.32	**4.01**				■■■■	■■■■	■■■	■■■■■
12	-	16.0	16.0	1.6	30	28.32	6.42	****	*****	■■	■■■	■■■■	.**	■■■■■
13	0.0	-	20.0	2.1	**45**	42.00	**7.00**	****	*****	*****	****	****	***	*****
14	-	16.0	16.0	1.6	**30**	28.32	6.42	****	■■■■	■■■■■■	■■■■■■	****	■	■■■
15	**7.0**	-	7.0	2.1	**30**	28.32	3.90			■■■■	■■■■■■	****	***	**
otal				2.16	**195**							■■■■	^	
C 2	**3.0**	57.0	90.0	1.85	165	170	7	■■■■	*****	*****	****		**	*****

Note :-(1) The above schedule is for the peak weekly crop water requirement

(2) Schedules for rest of the period are obtained by adjusting the discharges at heads of FCs in proportion of crop water demand in any week to that during peak

(3) Time schedule of delivery is indicated by ********

(4) Overloading is indicated by ^^^^^^^^^^

CHAPTER V

IRRIGATION SYSTEM PERFORMANCE

INTRODUCTION

Objectives and Research Questions

As outlined in the Inception Report (IIMI 1988a:11), this research module was included with the object of assessing the performance of an irrigation system in a holistic sense. A sample subsystem of one distributary canal and its field channels are used to assess the performance and understand the systemic interactions and processes that underlie the performance. In more specific terms, this chapter tries to:

1. Document the performance of a selected subsystem in the Kirindi Oya irrigation system including changes in performance over the seasons;

2. Test methods and criteria for assessing performance of an irrigation system in a holistic sense;

3. Develop or select indicators that could be tested for use in Kirindi Oya project; and

4. Assess opportunities for improving system performance.

The research results are expected to answer the following questions:

1. What are the objectives against which system performance should be assessed? What are the objectives of national policy makers, the agency personnel operating the system, and the farmers, respectively?

2. How are the objectives translated into criteria to govern system operation and into operational plans of the system? What are the targets against which performance is now assessed, or could be assessed in future?

3. What are the indicators of performance that should be used in the assessment of performance for the following:

   i. irrigation water delivery system,

   ii. irrigated agricultural production system, and

   iii. social and institutional system.

4. What are the dominant attributes of the environment that promote or inhibit the performance of the system?

5. What are the key factors, incentives, constraints and interactions affecting the system performance?

6. What are the opportunities for improving system performance? For example, what steps are required to promote diversified crops in the Kirindi Oya project?

Definition of Performance

"Performance" is used here in a simple way, to refer to outputs at various levels and in various time frames. Performance is measured by comparing the degree to which the specific outputs match the specified objectives.

Conceptually, 'short term performance' of an irrigation system may differ materially from its 'long term performance'. If managers take a short term view, for example, satisfying water users clamoring for water during a particular season regardless of the long term implications or maximizing short term profit at the expense of long term benefits, then the system may go "off-track" in terms of its long term objectives, and its sustainability. If the long term objectives are the primary rationale for decisions, then a very different set of decisions has to be made than what is aimed at for achieving the short term objectives.

The performance of an irrigation system is governed by many factors ranging from policy and planning decisions at the national level to the operation and management decisions at the farm gate level. This chapter focusses on the performance of the water conveyance and delivery system of the Kirindi Oya project. Figure 5.01 provides a schematic representation of the factors affecting the water delivery performance of an irrigation system. The water delivery performance itself is analyzed using the concepts of reliability, adequacy and equity. The adequacy of water supply is characterized by the parameter Relative Water Supply (RWS) and Cumulative Relative Water Supply (CRWS), while equity is explained using Water Delivery Performance (WDP).

A systems analysis approach has been used in this report to analyze the interactions of various elements and factors in the subsystem whose performance is being assessed. The system has been analyzed on several aspects such as water delivery, agricultural production, economics of crop production, institutions, and management. The results of this analysis have been integrated to develop insights and draw guidelines for improvement of system performance. The results and findings of research reported in other sections also have been used to draw final conclusions and answer the research questions raised at the beginning of this chapter.

Seasons Selected

The water issues to right bank tract 5 for the 1987/1988 maha (or "mid") season commenced on 25 January 1988 according to the decision arrived at the cultivation meeting held on 18 January 1988. However, our systematic data collection and water flow measurement started only in the first week of March 1988, missing data collection during land preparation period. Therefore, the analysis of the results for maha 1987/1988 does not present full quantitative data and findings for the land preparation period for that season. This season ended in June 1988 and there was no water issue for the 1988 yala season for tract 5. The 1988/1989 maha season started on 20 September 1988 but due to unsettled and disturbed conditions prevailing in the project area, the study had to be discontinued in November 1988. The 1989 yala season was the third season of study. We were able to capture the whole season. This season commenced 15 March 1989 and continued up to 27 July 1989. The 1989/1990 maha season started with water issues for tract 5 on 20 November 1989. After ten days of water supply, the irrigation to this tract had to be stopped due to the very low storage position in the reservoir. Therefore, the results presented herein are based mainly on two seasons of observations (full yala **1989** and part maha **1987/1988).** The analysis and interpretation of the results are based on actual field measurements and observations, interviews of farmers, and regular discussions with the Irrigation Department officials who are responsible for the operation of the right bank main canal system. While the findings are based on a study of all the data collected, only a selected set of figures are included in this chapter.

Data collected

The major data collected under this research module are as follows:

1. Discharge measurements at the heads of X2, and DC8 (head), Dc2 (middle) and DC5 (tail) of X2, as well as at the heads of all field channels under the intensive sample of DC2, and at two intermediate locations along DC2, representing middle and tail of the canal. The discharge measurements at the head of DC8 had to be abandoned early during the yala **1989** season, due to heavy silting up of the canal. Alternatively, FC6 was selected to represent the head of the subsystem and the measurements were continued there.

2. Daily observation of pan-evaporation and rainfall in the system.

3. Measurement of seepage and percolation by sloping gauge method in nine allotments in the DC2 command area, representing well-drained (RBE), moderately drained and poorly-drained (LHG) soils.

4. Observation of daily water levels in nine allotments in FC10, **12** and **13** in DC2, by perforated tube method.

5. Observation of half hourly water level fluctuations at the heads of BC2, **DC8, DC2** and **FC9 and 10** of **DC2,** during a rotation week.

OPERATION IN GENERAL

During **maha 1987/1988,** the water issues to tract 5 commenced on 25 January **1988** as agreed to at the cultivation meeting, but only with **30** percent of the scheduled delivery because most of the farmers were not ready to start farming activities. Only after seeing the flow of water in the canal, the fanners took steps to initiate land preparation activities such **as** hiring tractors, getting loans, etc. During this initial period, the irrigation agency **was** compelled to reduce the supply of water in older to prevent wastage. However, the releases were subsequently increased to **100** percent of scheduled discharge on the request of fanners.

The Irrigation Department's plan was to deliver a continuous supply during the first five weeks of land prepration period and then to implement rotational delivery. There were substantial time delays by farmers in completing the land preparation due to delays in obtaining bank loans, hiring tractors and procuring seed paddy. As a result, the continuous delivery prevailed until about 28 March, i.e., for a period of roughly 2 months. However, during this period, the discharge in the canal was reduced in an ad-hoc manner by the Irrigation Department officials. The implementation of the proposed rotation schedules in terms of target quantities and time in BC2 and the distributaries under study was not successful during the season. Water was available in plenty during the season in comparison to the scarcities and hardships experienced during the previous season. Therefore, apparently both the Department and farmers had somewhat relaxed attitudes and did not comply with the rotation schedule. In addition, the implementation of the rotation on BC2 was greatly hindered by the use of BC2 as a drainage by-pass for the right bank main canal, in order to protect the cofferdam erected across the canal for phase II construction activities in the downstream reaches. This practice masked to a considerable degree the typical operation and flow behaviors of the study area.

The design of Kirindi Oya project envisages cultivating mainly other field crops during the yala season, as a measure to spread the benefits of the limited water available over a large number of settlers. However, the yala 1989 commenced with clear signs of reluctance by fanners to go in for cultivating other crops, due to various institutional, economic, technical, and management constraints, which are yet to be solved by the agencies responsible for irrigated agriculture. The farmers recommended the cultivation of 3 to 3.5 months rice in yala at the pre-kanna meeting held on 20 February 1989. This decision was later ratified at the cultivation meeting held on 8 March 1989. It was also decided to commence water issues on 15 March and to terminate on 15 July with one month allowed for land preparation period. The last date of water issue was later amended to 27 July but the water issues for rice cultivation continued till about *10* August.

The Department of Agriculture launched a demonstration program to cultivate other field crops in right bank tract 5 on some distributaries including DCs 12 and 13, which are the tailmost distributaries in tract 5. Though the water issues for rice cultivation was virtually over by mid-August 1989, the Irrigation Department was compelled to make intermittent deliveries to the non-rice crops till the end of September 1989.

It was observed that though the water issues for the season commenced on 15 March, most of the fanners in tract 5 area were not ready to receive water so early in view of the yet standing maha crop and harvested product awaiting disposal in some allotments. This resulted in limited time available to the fanners to properly clean the field channels and to the Irrigation Department to carry out pre-seasonal maintenance work in full scale.

The consequences of the hasty decision to start water issues prematurely were reflected clearly in the unsteady flow that prevailed in the distribution system during the land prepration period. Since the water releases commenced with the minimum operating level in the reservoir, anticipating a designated quantity of inflow into it, the Irrigation Department had to exercise great care in releasing water from the reservoir. The land preparation progress in the entire command area was carefully monitored by the Irrigation Department with a view to economize on water use. The land preparation in tracts 2 and 5 extended over a period of two months. During the land preparation period, the

Irrigation Department was compelled to close completely some distributaries for a few days, to *carry* out essential desilting work, when they realized that the design discharges could not be pushed into those distributaries without removing the silt. This resulted in interruption of water deliveries and fluctuations of supply in some distributaries.

The flow in the system was continuous during the land preparation period followed by rotation within the distributaries. In view of the unsatisfactory storage position of Lunugamvehera reservoir, the water management unit took early precautions to prepare the farmers for any eventual crisis situation of inadequate supply, by informing the fanners and appealing to them to use water with care, through posters and leaflets. This was effective in the subsequent operation, because the Irrigation Department was able to economize on water supply without stepping into a conflict situation with the fanners. The improvement in operation during the second season is the introduction of rotation in field channels after the land preparation period.

CLIMATIC DATA

The daily rainfall and computed evapotranspiration (ET), based on measured pan evaporation data at Weerawila, Tissamaharama (right bank tract 5) for the period 6 March to 18 June 1988 and 15 March to 16 August 1989 are given in Figures 5.2 and 5.3. The total rainfall during the 1988 study period was 413 mm while during the 1989 season it was 220 mm. The long term average rainfall of the project area for the season is 250 mm.

The month-wise rainfall, number of rainfall Occurrences per month and highest recorded monthly rainfall are presented for both 1988 and 1989 seasons along with long term averages in Table 5.01. The amount of rainfall and its pattern of occurrences are entirely different for both seasons, indicating the high variability of rainfall Occurrences from year to year. On the other hand, the computed values based on Weerawila data in both the seasons remained more or less the same and are higher than the values used based on the measurements from Angunukolapellessa for preparing irrigation scheduling (Table 5.02).

Though the Operation and Maintenance Manual for Kirindi Oya prepared by the Water Management Consultants (1989) indicates how the effective rainfall is to be computed for the preparation of water delivery schedules, it does not provide guidelines for adjusting the supply of water in the event of rainfall. The effective rainfall depends on a complex interaction of many physical parameters and processes. As such, it is difficult to lay out precise rules for adjustments of irrigation deliveries to account for effective rainfall. The question of deciding when to stop supplying water to a given area and for how *many* days becomes difficult when the rainfall and its distribution are not uniform over the irrigated area. Theoretically speaking if the rainfall amount is higher than the evapotranspiration and seepage and percolation losses, then the irrigation *can* be stopped on that day, or a number of days in succession. But it may be difficult to decide precisely, on which day or after how many days, the irrigation should be reintroduced in order to make the best use of the effective rainfall. The rotational schedules prepared by the Irrigation Department usually detail the specific days on which the field channels in a distributary canal should be closed or opened, i.e., opened on Sunday, Monday, Tuesday, etc., and closed on Friday, and Saturday. The reintroduction of irrigation after a closure of the system due to rainfall may disrupt the rotation schedule and as a result the days of opening and closing in a typical week may have to be revised immediately. This is very difficult in practice. Also to know whether a particular site had rainfall or not is difficult and needs a high density of rain gauge stations.

However, Sir M. MacDonald and Partners (MMP) have suggested certain adjustment rules for accounting for weekly rainfall in rice irrigated areas. They suggest no adjustment for rainfall be made during weeks 1, 2 and 16 of rice cultivation. For weeks 3 to 15, irrigation can be withdrawn for a specified number of days (Table 5.03) in the event the 7 day running total rainfall is in excess of 35 mm (MMP, 1986). If the same adjustment rule is applied in Kirindi Oya operation, then during 1987/1988, irrigation would have been stopped during 4 spells for a total period of 15 days, while during 1989, it would have been stopped for one spell of three days. In a water deficit project like Kirindi Oya, accounting for the rainfall in scheduling has to be given considerably more importance than it has so far. The possibility of storing the excess rain water and irrigation water at times of rain in the service area is another possibility worth exploring.

SEEPAGE AND PERCOLATION

The seepage and percolation losses were measured with great care during the 1989 yala season, based on the experience gained in handling seepage and percolation measurements during the previous yala 1988 season.

The measured average value of seepage and percolation over the season varied from 10.8 mm/day to 4.74 mm/day (Table 5.04). As one would expect, the measured values in the DC2 command area indicated a wide variation and a location-specific nature. The seepage and percolation values adopted for preparing the scheduling in the Operation and Maintenance Manual are 6 mm/day for upland soils (RBEs) and 3 mm/day for lowland soils (LHGs), which are very much at variance with the measured values. Similar measurements conducted in Walawe indicated comparatively high average seepage and percolation values (14 to 16 mm/day).

One may wonder why the soils under a relatively old irrigation system like Walawe give rise to higher values of seepage and percolation while soils under a relatively new irrigation system like Kirindi Oya. IIMI's soil scientist argues that Kirindi Oya soil has more clay content in its dispersed form and therefore its permeability is reduced. But the major reason for such a large difference in seepage and percolation values between the two projects appears to be the seepage and surface drainage losses occurring through bunds. Basically it relates to bund condition, maintenance and water control exercised by the farmers. It has also been observed that in places where water availability is high, seepage and drainage losses are also high due to less management control. The Uda Walawe project is endowed with much greater water resources than Kirindi Oya and this may be one of the reasons for higher seepage and percolation values obtaining there. However, further investigation and verification of seepage and percolation values over a few seasons are required in both the systems to arrive at firm values of seepage and percolation for these two projects.

LAND PREPARATION

The assumptions made in the preparation of water delivery schedules (Progress Report, IIMI 1988b: 16-17) with regard to land preparation are given in chapter 4.

The monitored land preparation progress during yala 1989 in Dc8, DC2 and Dc5 sample subsystems is shown in Figure 5.04. The following points are observed:

1. A typical farmer takes about 4.0 to 5.0 weeks for completing land soaking and prepration from the day he receives water on his allotment until sowing.

2. On an average, a farmer needs 6 to 8 days between the receipt of water and first ploughing, 10 to 18 days between the first and second ploughings, 7 to 10 days between second ploughing and puddling, and 1 to 3 days between puddling and sowing.

3. The total time required until 100 percent completion of sowing on a distributary from the first date of water issue ranged from six and half weeks in Dc5 (tail-end) to nine weeks in DC8 (head-end). The farmers in DC2 spent about eight weeks for this.

4. The total quantity of water used by a typical fanner in Dc2 for land preparation is about 880 mm/ha comprising about 400 mm/ha for land soaking and about 480 mm/ha for the other activities in land prepration.

5. The effective rainfall received during the land preparation period was about 6.0 mm.

6. The peak daily deliveries of irrigation during the land preparation period are 3.41, 3.58 and 2.68 l/s per hectare at the heads of BC2, DC2 and DC5 respectively. These values are slightly higher than the anticipated peak land preparation irrigation requirements as per design at this level of the subsystem,

7. The total quantity of water delivered at the heads of Dc2 and DC5, and the corresponding farming activities carried out in every week during the land preparation are shown in Table 5.05.

8. As seen from Table 5.05, total water used for the completion of the land prepration period in DC2 and Dc5 is 1168 mm/ha and 683 mm/ha respectively. These figures include a part of the water used for the subsequent crop growth as well.

Table 5.01. **Rainfall distribution in right bank tract 5 at Weerawila**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nw	Dec
1988												
Rainfall	-	-	120.4	225.6	3.8	34.9	44.9	17.9	34.0	143.7	249.5	158.2
No of Occurrence	-	-	11	12	3	6	4	a	7	10	18	11
Highest recorded (mm)	-	-	19.4	79.4	2.4	10.5	35.3	3.7	12.0	65.9	ma	42.7
1989												
Rainfall	140.2	28.2	110.1	7.1	62.5	10.1	118.3	7.8	39.4	137.5	87.1	-
No of Occurrence	5	3	3	4	7	2	11	5	5	a	10	-
Highest recorded (mm)	116.7	17.0	55.8	3.3	20.7	18.5	29.0	6.4	17.5	61.2	22.6	-

Table 5.02. A comparison of computed evapotranspiration (ET) based on pan evaporation measurement at Weerawila with evapotranspiration values adopted for the design based on climatic variables at Angunukolapelessa

	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Measured ET (mm/day)	**1988**	-	-	5.8	4.5	3.9	6.1	5.5	5.2	6.7	5.8	6.1	6.0
	1989	2.6	4.1	3.7	4.8	6.5	6.6	5.1	8.4	6.6	6.0	4.6	-
Design ET (with 25% e.p*) (mm/day)		3.8	4.8	5.1	5.0	6.2	6.8	6.1	6.2	6.3	5.1	3.6	3.7

* - **exceedance probability**

Table 5.03. Adjustment rules for rainfall in yala

A) Week 1, 2 and 16

- No adjustment for rainfall
- Canals to be run at the calculated discharge shown on Forms A1 and A3

B) Weeks 3 to 15

Running 7 day Total Rainfall R7 (mm)	Stop Irrigating for N days (days)
< 35	0
36 - 50	1
51 - 65	2
66 - 85	3
86 - 100	4
> 100	5

Weekly Rainfall Total RW (mm)	Adjustment to Flow in Next Week P (%)
< 5	100
6 - 20	85
> 21	75

Source : MMP (1986).

A comparison of the water used for land preparation between Dc2 and DC5 indicates that DC2 had used roughly twice the amount of water as DC5. The soil characteristics of Dc2 and DC5 are similar. The only difference between the two distributaries is their location and possibly the management control of water during the land preparation period. While Dc2 is in the middle of BC2, DC5 is the tail-most distributary. The location of DC2 in this case has had a major influence in using twice the quantity of water that DC5 had used. This brings out the fact that water availability and locational advantages for water access have a marked effect on use of water during the land preparation period. By proper management and water control, the water used for land preparation could have been reduced from **1168 mm** to **as** low as **683 mm.** Dc2 had taken one week more than DC5 in completing the land preparation. From the beginning of the first week, the water delivery of **Dc2** was roughly twice that of DC5, indicating that the farmers who had easy access to water used it less carefully and were complacent about using the water efficiently.

TARGET AND ACTUAL DISCHARGES AT HEADS OF BC2, DC8, DC2 AND Dc5

Mid-Maha 1987/1988

Figures 5.05 and *5.06* indicate the actual daily deliveries at the heads of BC2, DC2, **DC5, Dc8** and FC12 under DC2, compared with the **target** deliveries. The quick conclusion that can be drawn from the figures at a glance is the non-compliance to the scheduled operation. It might appear that an erratic supply prevailed during the season, but this does not appear to be the actual *case*. In all these canals except on Dc2 the actual supply during the months of March and April **was** below the targeted values. This is mainly because during these months the total rainfall was **330** mm, which is much higher than the long term average for the two months. During these two months, there was rain on **22** days and hence the supply in the main and distributary canals had been reduced. Discrepancies in the actual quantity supplied occur because the targeted values do not take actual rainfall into consideration. This non-adherence to the targets actually indicates management interventions to save water. On the other hand, one can also notice that during the months of May and June, the delivery **was** equal to or more than the targeted values, indicating oversupply of water during this period.

The summary of findings from daily flow hydrographs is tabulated in Table **5.06.** It implies that supply to BC2 from right **bank** main canal was below the target for **68** percent of the time captured by the research. However, it is interesting to notice that DC8, which is at the head reach of BC2, was undersupplied for **64** percent of the duration, while Dc5 in the tail-end was undersupplied **for** only 20 percent of the time, and **Dc2** in the middle for 15 percent of the time, It **was** observed that the total area under DC8 was not cultivated during the season and this **was** the cause for the large discrepancy of undersupply. The high degree of oversupply in Dc2 and DC5 **was** due to the Irrigation Department practice of diverting excess water in right bank main canal to BC2. **As** a result X2, **DCs 8,** 2 **and** 5, as well as field channels in DC2 received heavy deliveries at times, as recorded by the flow hydrographs.

Table 5.04. **Measured seepage and percolationvalues, DC2, tract** 5

Location FC No	Allotment No	Minimum (mm/day)	Maximum (mmIday)	Average (mmIday)	Standard Deviation
FC 10	115	2.54	21.90	10.24	6.73
FC 10	108	2.10	13.92	3.92	3.92
FC 10	110	1.84	11.73	5.51	2.41
FC 12	128	3.00	7.77	7.77	4.99
FC 12	130	1.83	9.11	4.74	1.92
FC 12	133	3.00	18.04	7.61	4.11
FC 13	145	2.50	17.39	7.64	3.62
FC 13	155	2.68	9.60	5.20	1.63
FC 13	152	1.94	18.49	10.81	3.80

Table 5.05. Progress in land preparation during yala 1989

	DC 2		DC 5	
week number	Water delivery (mm/ha)	Farming activities during the week	Water delivery (mm/ha)	Farming activities during the week
01	88	Land soaking and first ploughing	48	Commencement of land soaking
02	97	Completing land soaking begining second ploughing 20 percent completion of first ploughing	45	Land soaking, slow progress in first and second ploughings
03	182	Completing first ploughing 20 percent completion of second ploughing, begining of puddling	121	80 percent completion of first ploughing slow progress in second ploughing
04	198	80 percent completion of second ploughing, puddling and begining of sowing	144	Completing first ploughing 50 percent completion of second ploughing, begining of puddling and sowing
05	190	90 pewrcent completion of second ploughing, slow progress in puddling and sowing	130	Slow progress in second ploughing, 25 percent completion of puddling and sowing
06	147	Completion of puddling an 80 percent completion of sowing	113	Rapid progress. 80 percent completion of sowing
07	137	95 percent completion of sowing	83	100 percent completion of sowing
08	129	100 percent completion of sowing	-	Crop growth begins
Total (mm)	1168		684	

The daily flow hydrographs reflect two periods of remarkable water shortages, from **20** to **22** March and again from **10** to **18** April, though it **was** reported that continuous delivery was maintained until about **28** March. Our discussions with Irrigation Department officials revealed that on the first occasion the shortage occurred as a result of reducing the main sluice releases to right bank main canal on **20** March, for the sudden implementation of rotation by the resident engineer on **21** March, without any prior communication with the senior irrigation engineer or intimation to the farmers. The irrigator in DC2, with no instructions received from his immediate supervisor, had no other alternative except to shut down field channels gates either fully or partially, in order to respond to the **reduced** supplies in **EC2 and** DC2. This erratic operation created difficulties for some of the fanners, who had been waiting to irrigate their allotments after having sprayed them with weedicides. The flows were restored after **22** March, with the increase of main sluice discharges to the main canal, after the Irrigation Department realized the impact of its premature decision to implement the rotation. This incident suggests communication **gap** within the department as well as between the irrigators and farmers (see chapter 3).

The second occasion of water shortage occurred as a result of the cutoff of supply from the main sluice after rainfall (79 mm) on 09 April, to prevent damage to canals and canal structures. However the operation of the system seemed to have become virtually paralyzed during this period due to continued closure of the sluice for about 5-6 days. This resulted, according to our data, from the absence of most of the officers and irrigators who were on leave for their Sinhala New Year festival[1].

It is also apparent that the flow in the canals had been rapidly increasing from **28** April until it reached a peak on 03 May. The figures also indicate peak discharge once again on 19 May. These peaks occurred due to deliberate increase of main sluice releases by the Department for a separate IIMI research study on main system management (Sally et al. 1989).

Table 5.07 is a comparison of weekly irrigation water requirements as per Irrigation Department schedules, with the average weekly deliveries made at the heads of field channels under DC2, for weeks **7** to **18.** It shows that FC9 was the most undersupplied while FC12 **was** the least undersupplied. It is also seen that all field channels under DC2 were severely undersupplied during weeks **8 and 12.** Week **8** corresponds to the period during which the Irrigation Department suddenly implemented the rotation, while week **12** corresponds to the Sinhala New Year period. **Some** field channels received less than targeted supplies during weeks 7, **9, 10** and **11**, but the rainfall might have compensated for the small deficits. Table 5.07 also indicates that the water deficit in field channels is closely related to the rainfall that occurred during that week. If rainfall is converted into mm/day as an average value from weekly rainfall and **added** to the actual release, then there is very little inadequacy in any field channel throughout the crop season.

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[1] The Irrigation Department is not in agreement with this statement.

Table 6.06. Summary of findings from dally hydrographs, maha 1987/1988 season

DESCRIPTION	BC 2	DC 2	DC 8	DC 5 80%	FC 9 35%	FC 10	FC 11	FC 12	FC 14	FC 15
PERIOD OF OVER SUPPLY (%)	32%	86%	36%	20%	65%	37%	11%	58%	49%	46%
PERIOD OF UNDER SUPPLY (%)	68%	15%	64%	92%	100%	63%	89%	42%	61%	54%
PERIOD OF SUPPLY DURING WHICH SUPPLY IS BELOW 75% TARGET	23%	12%	42%	92%	100%	75%	92%	62%	42%	44%
DAYS OF EXTENDED SUPPLY (days)	7	7	7	7	7	7	2	5	3	0
DATES OF PEAK DELIVERY	3MAY	3MAY	19MAY	3MAY	30APR	W A Y	5MAY	3–4MAY	W A Y	3MAY
DATES OF ZERO DELIVERY	14-15APR	)-16APF	-12MAR)-15APF	-12MAR 3-17APR	9-10,13-16 21-22APR	22MAR)-17APF	17MAR -6,13-17 3-27APR)-17MAY	22MAR 13-17APR	22MAR)-17APF	)-17APF
CANAL CAPACITY (l/s)	1169	170	113	142	28.32	28.32	28.32	28.32	1	1
MAXIMUM DELIVERY (l/s)	1444	396	170	236	1.3	2.8	0.93	2.24	1.9	1.85

Note:– Indicates the extra number of water issue days after the agreed last date of issue.

Table 6.07. Comparison of actual delivery with targets In maha 1987/1988 season

Weeks	Rainfall (mm/week)			FC 10		FC 16		FC 11		FC 12		FC 14		FC 13	
		Target	Actual	Target	Actual	'arget	Actual	ʼarget	Actual	Target	Actual	arget	Actual	ʼarget	Actual
7	17	15.72	13.46 •	11.49	11.71	15.72	18.43	11.49	13.73	11.49	15.99	11.49	6.67	15.72	18.98
8	33	16.42	7.46 *	12.01	6.91	16.42	11.27	12.01	6.04 •	12.01	7.17	12.01	8.01	16.42	15.69
9	39	16.65	12.22 *	12.61	8 2 '	16.85	20.58	12.61	13.5	12.61	12.96	12.61	12.22	16.85	1761
10	2	17.88	12.62 *	13.05	14.14	17.88	21.3	13.05	12.45 *	13.05	16.96	13.05	15.21	17.88	22.07
11	26	17.88	6.42 •	13.48	7.34 '	17.88	35.11	13.48	13.28	13.48	14.75	13.48	15.14	17.88	13.30
12	91	17.88	4.10 *	13.74	1.17 '	17.88	5.71	13.74	3.74 *	13.74	2.01	13.74	1.71	17.88	1.30
13	14	16.14	7.71 *	13.91	11.19 '	18.14	182	13.91	13.02	13.91	19.98	13.01	13.63	18.14	19.74
14	2	18.14	45.73	13.91	32.64	18.14	46.28	13.91	14.87	13.91	24.87	13.01	21.53	18.14	27.37
15	108	10.14	16.69 •	13.82	30.03	18.14	33	13.82	19.25	13.82	2421	13.82	16.68	18.14	20.52
16	2	17.46	17.12	13.05	17.6	17.45	12.39	13.05	0.07 •	13.05	21.15	13.05	19.16	17.45	16.04
17	0	12.61	41.16	9.16	22.24	12.61	31.72	9.16	13.46	9.16	26.24	9.16	10.6	1281	21.5
18	5	2.94	11.86	2.16	6.47	2.94	18.2	2.16	5.98	2.16	18.4	2.16	13.14	2.94	14.4
10	0		2.11		3.18		0		0		3.92		1.22		0

• represents the week6 during which supply had been below targets.
Delivery and target values are In mm/day

Predictability of Supply during **Yala 1989**

The actual deliveries measured and the target deliveries at the heads of BC2, DC2 and Dc5 are shown in Figure 5.07. A close study indicates the following:

1. The supply at the head of Bc2 and other sample distributaries fluctuated significantly during the first week of land preparation. A study of right bank main sluice issues from the reservoir reveals that an almost constant supply (13.4 cusecs) was delivered into the right bank main canal during this period. Yet there was considerable variation in the discharge at the head of BC2. As has aready been explained, this is mainly due to opening and closing of distributaries and field channels taking off from the main *canal*, which was necessitated by the inability of the fanners to receive an early supply of water, and also due to pre-seasonal maintenance activities. The same phenomenon can be observed in all the lower control points such as distributary and field channel heads too,

2. After the first week, the discharges were increased from 26 March onwards and kept approximately constant, always above the target, for a period of about two months, except on 4 May, when there was a rainfall of about 30 mm occurring on two days before. It is also seen that from June onwards, the supply was gradually reduced and also at times further reduced causing fluctuations at the head of BC2 and other distributaries. This gradual reduction was effected in order to conserve the dwindling storage in the reservoir, while the major fluctuations were caused by the operation of the system to account for the rainfall in the command area. The study of right bank main sluice discharges and the pattern of increasing and reducing the canal deliveries confirms this. In contrast, the degree of discharge fluctuations at the head of DC5 was remarkably more than the other distributaries, or the fluctuations at the upper part of the system were rather amplified at DC5. This may be because DC5 is the tail-most distributary canal and also the continuation of BC2.

3. In the subsystem studied, though the supply has deviated from the targeted schedule, the supplied quantities were by and large above the targeted values.

Figures 5.08 and 5.09 indicate the plots of measured discharges against the targets at the heads of field channels served by the intensive sample DC2. The following are observed:

1. The rotation was not implemented in all the field channels of the DC2. Also the rotation in other distributaries was introduced only two months after the date of water releases, due to slow rates of land preparation progress attained by the farmers in completing land preparation.

2. In almost all the field channels except FC13, the water supply against the target was predictable. In FC13, which is the tail-most of DC2, more than one third of the allotments (about 7 ha) did not depend on the irrigation supply, as they had access to the drainage water for cultivation.

3. During the periods of rainfall, almost all the field channels were closed completely.

4. The trend of fluctuating discharges and the gradual reduction of water supply in the latter part of the season as observed in the upper control points of the system *can* be observed in the lower control points too.

Discussion

The present procedure of comparing the rigid schedule prepared by the irrigation officials with that of the actual deliveries at chosen points of the subsystem such as branch canal, distributary and field channel heads has certain inherent weaknesses. The schedule prepared by the officials does not take rainfall or the reuse of drainage water into consideration, and is based on certain assumed parameters and assumptions such as so *many* days for land preparation, etc. Many reasons may be attributed for the mismatch of the actual deliveries with the scheduled deliveries. However, the two seasons of comparison of scheduled and actual deliveries of Kirindi Oya project brings out the following points as the dominant factors causing discrepancies:

1. The irrigation officials used the delivery schedule as a guideline and did not strictly follow the schedule for supplying water since rainfall and reuse of drainage water etc. have not been taken into account in preparing the scheduled delivery.

2. The actual delivery of water is intimately related to farmers' activities and needs. Often the farmers were not able to follow the schedule strictly, especially with respect to the time stipulated for land preparation. Due to this, the quantity of water had to be adjusted to suit the requirement; otherwise the water would go waste. Therefore flexible water delivery **was** adopted by the irrigation officials.

Item **2** above brings out the fact that irrigation supply schedules prepared before the start of the season have to be reviewed frequently, possibly every week during the irrigation season and are to be updated taking into consideration the state of irrigation activities, area irrigated, rainfall occurrence, etc. Such updating has to be done by the agency officials in close collaboration with farmer representatives so that the requirement can be estimated more realistically. This procedure needs more management effort from the agency officials and more interaction with the farmers than what is **happening** at present. Such a schedule updated periodically during the season **when** compared with the actual deliveries would bring out the deficiency in the management of water, if ***any***. The present procedure of comparing the rigid schedule prepared at the beginning of the season with the flexible water supply delivery adopted by the irrigation officials gives only a rough guideline and cannot be used effectively as a management tool for monitoring the water supplies at different points of the sub-systems. In other words, rigid irrigation scheduling which is used now as a standard for comparison is not suitable because it is not dynamic. A dynamic schedule, periodically updated during the season, would be more suitable and effective.

Presently land soaking and land preparation consume anywhere between one third to one half of water supplied for rice cultivation; yet this is the period of least interaction at the field between farmers and agency officials. There is a very high potential to save at least half the present water used for land preparation if a procedure is adopted for close interaction between farmers and officials and if effective monitoring and control of flexible water supplies is adopted by the agency officials during the land preparation period (as proposed in chapter 4).

WATER TABLE FLUCTUATIONS

The water table above or below the paddy allotments was measured during 07 April - 03 June 1988, in each of the selected allotments in field channels 10, 12 and 13. Figure 5.10 shows the water level fluctuations in a tail-end allotment under FC12.

If the number of continuously drained days without water in the field in excess of three are defined as stress days, all allotments except FC12 at the tail suffered crop stress for varying durations between 10-22 April, as a result of the main sluice closure. The analysis of water level fluctuations in other selected allotments indicates crop stress during 16 May to 03 June (weeks 16-18). However Table 5.07 does not indicate *any* short supply during this period, except for FC12 in weeks 17 and 18. This brings out the fact that farmers were not organized to distribute the water uniformly in their fields, although the supply to the field channel was adequate.

Table 5.08 is a summary of findings on water table fluctuations in field channels 10, 12 and 13 compared with the average yield obtained from each allotment. The number of stress days and the average yield do not follow a well defined relationship with each other. Other factors such as use of fertilizers, and weedicides and pest attack might have influenced the yield to a greater extent.

CONVEYANCE LOSSES

The daily supply hydrographs at the head of DC2 and the sum of daily supply hydrographs at the heads of field channels under DC2 are shown in Figure 5.11. The difference in daily hydrograph ordinates is a measure of losses during the period under study. The steady state periods between 11-19 March, 24 March-4 April, and 22-28 April in Figure 5.12 correspond to conveyance efficiencies of 69, 74 and 69 percent respectively, with an average of 71 percent. This value is close to the recommended value of 75 percent in the irrigation department's (1981) Technical Note no. 6, but far below the value of 93 percent adopted by the Department in water delivery schedules for the season. The average loss in DC2 is therefore about 5170 cubic meters per day which corresponds to a loss rate of 0.6 cubic meters per day per square meter of wetted area (6.94 cusecs per million square meters of wetted area or 22 cusecs per million square feet of wetted area).

Table 5.08 Summary of water table fluctuations

Water table below the ground level	FC 10			FC 12			FC 12		
	HEAD	MIDDLE	TAIL	HEAD	MIDDLE	TAIL	HEAD	MIDDLE	TAIL
0-loom	7	4	5	0	10	6	3	26	3
10 - 20 cm	8	0	3	1	I	1	3	10	1
20 - 30 cm	4	2	2	2	3	0	3	4	1
30 - 40 cm	4	2	1	6	4	2	1	0	2
40 - 50 cm	5	1	0	0	6	1	1	0	3
> 50 cm	0	3	0	0	6	0	0	0	6
Total measured days	54	55	55	55	54	55	50	55	56
Number of stress days	28	12	11	12	30	7	11	21	16
Yield (kg/ha)	4393	4737	3679	3158	3498	4459	4134	3869	3171

Note :-The water table fluctuations were observed from 07 April to 07 June.

HALF HOURLY **FLOW** OBSERVATIONS

The flow of water at the heads of DC2 and the field channels under it were observed every half hour between **7:00 am** and **6:00** pm during two rotation periods in the season. The first rotation period spanned **26** April to **04** May, while the other **was** between **16** to **22** May. The half hourly flow fluctuations at the heads of field channels 9 and **13** observed during the first rotation period are indicated in Figure **5.12**.

A review of the observed flow patterns for both rotation periods indicates sudden jumps of discharge on **28** April afternoon and on 19 May, in BC2, Dc2 and in all field channels. This **was** a result of a deliberate increase of discharge in right bank main canal and BC2 by the Irrigation Department to facilitate studies conducted by **IIMI** mentioned above.

The second rotation period also reflects a sudden remarkable decrease of flow followed by an increase in **Dc2** and field channels, except in field channels **9**, **11** and **15**, within **a** few hours on **17** May. Field channels 9, 11 and 15 had been kept closed on this particular day. The daily flow hydrograph for **BC2** also indicates a similar pattern between 15 to **17** May.

The degree of flow variation in **Dc2** for both rotation periods was moderate, with steady flow conditions prevailing for significant periods during the day. The micro variations during near steady flow periods may be partly attributed to possible measurement errors in the field.

The study of half hourly flow variations at the heads of field channels for both rotation periods indicates a lesser degree of flow variations in field channels 9 and 10, and a comparatively high degree in the others. The variations in **FC15** axe apparently not realistic due to doubtful accuracy of flow measurements at the heed of the field channel, caused by the regular blocking of **FC15** by a farmer immediately downstream of the outlet in order to feed his allotment at higher elevation.

The near steady flow conditions in field channels 9 and 10 and comparatively high degree of daily flow variations in field channels **11**, 12, 13 and **14** reflects an increasing trend of unsteady conditions from head to tail of the distributary. It is noted that **FC13** suffered the highest degree of half hourly flowvariations. It is the tail-most field channel and functions as the continued last reach of DC2.

ADEQUACY OF SUPPLY

The adequacy of supply can be evaluated in terms of Relative Water Supply **(RWS)** which for our analysis is defined as:

For **Land** Preparation Period:

RWS □ [IW t Re] / [E t S&P + Land Soaking and Ponded Water]

For Crop Growth Period:

RWS = [IW t Re] / **[ET t S&P]**

where,

IW = Irrigation Water Delivery (mm)
RE = Effective rainfall in mm (assumed as total rainfall)
ET = Evapotranspiration (mm)
S&P = Seepage and Percolation losses (mm)
E = Evaporation

The weekly RWS values for yala **1989** at the heads of **BC2**, FC6 (head), **DC2** and DC5 were computed and are presented in Figure **5.13.** Similar computations were carried out for the field channels under **DC2** and are presented in Figure **5.13.**

The weekly RWS values for the maha 1987/1988 were prepared in exactly the **same** way as for yala **1989** and are presented in Figures **5.14.** The only difference is that in **maha 1987/1988**, measurements were made in **Dc8** instead of FC6 at the head of the branch canal.

A RWS = 1.0 on any given week, at the level of a typical farm allotment, means that the combined supply by the system and the rainfall in that week exactly matches the actual requirement or demand. The adequacy of irrigation delivery is in theory, best, i.e., efficient, at this level, implying no "oversupply" or "undersupply". But if RWS = 1.0 at the head of a typical field channel, then the water delivered by the farm turnouts in that field channel will be less than the actual requirements, because of the conveyance losses of the field channel, implying "undersupply to the farms". Therefore, the "critical RWS" at the head of a typical field channel, which corresponds to the condition where supply exactly matches the demand, may be deduced with due consideration for losses in that field channel. The same argument can be extended to arrive at "critical RWS values" at the heads of distributaries and branch canals in order to interpret the adequacy of water delivery at those levels.

For the purpose of our analysis, the conveyance efficiency in a typical field channel, distributary or branch canal were assumed ax **93** percent, **as** adopted in the water delivery schedules prepared by the Irrigation Department. This results in critical RWS values of **1.07, 1.15** and **1.24** at the head of a typical field canal, distributary canal and branch canal respectively.

A comparison of the weekly RWS values in the sample subsystem for yala **1989** with the critical **RWS** values indicates that during the first four weeks of the crop growth period that the system delivered an adequate or rather an "oversupply" to the farm allotments. It is **assumed** that the crop growth period starts **around 20** April **1989**, the date on which about 50 percent of sowing has been completed. In contrast, for most of the time in the remaining period, less than the critical RWS both along the branch canal as well as within Dc2 prevailed. If one compares the computed RWS for the crop **growth** period against the line RWS = **1.0** (Figures **5.14** and **5.15)** then the actual RWS for most of the time prevailed above the RWS=1.0, both along the branch canal as well as at the heads of distributaries (including FC6).

At the *same* time, a general trend of gradually declining RWS values can be observed from the beginning of the crop growth period which may be due to the deliberate reduction of supply by the department in view of the gradually declining storage in the reservoir. Also, during week **13 (19-26** July), high **RWS** were observed due to high rainfall that *occurred* in that week, and low RWS values were observed in the subsequent week **14**, due to cut-off of the supply by the department to account for the rainfall in the previous week.

The distribution of computed RWS values at the heads of field channels under the intensive sample canal (DC2) as presented in Figure 5.14 indicates high RWS values throughout the growing season except for FC10, 12 and 13. It is also seen that the general pattern of RWS distribution at the head of BC2 over the growing season is clearly transmitted to the field channels as well as the distributaries, with low RWS values in the range of **0.50** - 0.80 prevailing at the heads of field channels during the latter **part** of the season, implying "undersupply."

However, a more sensible comparison of the actual RWS values with the distribution of rainfall over the season, as well as the actual deliveries into the right bank main canal *and* to the other canals in the subsystem brings out the fact that the Irrigation Department **has** made its best effort to economize on water supply during the rainy periods by completely withdrawing or reducing the irrigation supply, either during or after the rains, or both, in view of the limited storage in the reservoir.

The RWS plottings for **maha 1987/1988** (Figure **5.14)** present an entirely different pattern of water distribution from that of yala **1989**.

1. During the first six weeks of study, the RWS values were relatively low, on the orders of **0.7** to **0.8** in the branch canal, distributaries and field channels. The lowest value had occurred on the sixth week. The reason for this low value appears to be high total rainfall of more than 100 mm during that week; there **was** a complete closure of canal supply for almost a week.

2. On week **8**, the RWS recorded the highest value because the water in the right bank main canal was increased deliberately by the Department for a separate IIMI research study on main system management.

3. During **weeks 7-13**, the RWS values were generally high (high than **1)** indicating that there had been an oversupply during the latter part of the cultivation season.

The RWS values presented in the plots for the two seasons bring out graphically the style of operation of the water distribution system by the Irrigation Department under two different situations. The yala **1989** represents a condition in which the rainfall is just below normal in the service area **and** the storage position in the reservoir is not very satisfactory from the beginning of the season. The **maha 1987/1988** season portrays **a** situation in which rainfall is much higher than the normal rainfall in the service area and the storage position in the reservoir is comfortable.

In the first case the Irrigation Department was very cautious from the very beginning in releasing water and focussed its attention on economizing the water by reducing the water supply in the canal whenever there was rainfall in the service area. By frugal and careful use of water, they were able to carry through the yala season successfully. On the other hand, during maha 1987/1988, the release of water in the canal systems during the beginning of the season was coordinated with the occurrence of rainfall in the service area, mainly to prevent breaches of canal sections. However, at the end of the season as the RWS values indicate, there has been a certain relaxation in the use of water, pushing the RWS to a higher value.

WATER DELIVERY PERFORMANCE

The Water Delivery Performance (WDP) is defined by Lenton (1983) as:

$$WDP = \sum_{i=1}^{n} \frac{K(t)\, V_i(t)}{Vi^*(t)} \qquad Vi(t) < Vi^*(t) \qquad K(t) = 1$$

where,

$Vi(t)$ = Volume of water delivered to farm i during week t of cropping season.

$Vi^*(t)$ = Target volume of water to be delivered to farm i during week t of cropping season.

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

n = Number of weeks in cropping season.

In this study, the WDP parameters were computed assuming equal weight for all periods of the growing season or study period for all the canals studied.

Equity of Water Supply

Table 5.09 indicates the mean RWS, maximum and minimum RWS as well as Water Delivery Performance (WDP) for both the seasons studied. It shows that both the mean RWS and WDP do not differ very much and are almost the same. The mean RWS and WDP both in the branch canal as well as in the sample distributaries are higher than 1. Along the branch canal, the supply is not equitable, as WDP varies between 1.39 at the head to 1.05 at the middle and tail during the yala 1989, whereas during maha 1987/1988, the WDP value at the head was 1.38, middle 1.71 and the tail 1.31, indicating abundant water supply and inequitable distribution. Though the head-end FC6 received more supply during the yala, which may be partly due to its position along the branch canal, the agency has succeeded in maintaining a fairly equitable supply between the middle and tail reaches of the subsystem studied.

Table 6.09. **Relative water supply (RWS) and water delivery performance (WDP) for right bank tract 5.** BC **2** sub **system**

		BC 2	DC 8 ^	DC 2	DC5	FC 9	FC 10	FC15	FC 11	FC 12	FC 14	FC 13
Maha 1987188	**Minimum RWS**	0.48	0.47	0.53	0.35	0.51	0.33	0.62	0.51	0.39	0.37	0.33
	Maximum RWS	2.74	3.03	3.52	2.80	4.57	3.88	4.78	2.35	3.22	2.93	3.23
	Average RWS	1.20	1.38	1.71	1.31	1.44	1.28	1.80	1.09	1.47	1.30	1.38
	WDP	1.19	1.32	1.89	1.29	1.34	1.25	1.73	1.06	1.45	1.21	1.40
Yala 1989	**Minimum RWS**	0.60	0.67	0.49	0.45	0.48	0.36	0.33	0.26	0.33	0.50	0.19
	Maximum RWS	1.57	1.87	1.55	1.59	2.74	1.52	2.19	2.16	2.00	1.87	1.31
	Average RWS	1.14	1.38	1.05	1.08	1.43	0.85	1.32	1.04	0.98	1.25	0.72
	WDP	1.12	1.36	1.08	1.08	1.36	0.81	1.27	1.00	0.94	1.23	0.74

^ **For yala** 1989 FC **6 was used, not DC 8.**

As far as the equity among the field channels within DC2 is concerned, except FC10 and FC13, the mean RWS was higher than 1.0. It is to be noted that, contrary to the common perception of progressively declining equity between head and tail, mean RWS alternated between 1.41 at the head to 0.75 at the tail. Only two field channels out of the seven received less than a mean supply of RWS less than one. Though FC10 and FC13 indicate low RWS values, FC10 and FC13 received the benefit of drainage water. During maha 1987/1988, all the field channels under DC2 received a mean RWS value greater than 1 with the values varying between 1.88 to 1.09. Again the variation is not progressively declining from head to tail (Figure 5.15). In both the seasons, there was no equity of supply at the field canal level.

An inherent weakness of the RWS methodology in assessing the adequacy of supply is that it fails to account for the use of drainage water as well as any residual water left in the fields due to rain or over-irrigation, which can still be used to supplement the water requirements in the subsequent weeks. The concept of cumulative weekly relative water supply (CWRS) instead of weekly RWS accounts for the residual water and gives a better representation of available water at the field level. Plots of CWRS as a function of time for BCs, distributaries and field channels are shown in Figures 5.16 and 5.17 for yala 1989 and maha 1987/1988, respectively. One can observe from these plots that the adequacy of water along BC2 as well as along DC2 has been brought out clearly and was always equal to or greater than the requirement, except in FC10 and FC13 which received drainage water during yala 1989.

Although equity among the field channels of the sample subsystem was found to be within acceptable limits, there was a wide variation of water level in rice fields in different areas as well as within the same field (maximum +18 cm to minimum -50 cm). The wide variation within and between the turnout areas is an indication of ineffective water distribution by the farmers in the field channel turnout areas. One of the operational assumptions of the design of the turnout area is that the farmers in *any* given field channel form a cohesive group to share the entire flow in the field channel *among* two farmers at a time during the rotation interval. While it is true that the Department too could not adhere to a strict implementation of rotation among field channels, it was also observed that farmers did not adhere to *any* systematic sharing of the water delivered. In fact, this was the first season in which we observed a pattern of farmer interventions such as manipulating field channel and distributary gates and cutting channel bunds. This, and the high degree of water level fluctuation in the fields pinpoint the importance of improved management at the farm level to avoid crop stress.

Water Delivery Ratio

The daily supply hydrographs indicate a high degree of overloading. As indicated in Table 5.10, the highest degree of overloading has taken place in DC2 during the yala 1989 and in FC10 during the maha 1987/1988.

Discussion

The water delivery system operation during maha 1987/1988 is a classic example to show how the agency and the farmers behave when the supply of water

Table 6.10. Water delivery ratio in BC 2 sub-system, tract 5

		BC2	DC 8*	DC2	DC5	FC 9	FC 10	FC 15	FC 11	FC12	FC 14	FC13
Design discharge (Us)		1300	30	170	170	28	28	28	28	28	28	-
Maha 1987/88	Peak discharge	1317	-	415	291	40	81	79	27	68	60	82
	Overload factor	1.01	-	2.44	1.71	1.43	2.88	2.84	0.96	2.42	2.13	-
Yala 1989	Peak discharge	1772	40	326	222	37	47	27	44	44	46	76
	Overload factor	1.36	1.33	1.91	1.31	1.32	1.67	1.00	1.57	1.15	1.17	-

* For yala 1989 FC 6 was used, not DC 8

is abundant. During this season, BC2 was used as a by-pass to send down excess supply from the right bank main canal. This resulted in unscheduled supply to the sub-system under study. During the months of March and April in 1988, fairly high rainfall (330 mm) led the agency to operate the system by reducing the discharge to conserve water as well as to safeguard the bunds of the channels from breaching. Also, the storage position in the reservoir was comfortable during this season. All these aspects combined together led to the farmers and agency officials taking a relaxed attitude and to their not introducing rotational scheduling. Table 5.11 gives the irrigation water used during the crop growing season of 13 weeks at branch canal, distributaries and field channels levels, which is very much in excess of the designed deliveries. In addition to abundance of water supply, there was a lack of supervision and monitoring of operation by the Department staff because of their preoccupation in achieving the construction targets. There was no systematic monitoring, communication and feedback mechanism. The irrigation schedules prepared on the basis of unrealistic values assumed for conveyance efficiency, seepage and percolation values, and soil distribution within the turnout areas without accounting for rainfall and reuse of drainage water resulted in either oversupplied or undersupplied schedules.

The study of micro-variation of flow in field channels in DC2 indicates that steady flow conditions do prevail for considerable periods as long as there is no fluctuation of head in the parent canal or no interventions with prevailing gate settings or both. It also shows an increasing tendency of flow fluctuations from head to tail.

The average loss rate in DC2 is about 0.6 cubic meters per day per square meter of wetted area which corresponds to a conveyance efficiency of about 71 percent. This is close to the recommended value of 75 percent in the design criteria of the Department but very much different from the 93 percent used by the project O&M division in preparing the water delivery schedules.

After the 1987/1988 maha season, selected farmers whom we met did not complain of water shortages except for two specific instances which were mentioned earlier. Some tail-enders complained that they did not receive their due share from the field channel most of the time, but they did not have any shortages as they were able to tap seepage and drainage water to feed a major part of their allotments. Though FC9 had been the most undersupplied out of all field channels, farmers did not complain of any water shortage because of the seepage water from BC2. From the farmers' point of view, the adequacy or availability of water during the season was satisfactory.

The main constraint to proper operation during the yala 1989 season resulted from the hasty decision taken by the farmers to start the season, even before the previous maha season in some areas was over. The environment and the process in which this decision was arrived at imply: 1) the farmers' lack of understanding of the importance of pre-seasonal maintenance both by the department and themselves; 2) the lack of communication among farmer representatives - farmers - irrigation Department officials; 3) the farmers' reluctance to go in for other field crops as envisaged in the project design due to various constraints faced by them; and 4) the inability on the part of the agencies to convince the farmers to grow other field crops in yala, due to lack

Table 5.11. Total water use in BC2 sub–system in right bank tract 5.

	BC				DC				DC				D(			
	Maha 1989/88		Yala 1989		Maha 1987/88		Yala 1989		Maha 1987/88		Yala 1989		Maha 1987/8(		Yala 1989	
	Target*	Usec	irget*	Used	irget*	Used	irget*	Used	Target*	Used	irget*	Used	irget*	Used	irget*	Used
Land Preperation (mm)	-		596	723	-	-	450	886	-	-	445	822	-	-	442	544
Crop Growth (mm)	1274	1169	1585	1974	1407	1354	1190	2405	1263	1784	1182	1790	1407	1258	1177	1662
Total (mm)	-		2181	2697	-	-	1640	3290	-	-	1627	2612	-	-	1610	2206
Land Preperation (Acft/	-		1.95	2.37	-	-	1.47	2.9	-	-	1.46	2.7	-	-	1.46	1.78
Crop Growth (Acft/Ac)	4.18	3.83	5.2	6.47	4.61	4.44	3.9	7.89	4.14	5.85	3.88	5.07	-	4.12	3.86	5.45
Total (Acft/Ac)	-		7.15	8.85	-	-	5.37	10.79	-	-	5.34	8.67	-	-	5.31	7.23

* means target values have been computed on the basis of irrigation schedules prepared by the Irrigati

^ means FC 8 was used in yala 1989, not DC 8.

- means data not available.

of technical know how and other institutional and management constraints yet to be solved. The low reservoir storage at the start of the season coupled with the decision to grow rice in right bank tracts 2 and 5 forced the Irrigation Department to be cautious in distribution and allocation of water from the beginning of the season in order to avert the risk of water scarcity during the tail-end of the season. The sudden on-set of the cultivation season together with the limited availability of water resulted in an uneven supply of water due to the attempts of the water management unit of the Department to match the supply to the actual requirement in a sensible way. The release of water, taking into account the rainfall and the essential maintenance requirements of some distributaries, led to closing and opening of the canals at times. In general, the Irrigation Department succeeded in the attempt to economize on water use and in the effort to distribute and manage the limited resource of water to a satisfactory level from the point of view of adequacy and equity.

The total rainfall during the season (215 nun) was more than the 80 percent probability of exceedance value at Tissamaharama. It was observed that the rainfall was effectively utilized for crop growth in the season by cutting down the supply whenever there was a rainfall. The limited availability of the water was a plus factor for the Irrigation Department to exercise more care in utilizing the rainfall for crop growth, as against the previous mid-maha season which was blessed with an abundance of water availability.

The seepage and percolation value measured in yala 1989 over the command of DC2 is about 8 mm/day on average. This is a significantly higher than the values adopted (5.7 mm/day for RBEs and 3.0 mm/day for LHGs) for the design and the preparation of irrigation schedules. The measured values are scattered over a wide range. This wide variation of seepage and percolation values deserves further investigation and verification over the whole command area over several cultivation seasons before one or more representative values can be adopted in the models used for irrigation scheduling for rice. Presently, the seepage water which is likely to re-emerge as drainage and ponding water in the lower fields is not being accounted for in the delivery, both in the scheduling and the real time application. Nevertheless, it is difficult to account for the reuse of water accurately, due to the difficulty in understanding the processes and magnitudes associated with the re-emergence of seepage water. One way of accounting for drainage reuse is to apply a correction factor for some of the parameters like seepage and percolation and conveyance efficiencies.

The time required for a typical farmer to complete the various farming activities during land preparation and the actual use of water for land soaking and puddling are some areas not adequately addressed in previous irrigation management research. Our study and analysis of the land preparation period and the irrigation water requirements in Kirindi Oya as well as in Uda Walawe irrigation projects confirm this. While accepting that the assumptions made in the design for the land preparation period are not expected to be realized exactly, a proper understanding of the reality of land preparation as affected by socio-economic factors would be necessary to develop an irrigation schedule which matches the actual requirements of irrigation. It is therefore worthwhile to monitor these variables in the command of Kirindi Oya over a few seasons, in order to further refine the model adopted for the determination of irrigation requirements for any given yala or maha season.

The predictability of supply during the season was not up to the levels expected by the farmers, with respect to the closing and opening of the distributary canal gates as per the schedule. However, the Irrigation Department had to deviate from the schedule it prepared at the beginning of the season in order to: 1) conserve the limited water; 2) match the operation to the actual rate of progress attained by the fanners due to initial delay in land preparation; 3) capture the maximum possible rainfall to supplement the delivery: and 4) upgrade the canals by carrying out rapid maintenance work after the commencement of water releases.

If one assesses the adequacy of supply strictly based on the actual and critical RWS values, then the overall supply to the farmers during the season was not adequate. An inherent weakness of the RWS methodology in assessing the adequacy of supply is that it fails to account for 1) reuse of drainage water and 2) residual water in the rice fields after it rains that can still supplement a part of the crop water requirements in the subsequent weeks. As observed during the season, not many complaints were heard from the farmers on the inadequacy of supply by the system. This means, though the computed RWS values are lower than the critical values most of the time, the operation by Irrigation Department attempted to take into account the drainage reuse and effective rainfall, in a practical sense. This suggests that CWRWS is a better parameter for assessing system performance than simple RWS.

As far as equity is concerned, the head-end canals of the sample subsystem received more water as against the middle and tail counterparts. However, there was no great inequity between middle and tail as well as among the field channels of the intensive sample (DC2), except for FC10 and FC13. These two field channels had the benefit of using the drainage water for the cultivation of a part of their command areas. Had a correction factor been applied in the RWS computations to account for the actual area benefitted by the irrigation supply from the canal system or the actual area benefitted by the drainage water, then the actual RWS value would have been very much higher.

It is encouraging to observe that the water management division of the Kirindi Oya project has prepared a plan to operate the different parts of the system in such a way that the lower parts are benefitted by the drainage return flow from the upper parts. While this is considered necessary for the long term development of the potential area by optimising water use, it is equally necessary to utilize efficiently the drainage water generated by the upper parts of the subsystems in the lower parts whenever possible. It is necessary to delineate the areas which receive drainage water and to quantify such water in order to prepare more realistic water delivery schedules.

Though the equity among the field channels of the sample subsystem was found to be within acceptable limits, yet there is a wide variation of water level in the rice fields in the different areas, well within the fields (maximum +18 cm to minimum -50 cm). This indicates that the field level. distribution by the farmers is not being carried ut effectively. One of the operational assumptions of the design of the field channel turnout areas is that the farmers in any given field canal will form a unified group to share the entire flow in the field canal among two farmers at a time during the rotation interval. While highlighting the fact that Irrigation Department too could not adhere to a strict implementation of rotation among field channels, it was also observed that farmers did not adhere to any systematic sharing of water delivered by the field channels. The high degree of water level fluctuation in rice fields pinpoints the importance of improved management at the farm level in order to avoid crop stress. The weakness of field channel groups is also discussed in chapter 3.

RESEARCH QUESTIONS AND RECOMMENDATIONS

Irrigation System Objectives

Irrigation development in Sri Lanka until recently has been focussing on the construction of major new irrigation schemes with the primary objective of increasing food production, achieving self- sufficiency in rice production and providing employment through settlement of landless people. Higher rice production in recent years, mainly as a result of increased irrigated area and higher yields obtained by farmers through higher input use, has brought Sri Lanka closer to self-sufficiency in rice, though recently there have been some setbacks. The recent realization that water availability during the dry season is limited and water is used inefficiently in areas with soils not suited to rice production have led the Government to embark upon a policy of encouraging diversification into subsidiary food crop production in irrigated systems. Improved management of irrigation systems in general and efficient management of irrigation systems for crop diversification in particular, are thus a high priority in the agricultural development strategy of the Government.

Ever since the Kirindi Oya project started functioning in 1986, only irrigated rice has been grown in the project area with very small areas allocated for non-rice crops. The farmers and agency officials seem to accept rice cultivation as the desirable cropping pattern during both the yala and the maha seasons and do not consider alternative scenarios, such as the one proposed by the water management consultants, as practical, or at least worth a serious trial. From the farmers' point of view, rice gives a fairly good yield (3.5 to 5 tons/ha), is comparatively risk free, is less labor and capital intensive, and provides the staple food. On the other hand they are not sure of having a good market, credit, insurance and making higher profit out of other crops. Therefore, they are interested in growing only rice during both the seasons in spite of its large water consumption. Moreover, water does not cost them, they get it almost free of charge. Therefore, their concern is not with respect to water consumption of rice.

A far more significant factor lies in the way the project is managed. A number of departments are presently involved in implementing different activities of the project. There is no single department which has the responsibility for achieving the overall project objectives, or especially, for implementing a long term agricultural production plan, Consider, for example, the roles and functions of the Irrigation Department which is the major department involved in managing the project. Its job is to deliver water, within the constraints imposed by water availability, finance, the physical condition of the system, etc. It responds to farmers' demands, to the extent possible. Other agencies have their own specified technical functions. But no single agency is responsible for achieving the long term objectives of the project.

Presently the Irrigation Department caters to short term objectives of providing water for rice in a few tracts, on an **ad hoc** tract-wise rotating basis, depending on the water in the reservoir at any given time, but with the old Ellegala system always getting sufficient water for growing rice for two seasons per year. This satisfies farmers' short term interests, as they wish to grow rice, and it is also easy for the agencies as they know how to support rice production. The end result of the above type of system management is that the system as a whole is not able to get into a seasonal rotation i.e., maha-yala-maha and cannot raise other crops as contemplated in the project design.

The above statement is validated by the operation of the system during the yala 1989. Because the reservoir was emptied to support the yala 1989 rice crop, the old area and only two tracts in the new area were able have an irrigated maha rice crop. Therefore, the ultimate objective of irrigating the whole project area of 12,900 ha under phases I and II with diversified food crops could not be achieved and may not be achieved at all if the present practice continues. We feel that a radical change in the system operation is required. The first and the foremost question to be answered is what is the ultimate extent of area to be irrigated under the Kirindi Oya project in view of the changed estimation of water availability and the present water use pattern? The second question is what should be the water allocation between the old and the new area which will then lead to choosing a proper cropping pattern? The third question to be answered is what institutional and organizational changes are required to implement the solutions with farmers' participation? Some suggestions are presented in the following paragraphs.

Water Delivery Performance

The research carried out by IIMI in the BC2 subsystem has provided certain basic operational parameters and has brought out the need and potential for improving the water delivery performance of the Kirindi Oya project. In analyzing the results at subsystem level, the concepts of reliability, adequacy and equity of water supply were introduced using cumulative weekly water supply (CWRS) and water delivery performance ratio as parameters which were satisfactory and adequate for the purpose. The salient research findings are as follows.

1. The irrigation water use per season during the two seasons of rice cultivation was far in excess of what has been generally allowed for in the design. The water used per season varied between 2.0 to 2.5 m/ha at the branch canal turnout against the normally allowed figure of 1.20 to 1.3 m/ha. Considerable potential exists for water saving.

2. The performance of the system appears to be directly related to the water availability in the system. In maha 1987/1988 when water was abundant, its use was much higher than in yala 1989 which was a relatively water deficit season. When water is abundant, the tendency for officials and farmers is to relax; no rotation was implemented, management input became less, and irrigation water use increased.

3. There exists a great potential for improving the water delivery performance with active involvement of the system managers including the farmers in actual operation of the system. The formation of a separate O&M division under a senior irrigation engineer with more powers and its active interaction with the fanners and field visits had considerably improved the operational performance of the system during the yala 1989.

4. Some of the operational parameters such as canal efficiencies, seepage and percolation losses, etc, measured in the field are much high than what has been used for preparing the irrigation schedule and therefore, they need to be reappraised.

5. The water used for land soaking and preparation was very higher and varied between 680 to 1180 mm. *Also,* the land preparation period extended up to a period of 2 months. There exists a great potential for water saving during this period with close interaction of the agency officials and the farming community, with a monitoring and feedback mechanism.

6. The fanners did not adopt rotation for applying water to their fields as envisaged in the design. Forming and sustaining water users' groups within field channel turnout is necessary to distribute the water more equitably and to operate and maintain the field channels.

In addition to the above findings relating to the subsystem level, there are certain macro-issues at the project and national level which appear to affect the performance of the system. The following dominant issues which have a bearing on water delivery performance are briefly discussed and possible further studies or solutions are recommended (see chapters 2 and 3 as well).

a. Water resources potential of the basin;
b. Water allocation between the old and new system;
c. Crop diversification;
d. Water management; and
e. Project management.

a. Water resources potential of the basin. As has been indicated in chapter 2 the present estimation of reservoir inflow appears to be on the high side by at least 30 to 40 percent of the estimated design inflow into the reservoir. The long term rainfall analysis indicates that there is a decline of rainfall at the average rate of 4.5 mm/year in the catchment area. Upstream development of water use within the catchment area is likely to have a greater impact on the water availability in the coming years. Therefore, the hydrology of the basin and the present upstream water use have to be studied systematically since the success of the project depends to a great extent on the accurate estimation of reservoir inflow and its distribution.

It is recommended that adequate rain gauges (both recording and non-recording) be installed in the catchment area to systematically collect rainfall data. Reliable flow measurement data at the newly established gauging station at Tanamalwila are also be collected. These reliable measurements should be used to update and revise the inflow series *and* arrive at dependable flow for reservoir operations. We have also recommended that the hydrology section of the basin be made directly answerable to the operation and maintenance (O&M) division of the Kirindi Oya project (chapter 3). Necessary wireless communication should be established between the O&M division and the hydrology section.

b. Water allocation between the old and new subsystems. The water allocation between the old Ellegala system and the new area is now decided **based** on the water use prior to the construction of the dam. Presently, irrespective of the storage position in the reservoir, the old area gets water for cultivating two rice crops, leaving very little water for the new area especially during sub-normal and drought years. A well defined policy for water release from the reservoir which takes into account allocation between the seasons, time of release, and the pattern of rotation between the tracts in case of short fall is needed.

It is recommended that the water allocation and release pattern for the old and new areas be studied with updated inflow series considering the available water in storage at the old tanks, water requirements for the proposed cropping pattern, and additional water that can be augmented from sources such as rainfall run off and receipt of drainage water from the upper tracts. For this purpose, a water balance study of the old Ellegala system should be undertaken for estimating the additional inflow required from the reservoir. This study has not been attempted by the present water management consultants group.

c. Crop diversification. In view of the water scarcity existing in the project area, there is an urgent need to switch over from the present rice cultivation to other field crops. Growing other crops requires development of a sustainable market, remunerative prices for the produce, eredit and crop insurance facilities, and storage and transportation. In addition, the introduction of other crops has to be done more carefully and in a phased manner in view of water scheduling problem associated with field channels having LHG and RBE soils, and design limitations in water distribution for the mixed cropping pattern proposed. It is recommended that other crops be intmduced in the project in a phased manner, tract by tract, with provision of good extension and other infrastructural services. Introduction of other crops in the project area must be a learning process for its success as far as water management is concerned. The long term objective of achieving a 100 percent diversified cropping pattern needs a well defined strategy with commitment from both the project authorities and the Government.

d. Water management. Presently in the Kirindi Oya project, irrigated rice uses roughly twice the water budgeted. Most of this excess water is used during the land soaking and land preparation period. It is possible that by proper water management and better water control, the operational efficiency of the system can be increased considerably and water use can be cut down during the land soaking and land preparation period. For this a close monitoring and supervision of the agency field level officials during the **land** preparation operation at the field level is required. The institutional aspects relating to water management and project management are dealt under chapter 3.

Figure 5.01. Schematic representation of the factors affecting the water delivery performance of an irrigation system

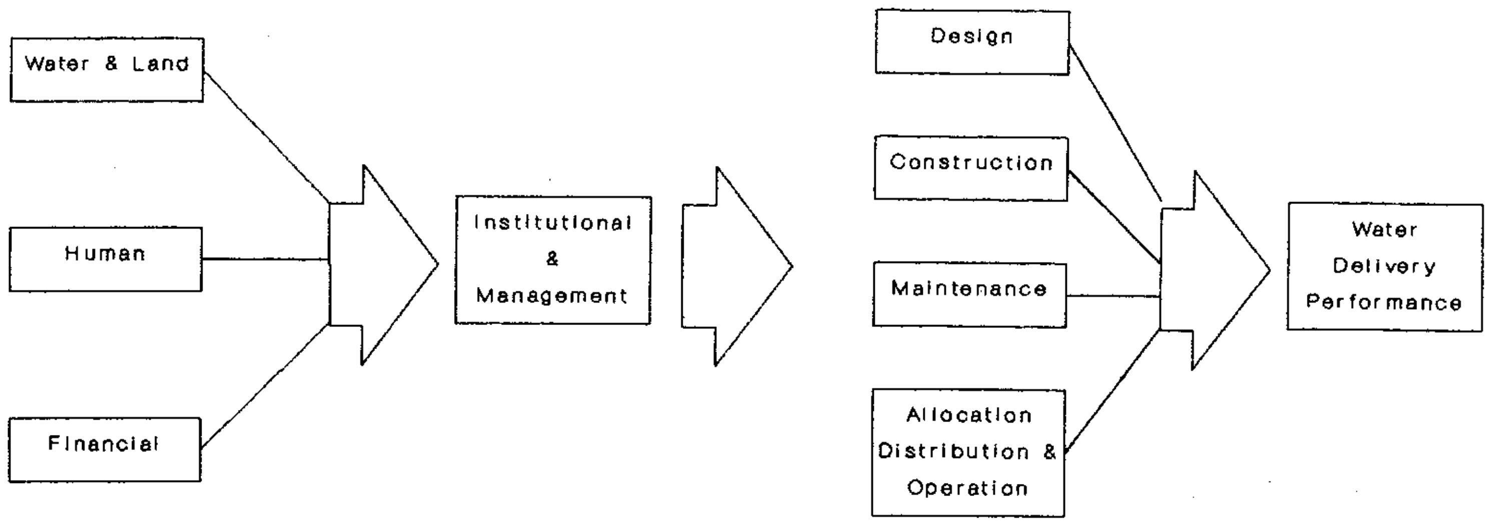


Figure 5.02. **Rainfall & Evapotranspiration**
RB Tract 5
Maha 1987/88

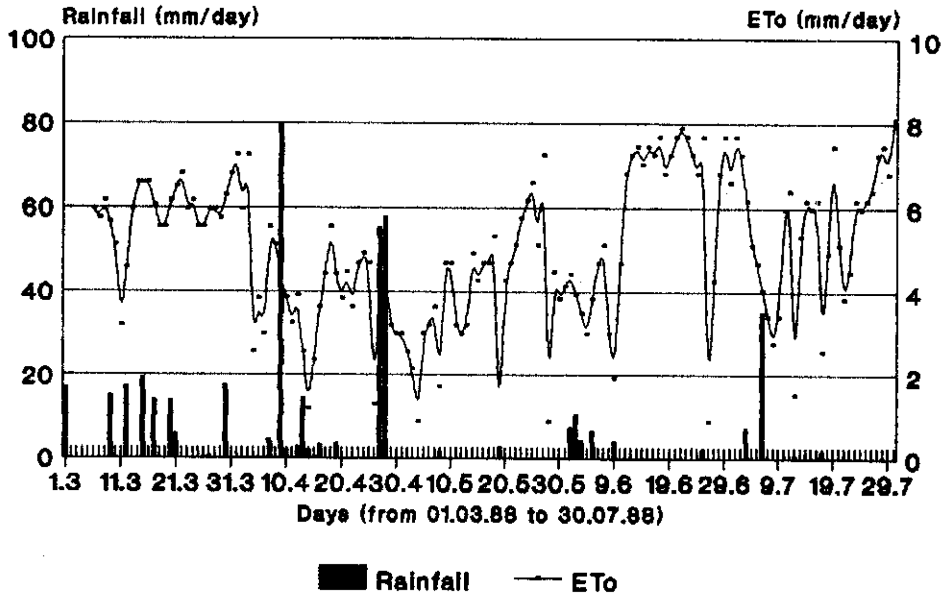
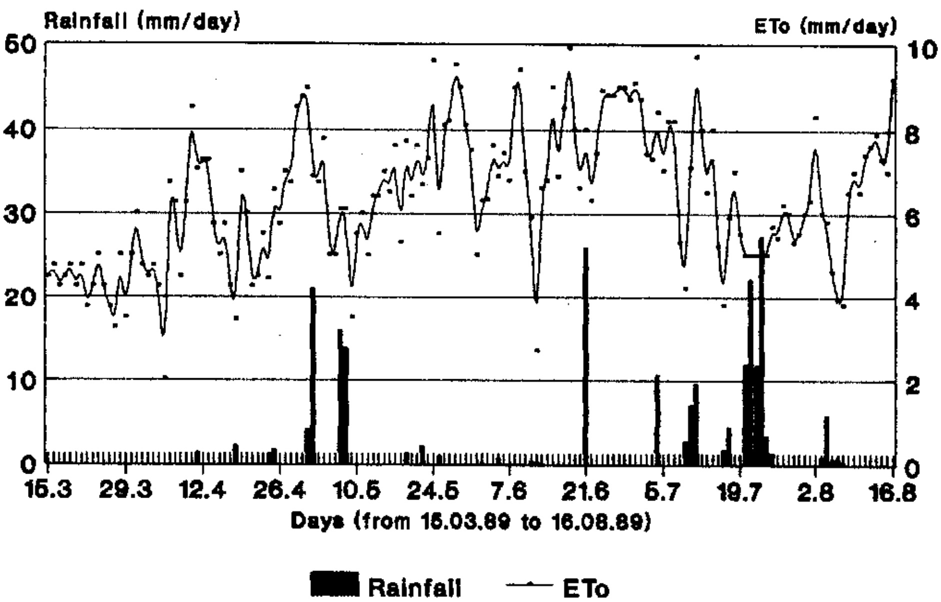


Figure 5.03. **Rainfall & Evapotranspiration**
RB Tract 5
Yala 1989



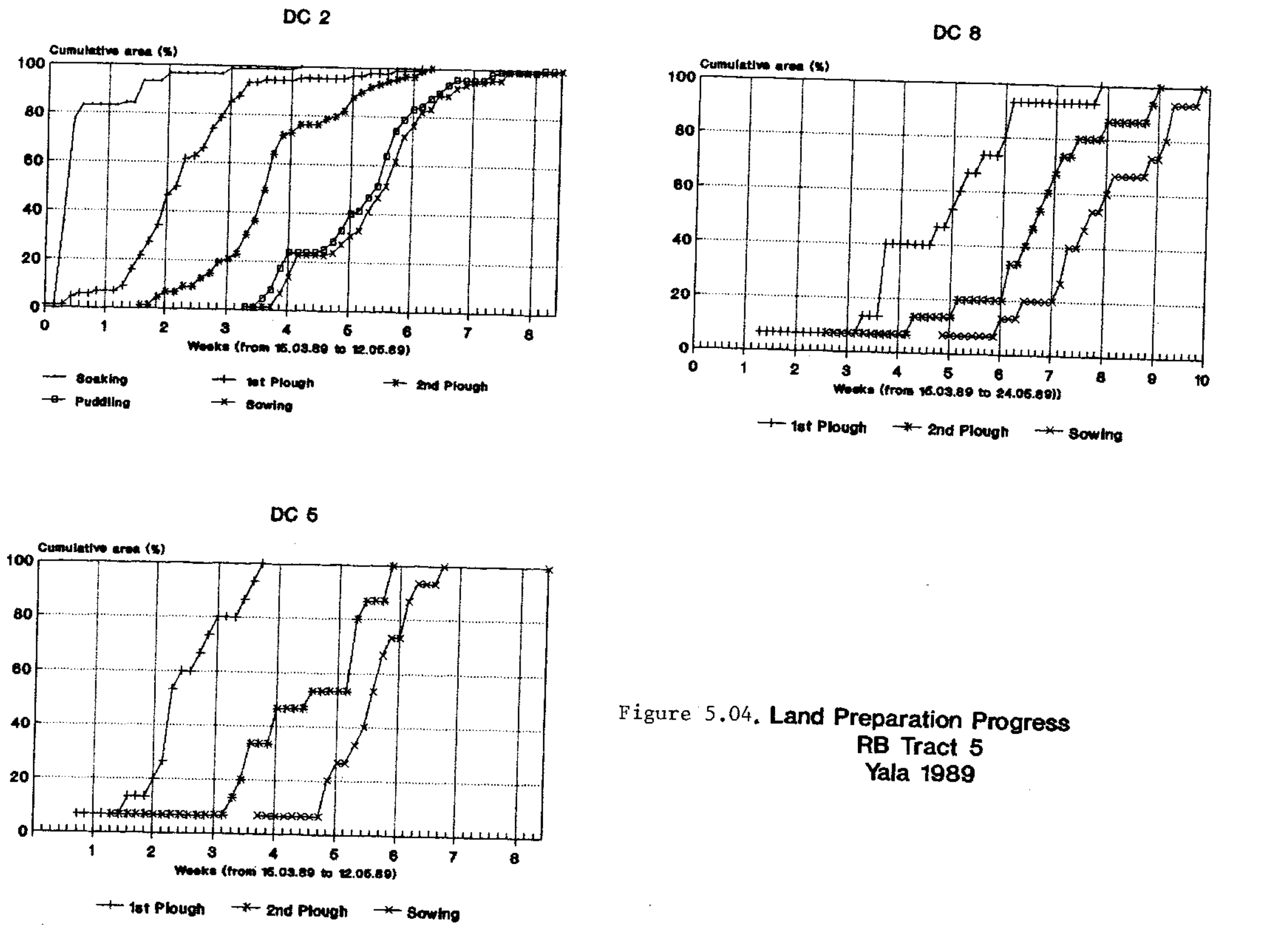


Figure 5.04. **Land Preparation Progress**
RB Tract 5
Yala 1989

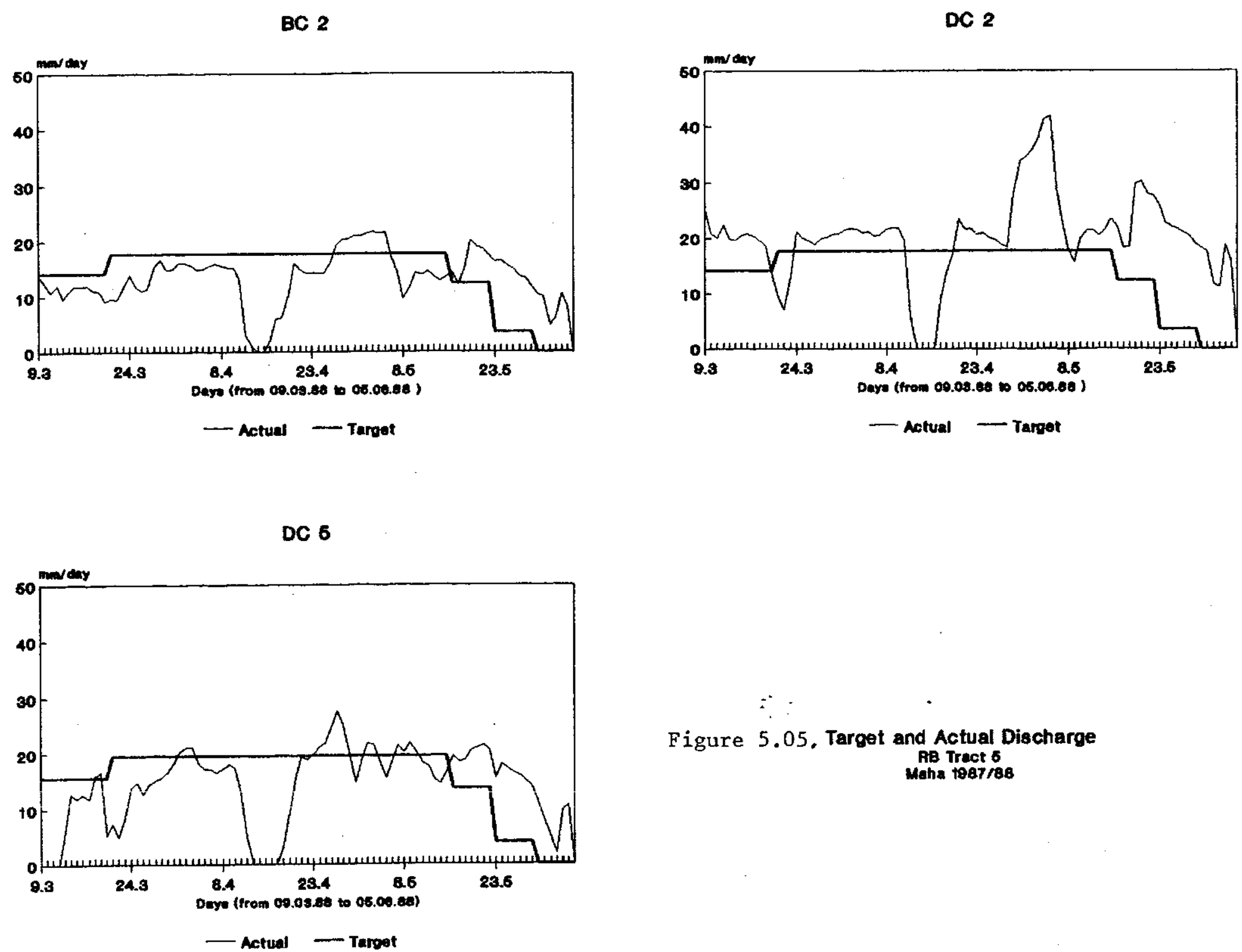
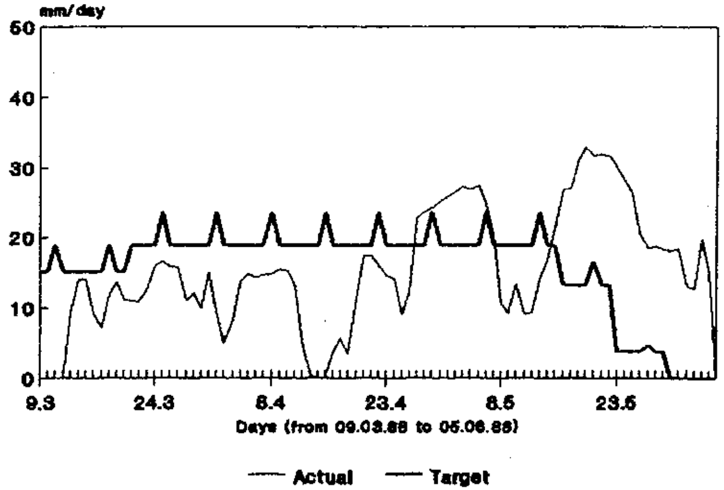


Figure 5.05, Target and Actual Discharge
RB Tract 5
Maha 1987/88

DC 8



FC 12 in DC 2

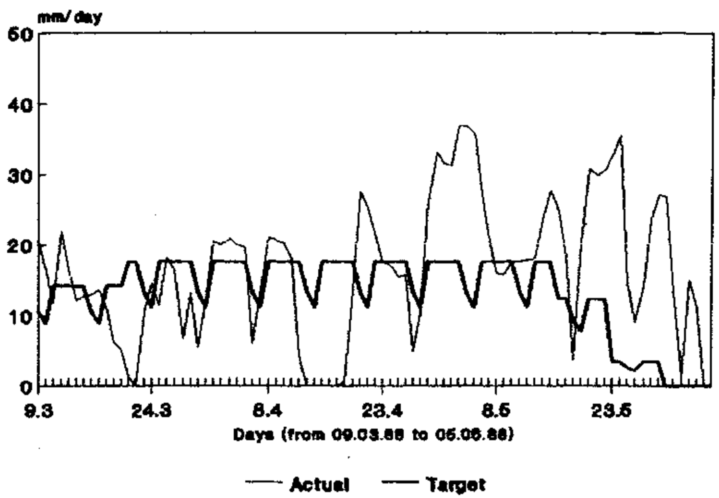


Figure 5.06, **Target and Actual Discharge**
RB Tract 5
Maha 1987/88

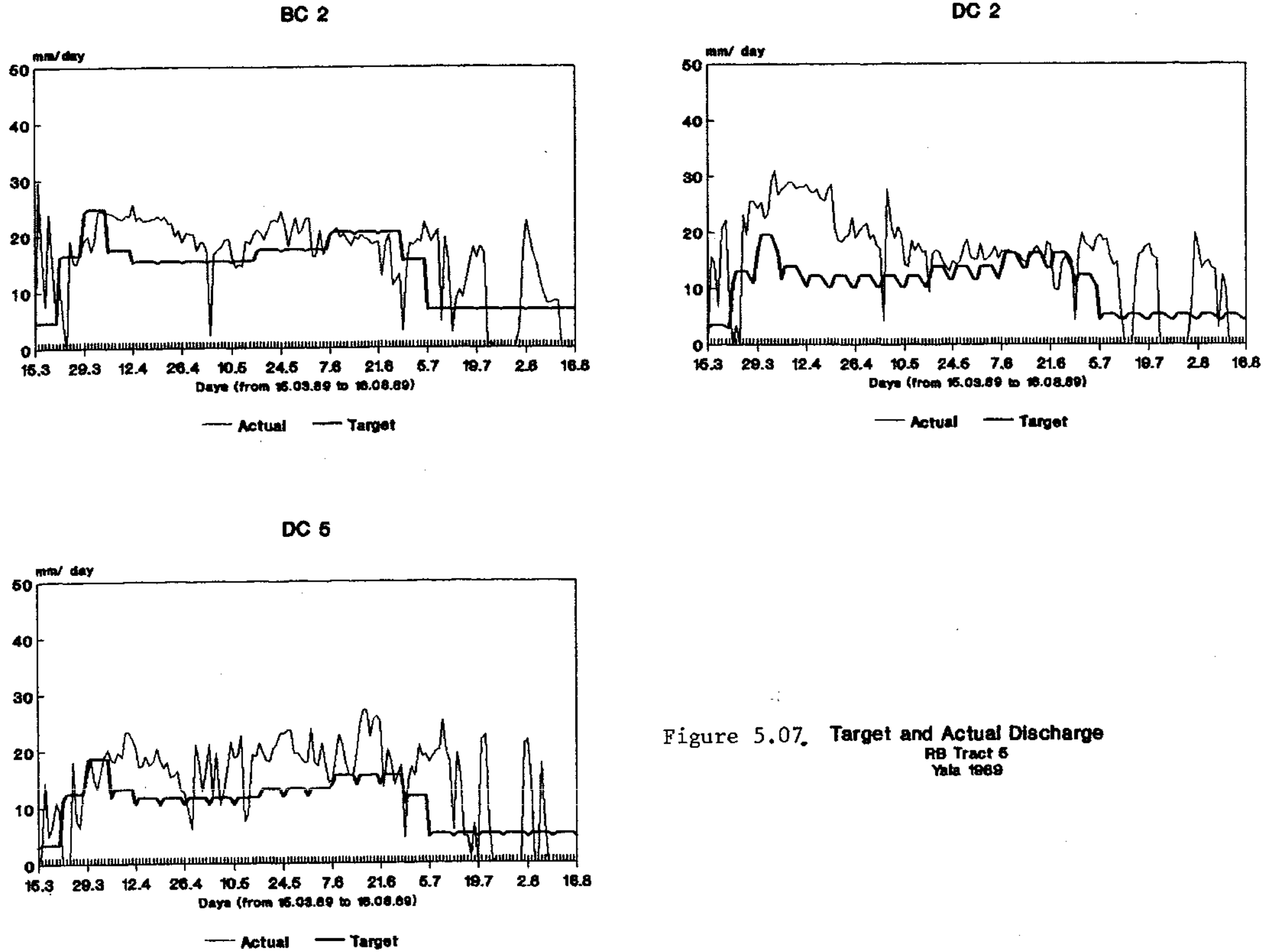
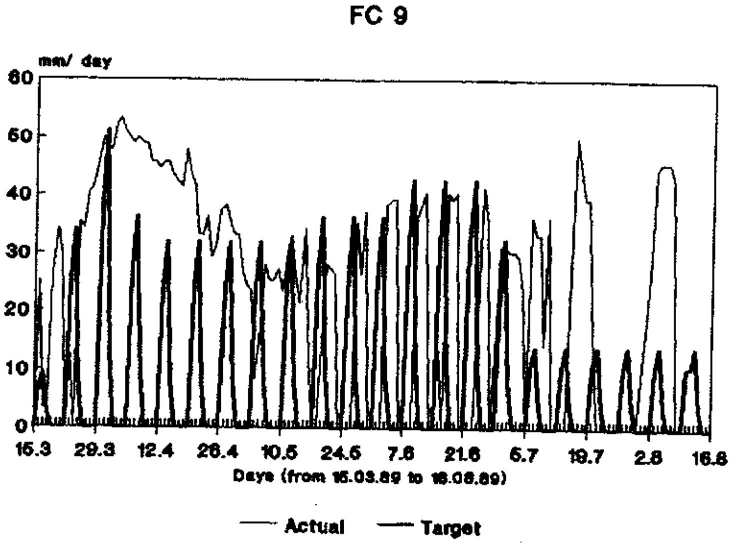
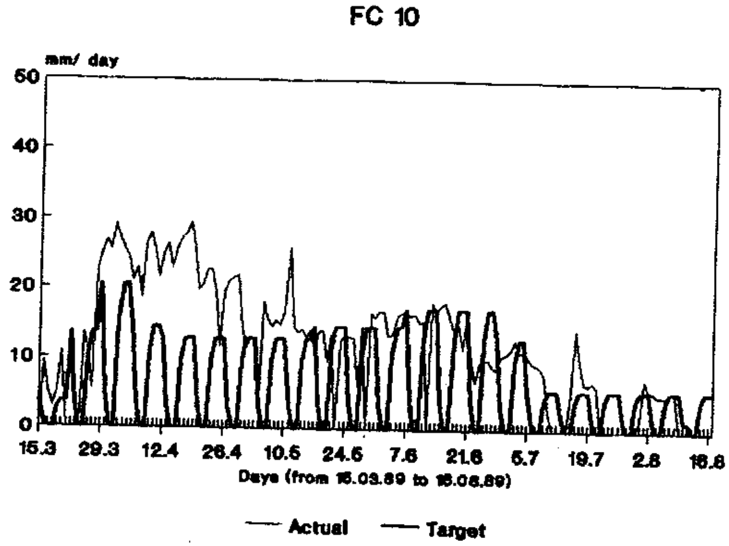


Figure 5.07. **Target and Actual Discharge**
RB Tract 5
Yala 1989





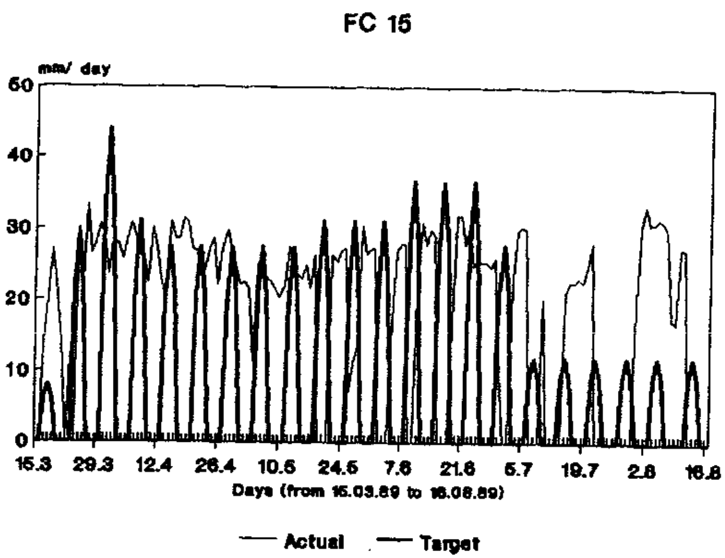


Figure 5.08. **Target and Actual Discharge**
RB Tract 5
Yala 1989

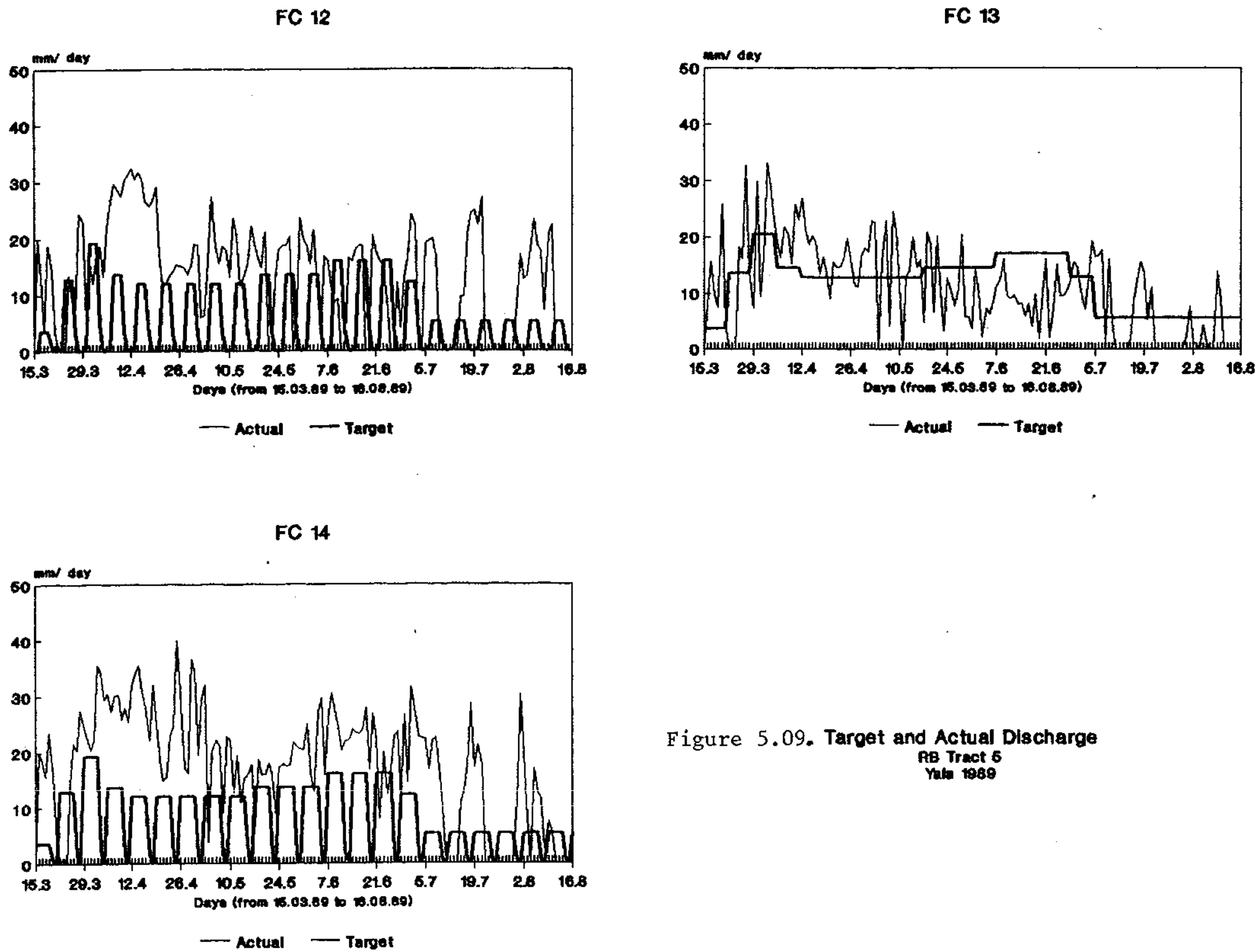


Figure 5.09. **Target and Actual Discharge**
RB Tract 5
Yala 1989

Figure 5.10. **Water Table Fluctuation**
RB Tract 5 - FC 12 - tail end allotment
Maha 1987/88.

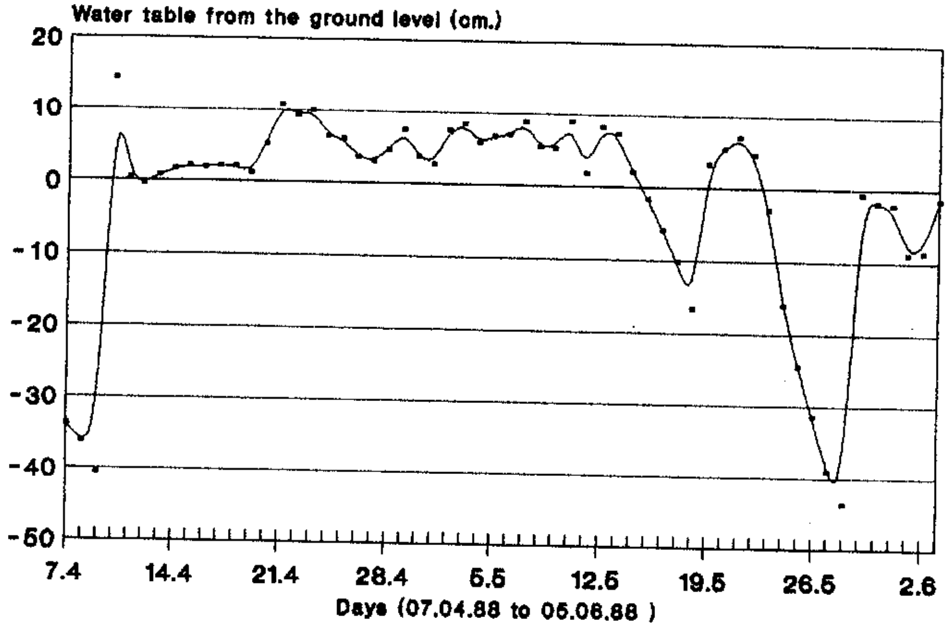


Figure 5.11. **Conveyance Losses in DC 2**
RB Tract 05
Maha 1987/88

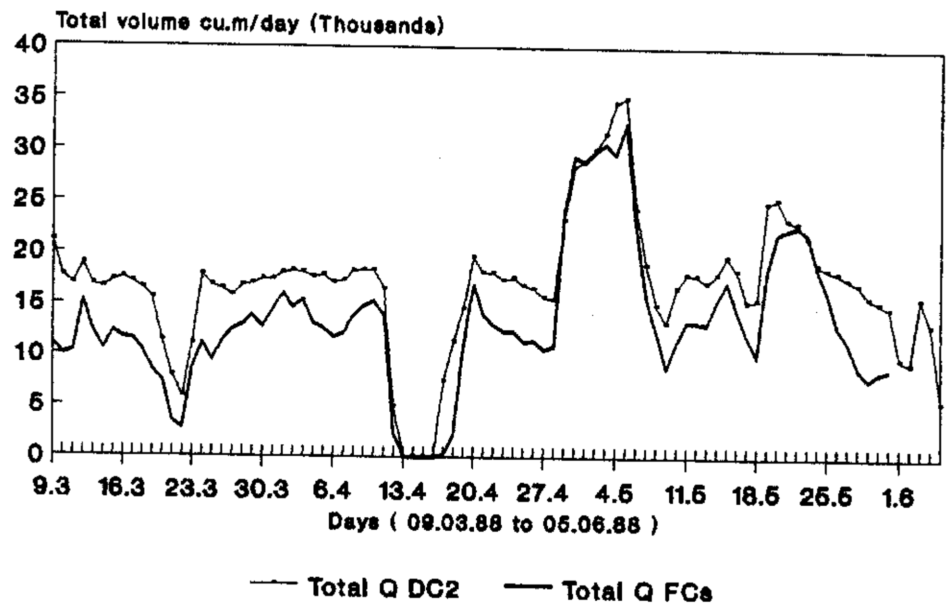
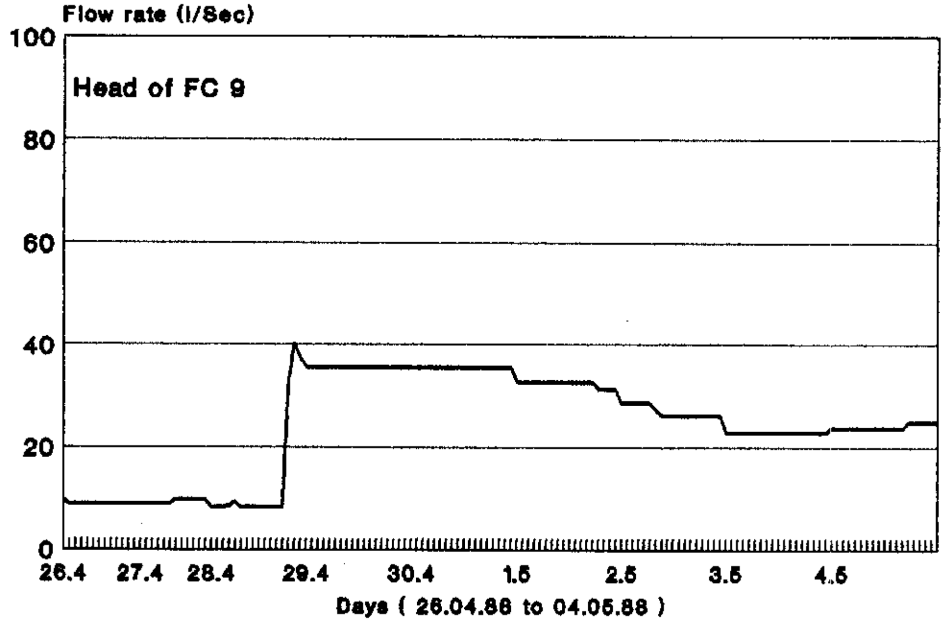
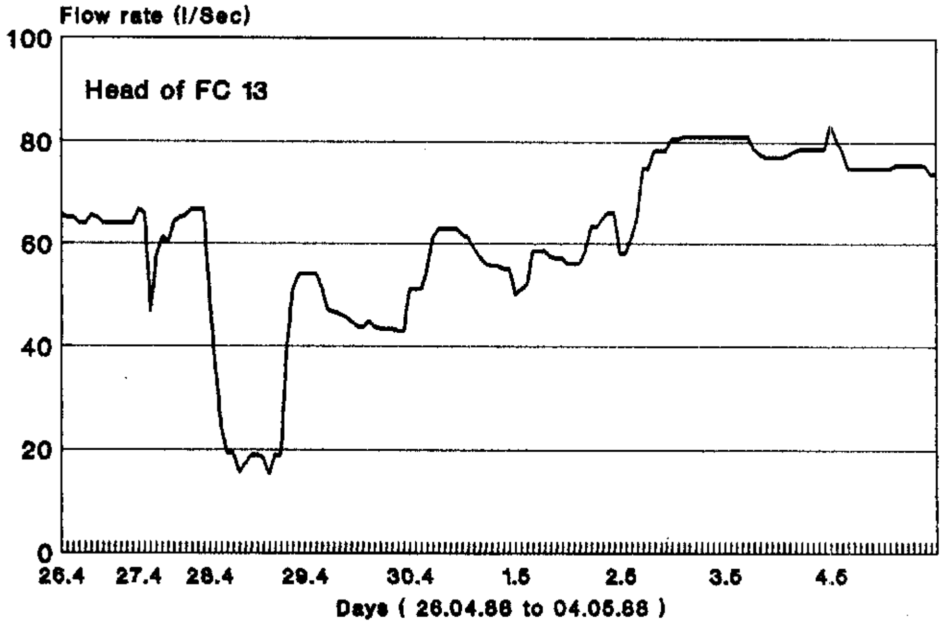


Figure 5.12. Half hourly Fluctuation
RB Tract 5
Maha 1987/88



Half hourly Fluctuation
RB Tract 5
Maha 1987/88



(Observed time - 7.00 am to 6.00 pm)

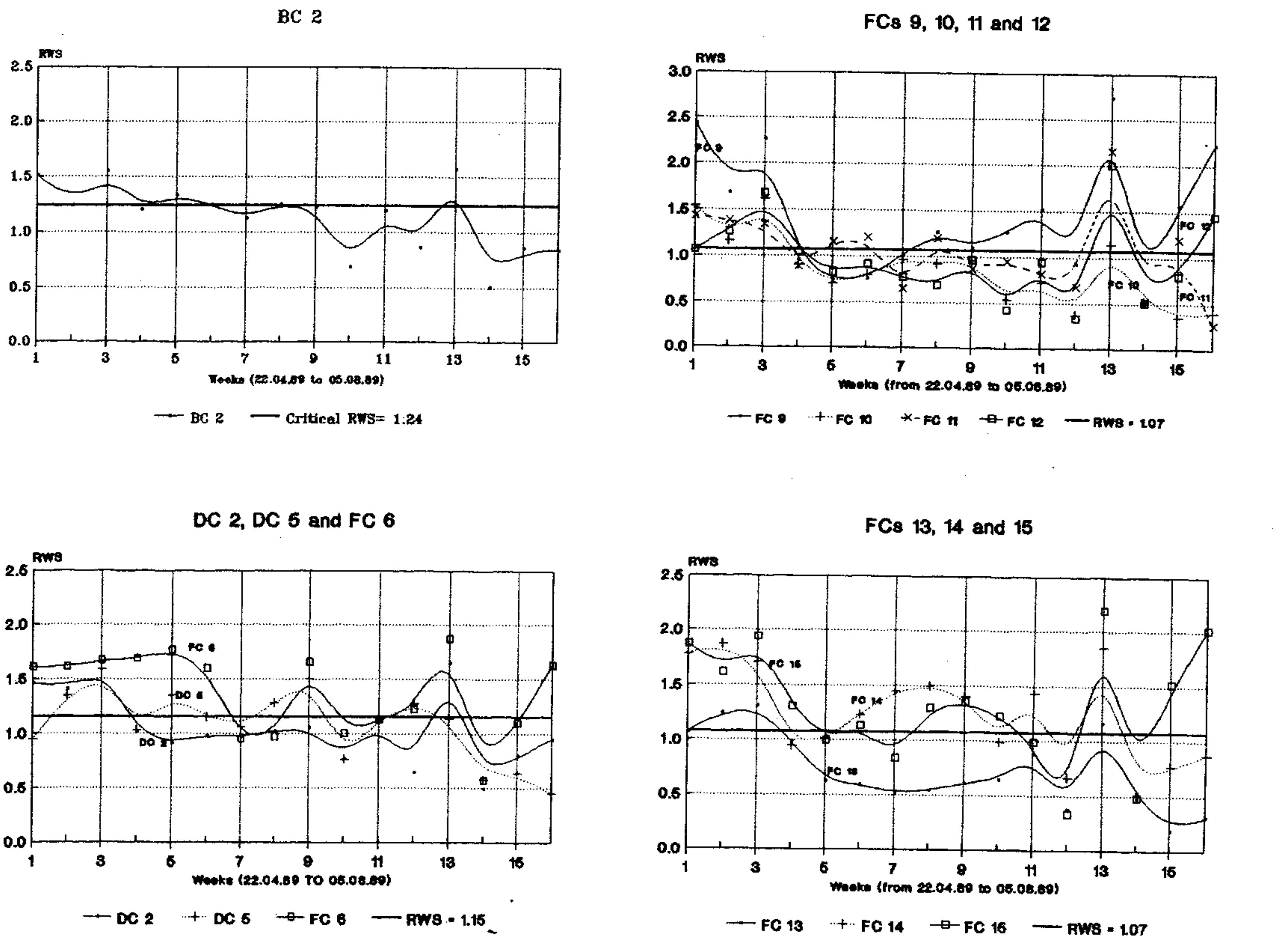


Figure 5.13. RELATIVE WATER SUPPLY (RWS)
Yala 1989

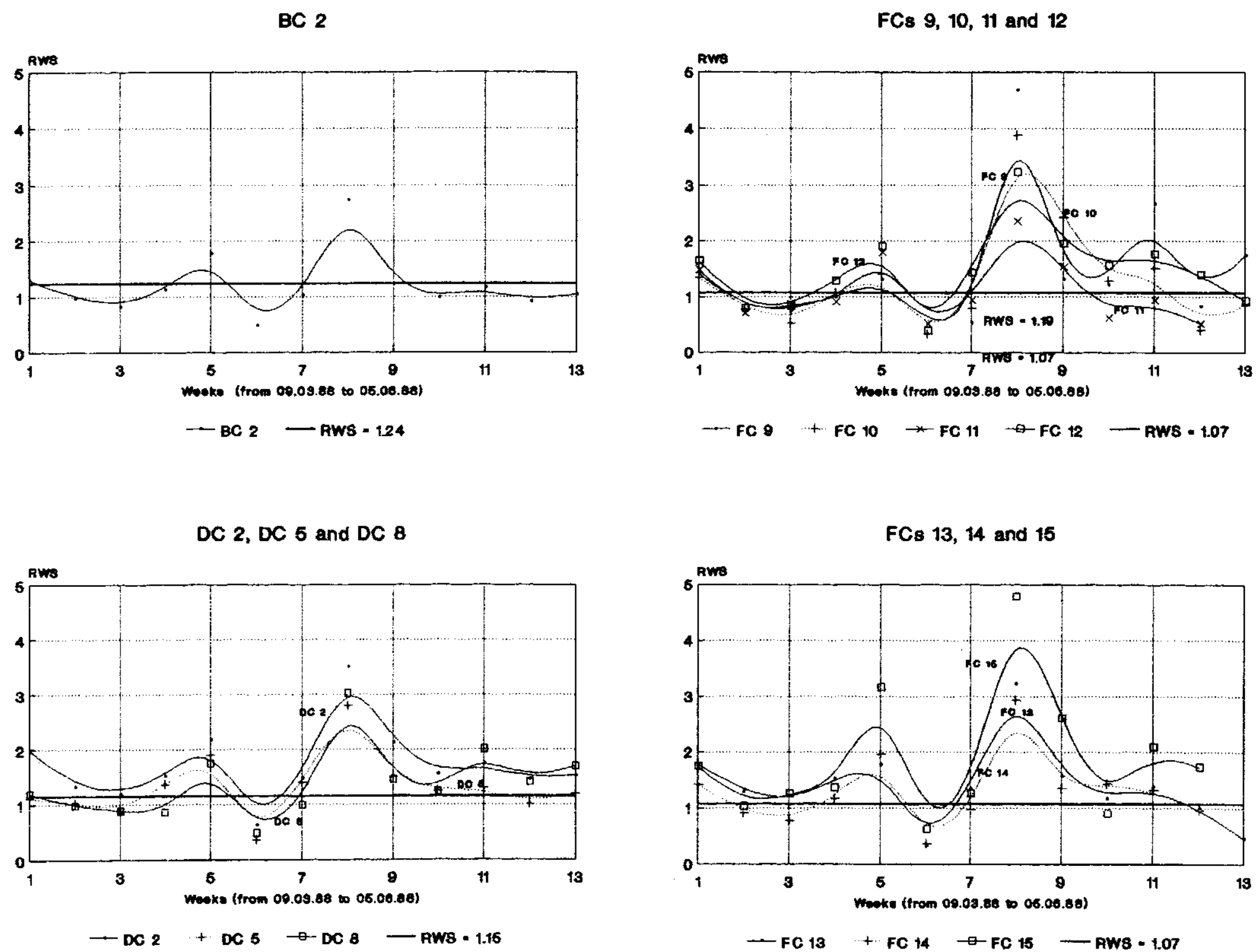


Figure 5.14. RELATIVE WATER SUPPLY (RWS)
Mid- Maha1987/1988

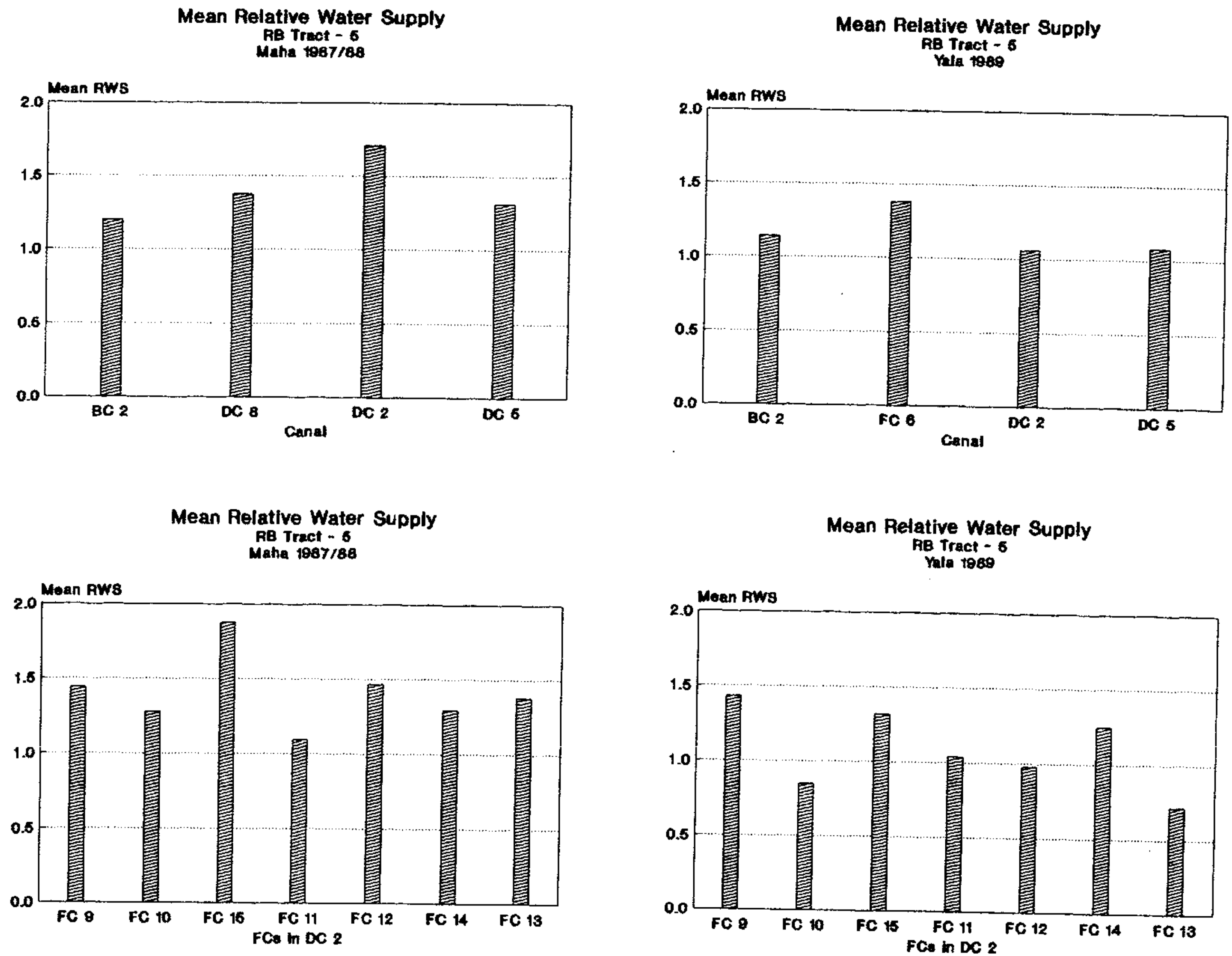


Figure 5.15. Mean Relative Water Supply along BC2 and along DC2, in Maha 1987/1988 and Yala 1989

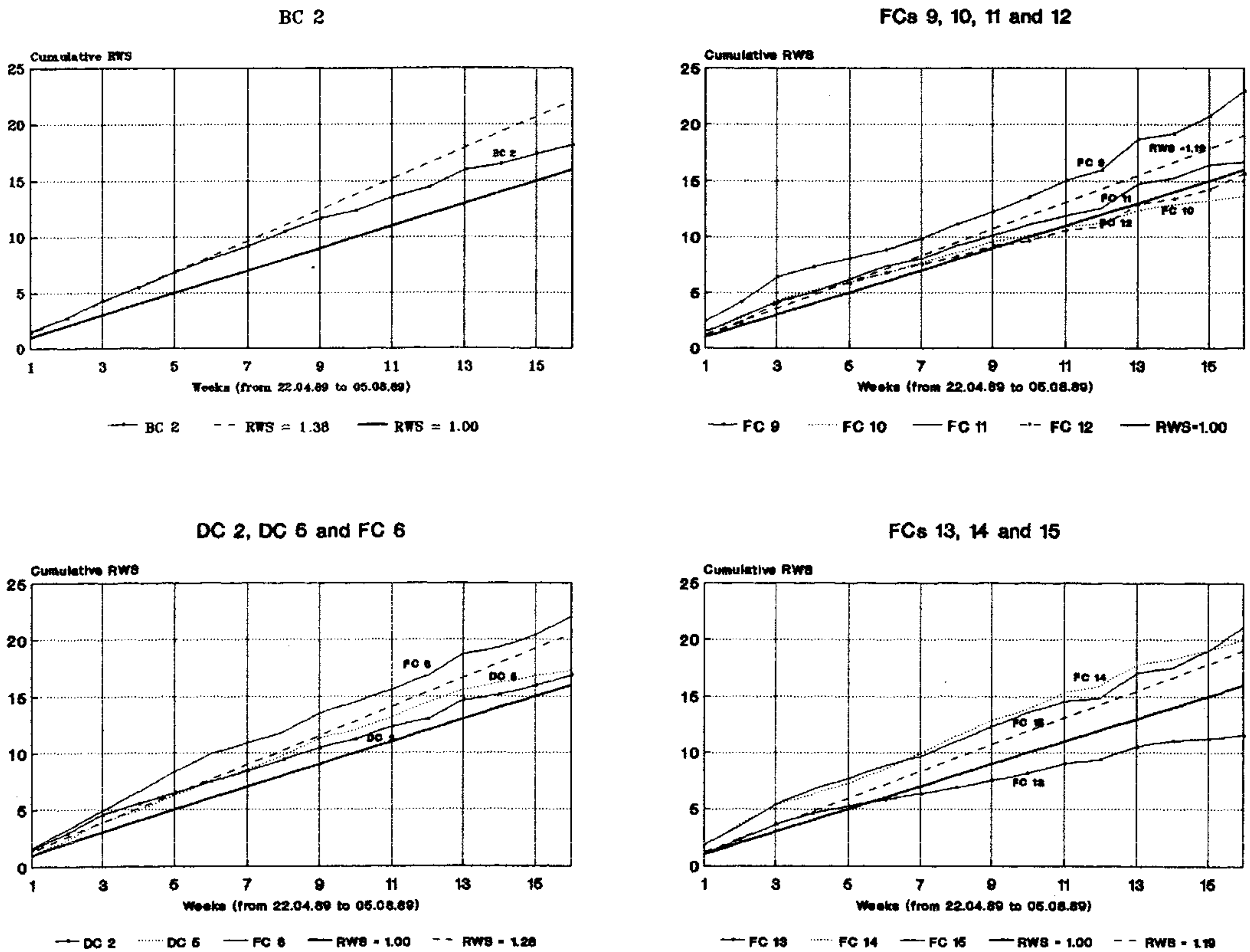


Figure 5.16_ Cumulative Relative Water Supply (CRWS)
Yala 1989

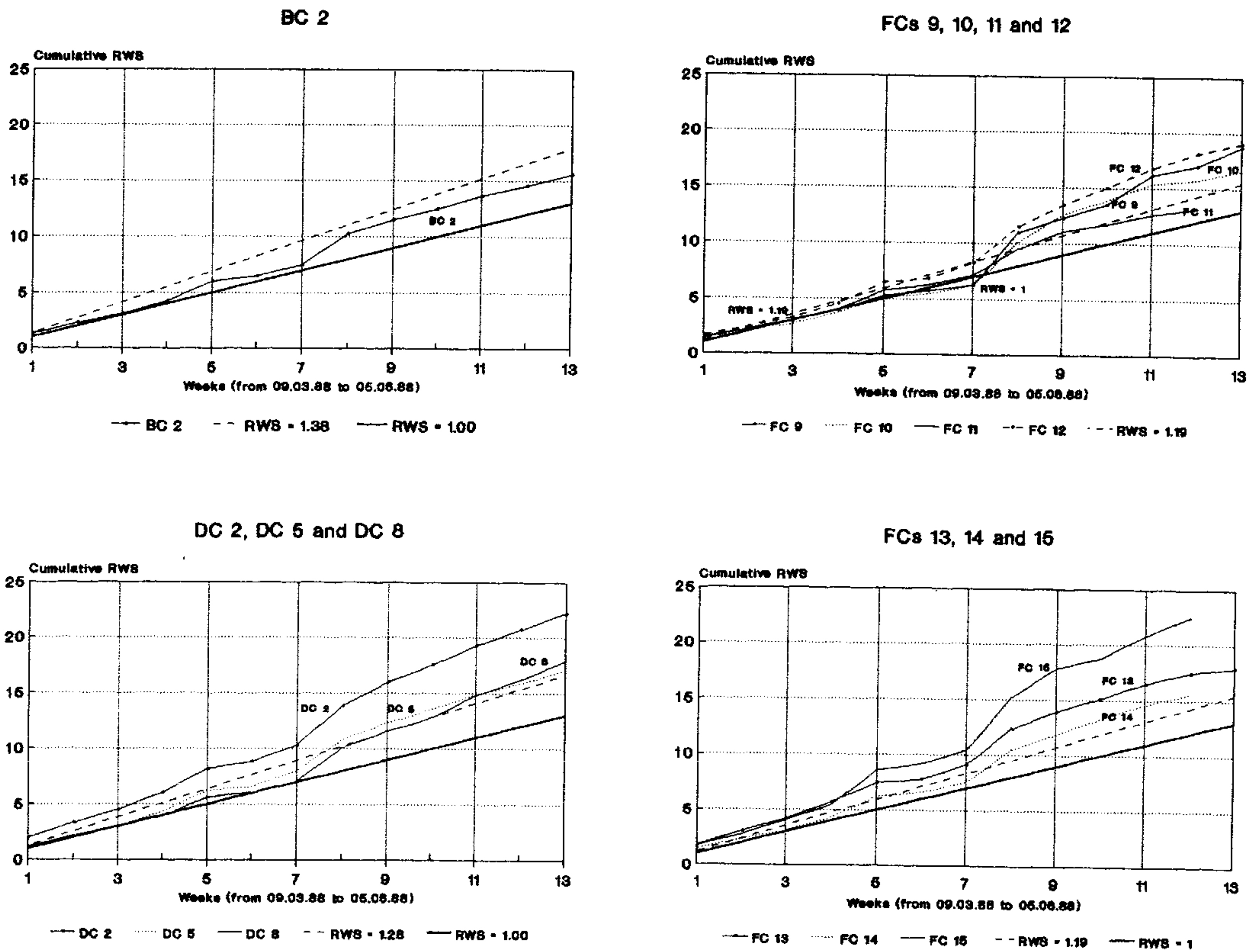


Figure 5.17. Cumulative Relative Water Supply (CRWS)
Mid-Maha 1987/1988

CHAPTER VI

RICX AND NON-RICE CROP PRODUCTION IN KIRINDI OYA: A STUDY ON SYSTEM PERFORMANCE AND CROP DIVERSIFICATION

INTRODUCTION

The economics component of this project has two major objectives: to assess irrigation system performance through the performance of irrigated agriculture in the system; and to analyze, mainly based on data from on-farm experiments, the relative profitability of non-rice crops that could be grown by farmers.

Since the first water issue in the 1986 yala season, there have been five cropping seasons in the Kirindi Oya system, of which the last three seasons, i.e., 1987/1988 maha, 1988/1989 maha, and 1989 yala, have been covered in this research project. Throughout all these seasons rice has been the major crop grown by the farmers. In spite of the intention for the Kirindi Oya system to be a diversified-cropping system, non-rice crops have virtually not been planted at all so far by the farmers, except the non-rice crop demonstrations organized by the Department of Agriculture, and sporadic cases in which farmers on their own planted by themselves some non-rice crops to a limited extent. Yala 1990 constitutes only a partial exception to this statement (see chapter 7).

Given such a situation, the analysis of irrigated agriculture is largely limited to rice production in the system. In this report, we first examine the agro-economic performance of rice production. As far as possible, attention is paid to such conditions as factor markets that would have an important influence on successful crop diversification in the study area.

Although on-farm experiments on non-rice crops have not been conducted so far, the data to attain the second objective of analyzing relative profitability of non-rice crops were obtained from the demonstration program on non-rice crops of the Department of Agriculture. In the following section, we present the results of demonstration trials conducted by some of system farmers in the 1989 yala season, together with some other available data on non-rice crop production under irrigated conditions in Sri Lanka.

Given the data on production of rice and non-rice crops in the system, we try in the last section to simulate possible changes in the system's income generating performance, assuming different scenarios as to cropping pattern and cropping intensity in the system.

Samples and Data Collected

The necessary data to attain the first objective were collected from the sample allotments i.nthe subsystem under study, right bank branch canal (BC) 2, tract 5. Of the eight distributary canals in tract 5, DC 2 is the sample distributary wherein our intensive monitoring of hydraulic: performance was carried out. Forty percent of population allotments in DC2 area were drawn as the sample for data collection, after stratifying the population according to location along the distributary and soil type (Table 6.01). In addition to DC2, located at the middle portion along BC 2, samples were drawn, with lower sampling ratios, from allotments in DC8 and E 5, in order to have a more general idea on farming in the sample sub-system as a whole. DC8 represents the head-end distributary canal along the branch canal and E 5 represents the tail-end. It should be noted that in the second and third seasons under study the data were collected from only a part of the sample farmers because of the security situation prevailing in the study area during that time: the total number of sample farmers from whom we were able to collect the data was 32 in the 1988/1989 maha and 55 in the 1989 yala season.

The following are the major items for which data were collected under this module.

1. Basic characteristics on the allotments and cultivating farmers, such as:

    a) drainage water use,

    b) channel route from distributary to allotment,,

    c) area cultivated other than the sample allotment,

    d) tenure status, and

    e) the extent affected by salinity problems in the last season.

2. Basic data which are necessary to estimate costs and returns of rice production, i.e., data on output and inputs for rice production, and on prices involved.

3. Data on farming practices, such as dates of land preparation and planting, and frequency of fertilizer application.

4. Data on output disposal and credit.

Aside from the data collection for the sample allotments, crop-cut surveys were conducted for the sample allotments in DC2 (except 1987/1988 maha when the crop-cut survey was made for all the allotments under this distributary), E 5 and DC8. Although each allotment in this system is designed to be a one-hectare paddy field, actual area varies from allotment to allotment. Therefore, area surveys were made for all allotments that underwent the crop-cut survey.

As for non-rice crops under the demonstration, data were collected from fifteen farmers who joined the demonstration in the 1989 yala season. The same set of data as for rice was obtained for each non-rice crop grown by the fanners. An area survey was made for each crop, but cropcut survey was not conducted for non-rice crops.

RICE FARMING IN STUDY AREA AS COMPARED TO SOME OTHER REGIONS

First, let us observe briefly how rice farming in the study area compares with that of other regions in Sri Lanka. Some indicators related to rice production in the 1986/1987 maha and the 1986 yala seasons are summarized in

Tables 6.02 and 6.03, respectively, for selected regions, together with the *summary* results of our Kirindi Oya data. The data for these regions are from cost-production sample surveys of agricultural crops conducted by the Department of Agriculture.

As is well known, there are two distinct agro-climatic zones in Sri Lanka; the wet zone and the dry zone. Among the regions shown in the tables, Kegalle belongs to the wet zone, Matale and Kurunegala to the wet-dry intermediate zone, and the other three regions to the dry zone. The tables reveal some interesting differences in rice production not only between the wet and dry zones but also between regions in the dry zone.

In the case of the 1986/87 maha season, all regions, except Kegalle, commonly recorded rice yields per hectare of more than 4 tons. It was 4.3 tons in Hambantota, the sample of which includes Kirindi Oya study area. For the 1986 yala, the northern dry zone regions recorded 3-3.5 tons, but. the southern dry zone regions recorded yields of more than 4 tons.

Heavy application of fertilizers, which would be an important explanatory variable for the high yield of rice, also commonly characterizes rice farming in the regions. The level of nitrogen use was as high as 80-120 kg per hectare. Although the level of usage differed, probably depending on the degree of pest-insect outbreak, farmers in all regions applied pesticides. Other farming practices, however, show some zonal or regional differences. For instance, transplanting is the major method of crop establishment in the wet zone, whereas it is broadcasting, even in the maha season, in the dry zone. The dry zone farmers commonly use herbicides and are less dependent on manual weeding, while weeds are controlled in the wet zone mainly by manual labor without using herbicides.

The factor payment to fixed capital services also differs between the wet zone and dry zones; it is higher in the latter than in the former. This difference is due mainly to the difference in fixed capital used for land preparation and post-harvest operations between the two zones. The wet zone farmers use draft animals as the principal power source, while their dry zone counterparts are more dependent on the 2- or 4-wheel tractor.

Above all, the most striking differences are found in labor intensity and sources of labor. The total labor use in terms of labor days per hectare was as high as 226 in Kegalle and 188 in Kurunegala in the maha season, while it was as low as 82 in maha and 88 in yala in Hambantota. There is a clear tendency that labor intensity is high in the wet zone and low in the dry zone. Even within the dry zone, rice farming in the northern part (Kalawewa) seems to be more labor intensive than in the southern part (Uda Walawe and Hambantota). As a result, the regional difference in labor productivity is much more pronounced than that of land productivity. The regional differences in the sources of labor, i.e., family and hired labor, follow a similar pattern; the dependence on hired labor is least in the wet zone, intermediate in the northern dry zone, and most in the southern dry zone.

To some extent, the difference in labor intensity of rice production among regions could be explained by agro-climatic factors. There would be certain agro-climatic advantages for the wet zone fanners to adopt such techniques as transplanting, manual weeding, and animal land preparation, all of which are more labor intensive farming methods than those adopted by the *dry* zone fanners.

A more important factor, however, seems to be the scarcity of labor. Although, generally speaking, the wage rate levels in rice fanning in these regions are all low, there are considerable wage differences among the regions as shown in Tables 6.02 and 6.03. There is a close negative correlation between the level of wage rate and the level of labor intensity across regions, suggesting that the labor intensity is determined largely by the scarcity of labor which is reflected by the wage rate.

It is more difficult to ascertain reasons behind the regional differences in the sources of labor for rice production. The size of cultivation could be one explanatory factor. It is a universal phenomenon that, ceteris paribus, the larger the farm size, the higher the dependence on hired labor. Among the regions listed in the table, this trend is clearly observed. The different patterns in family versus hired labor use among the regions, however, appear to be beyond the difference in farm size. More decisive factors must be sought in the structural differences of rural society in which rice farming is being practiced.

Whatever the reasons, these differences in labor scarcity and sources of labor should have important implications for irrigation management and crop diversification in the study area. At least, three implications can be pointed out immediately. First, being in the high wage region, non-rice crops to be introduced in the study area for crop diversification should not be too labor intensive, or, more accurately, they should be able to generate returns to labor as high as those generated in rice production.

Second, the study area belongs to the region where the dependence on hired labor in rice production is highest. More than 50 percent of the total labor input is supplied by hired laborers who capture around 20 percent of total rice output as their wages. This implies that there is a need to take these hired laborers into account while diversifying crops away from rice. Unless due consideration is given to them, their welfare position might deteriorate due to crop diversification.

As is the case in rice production in other parts of Asia, the labor tasks in which hired laborers are most popularly employed in the study area are crop establishment, harvesting and post-harvesting activities. Unlike production processes in industry, which can easily be standardized as in the factory system, production processes in agriculture are difficult to standardize and require personal judgments on infinite variations in plants, water and soil. Rice production is not an exception, but the above tasks have a common characteristic of being relatively easy-to-standardize and easy-to-monitor. As a matter of fact, crop care operations such as fertilizer and chemical applications, which require more specific decisions, are the labor tasks in rice production least dependent on hired labor not only in the study area but in all rice growing regions in Asia.

Generally speaking, non-rice crops require more attention for crop care than rice. It is therefore important that, while searching for suitable non-rice crops for diversification, attention should be given to the crops whose labor operations can be standardized as much as possible, in order to preserve employment opportunities for hired laborers who in most cases belong to the poorest and most vulnerable section in the rural society.

Third, as a corollary of the second point, it is necessary for the system management to take hired laborers into account, both as the beneficiaries of the irrigation system and as the subjects of system maintenance. The fanners are only one of the agents whom the system management should deal with. As shown in Tables 6.02 and 6.03, rice farmers in the study area receive about 50 percent of the rice output as their income. The ratio of farmers' income to hired laborers' income was 5:2 in Hambantota in both the 1986/1987 maha and 1986 yala.

RICE PRODUCTION IN KIRINDI OYA

Having identified the regional characteristics of rice farming in the study area, we observe in this section the rice production in Kirindi Oya in more detail. It should be noted that, throughout this study, the yield data used are those obtained from crop-cut surveys. It is generally the case that crop-cut survey yields are higher than those reported by the farmers, and this is so for our data sets in which the former consistently give yields about 10 percent higher than the latter.

Yield Performance

The average rice yields per hectare obtained from the crop-cut survey are shown in Table 6.04 for the three seasons studied by location in the system and by soil type.

The average yield per hectare for the sample as a whole was 3,675 kg per hectare in the 1987/1988 maha; 6,876 kg per hectare in the 1988/1989 maha; and 4,697 kg per hectare in the 1989 yala. Although yield variation across seasons is rather high, it could be said that rice yield in the sample area has been on an upward trend. Since the yield of the old irrigated area before the Kirindi Oya phase one project used to be about 3.5-4.0 tons in the maha season and 2.6 tons in the yala season (ARTI 1988: 35), the new settlers in the system have already caught up or even surpassed these levels. It seems, moreover, that the target yield levels assumed in the project appraisal, 4.5 tons for the maha and 4.8 tons for yala (ADB 1982: 22), have already been attained by the farmers, at least in terms of the average for the past three seasons.

There were differences in yield among different locations along the branch and distributary canals. But, contrary to the popular expectation, the farmers at the head-end of the branch canal as well as of the distributaries were not always the ones who got the highest yield, and those at the tail-end were not always the ones who got the lowest yield. In fact, the yield differences by location were not statistically significant for either the branch canal or distributaries in all the seasons studied, except for the location along the branch canal in the 1987/1988 maha in which the head-end distributary farmers recorded average yields significantly lower than the middle and tail-end distributary farmers. There is a tendency that the better the drainage, the higher the yield, though the yield difference is statistically significant only in the 1987/1988 maha. As shown in Table 6.05 for DC2, the poorest yield in this particular season was recorded in the poorly-drained sections of the tail-end along the distributary, while the highest yield was recorded in the well-drained allotments of the tail-end along the distributary.

All this suggests that water was not a limiting factor for rice production in the last three seasons in the study system. The major water-related problem for farmers was not how to get enough water to their fields but how to drain excess water from the fields. In fact, the salinity due to water logging was a serious problem for some farmers whose allotments were poorly drained, as shown in the following section for the 1987/1988 maha season.

The yield records thus support our findings in earlier chapters as to the water delivery performance; the system delivered water to the branch canal and the distributary turnout gates more than adequately. A result of this oversupply of irrigation water was low productivity of water. Table 6.06 shows the rice yield per unit of water for different locations of the sub-system under study for the 1989 yala season in which the data on total water supply are available by location. First, it should be noted in the table that the variation in the level of water supplied does not explain the variation in the level of yield (the simple correlation coefficient between yield per hectare and irrigation water supplied is 0.317, but it is not statistically significant at all), which confirms our statement that water was not a limiting factor in the rice production.

In spite of impressively high levels of land productivity ranging from 4.3 tons in the DC5 area to 5.3 tons in FC3 which is located along DC2, the yields per one mm of water supplied are low, ranging from 1.32 kg in FC9 to 2.71 kg in FC13. If rainfall is taken into account, water productivity becomes even lower. If we can assume that yield of the same level can be attained with an available water supply on-farm of 1,500 mm, the actual water productivity in this season for the entire branch canal area was less than 50 percent of the maximum water productivity attainable. In other words, nearly 50 percent of irrigation water was wasted.

With rice as the crop to be grown, the Kirindi Oya system has developed to a level comparable to other well-developed irrigation systems in the country, as far as land productivity for a single season is concerned. As explained in the following sections, however, this may not be a blessing for this water-short system which is supposed to be a diversified-cropping system, not a rice monoculture system; once these farmers with access to abundant water get used to high productivity rice production, it would become difficult for them to get out of it and shift to non-rice crops.

Farming Practices and Production Inputs

In this and following subsections, we observe the rice farming in Kirindi Oya in some detail, mainly based on the data for the 1987/1988 maha.

The levels of major inputs per hectare are summarized in Table 6.07, by distributary, by location, and by soil type. The level of labor use by operation is given in Table 6.08. Similar to the yield level, the pattern of input use shows some variation among distributaries, location along the distributaries, and soil types.

In the 1987/1988 maha season, the water issue to right bank tract 5 commenced on 25 January 1988. The land preparation in the Dc2 area ended by 1 March, including generally two times of plowing and a final land leveling (harrowing). It ended by 9 March in the tail-end Dc5 area. In spite of their head-end location along the branch canal, the end date of land preparation for many sample farms in the DC8 area was as late as the mid-March, the latest one being 20 March. On the average of all samples, 54 labor days per hectare were spent for this operation. Considering the fact that all farmers used tractors for plowing, this level of labor input seems to be too high. This is due partly to the long fallow that preceded this maha season caused by the serious drought in 1987. The tractor land preparation is mostly done as custom work, since very few farmers own a tractor. As a result, nearly 50 percent of labor for this operation was supplied by hired laborers. Among the strata for distributary and soil type, DC8 farmers and farmers cultivating the poorly drained soil used significantly less labor for land preparation.

Before or right after the water issue, the farmers spent about 2 days clearing weeds along their field channels. It is interesting to note that the tail-enders along the distributaries worked significantly longer hours than others for clearing weeds. This work was mainly done by family labor or the farm operator himself, but some fanners hired laborers even for this purpose.

Immediately after the land leveling, seeds were sown by broadcasting method. The seeding rate was, on the total average, 131 kg per hectare, which was about 30 kg higher than the seeding rate by the transplanting method (see Tables 6.02 and 6.03). The labor requirement for crop establishment was 14 labor days, more than 60 percent of which was from hired labor.

Fertilizer use by the sample farmers in this season was lower than by Department of Agriculture, Hambantota sample farmers in the 1986/1987 maha season. The nitrogen and potassium inputs per hectare were still as much as 82 kg and 30 kg, respectively, on the average. In the case of phosphorus, however, the fertilizing rate of our sample was just one half of the level of the Hambantota sample.

Typically, the farmers in Kirindi Oya apply fertilizers three times; once as basal, usually V fertilizer just before sowing, and twice as top dressing, usually urea about three weeks after sowing and TDM about one month after sowing. Some farmers add one more top dressing. As a result, the total average frequency for fertilizer application was 3.3 times. The farmers in the DC5 area applied significantly more P and K with significantly more frequency of application than the farmers in other sample distributaries. Compared to the farmers cultivating the well drained allotments, the frequency of fertilizer application of those cultivating the poorly drained allotments was significantly less.

Weed control in the study area is done by herbicide application and hand weeding. If herbicide is used, it is usually applied only once as post-emergence weed control, about one month after sowing. Though many farmers adopt both methods, the two methods of weed control are obviously alternative in nature: the more herbicide is used, the less the manual weeding labor, and vice versa. The DC5 farmers and the farmers cultivating the poorly drained allotments have a clear tendency to resort more to herbicide.

On the average, the sample farmers applied pesticide 4.5 times, for a total application of 927 rupees per hectare, which was slightly more than the application for fertilizer. Aside from scheduled spraying within a few weeks after sowing, many fanners had to apply pesticides even at the later stage of plant growth in May and June. Among the fanners in different categories, the fanners in the DC8 area, those cultivating the tail-end allotments, and those cultivating the poorly drained allotments applied a relatively lower amount of pesticides.

The crop care labor as a whole, including fertilizer application, weed control and pesticide spraying, totaled 17 labor days per hectare on the average, nearly 80 percent of which was carried out by family labor. Depending on the methods adopted for weed control and on frequency of chemical applications, however, the amount of labor used for this task varies significantly among strata in each category; the farmers in the DC2 area, those cultivating the allotments at the middle portion along the distributaries, and those cultivating well drained allotments used more crop care labor than other respective counterparts.

As opposed to crop care labor, nearly 80 percent of harvesting and post-harvesting labor work was done by hired labor. As expected, not much variance is observed across strata and categories as far as the total labor days for these activities are concerned.

As for the labor use for rice production in general, the following points are worth noting. First, of the total labor use, 39 percent was from family labor, 6 percent from exchange labor, and 55 percent from hired labor, on the average for the total sample. Though the share of exchange labor was relatively high for such farm tasks as crop establishment and harvesting and post-harvest, altogether the labor exchange tradition in rice farming is of less importance in the study area. Second, in terms of labor use, the DC8 farmers reveal a remarkable difference from those in other distributaries. They did not use exchange labor at all. Moreover, their dependence on hired labor was significantly higher; of the total of 112 labor days, 87 days were supplied by hired laborers, whereas only 26 labor days were utilized out of their own labor. Such a distinct pattern of labor use in the DC8 area suggests that the rural society to which the DC8 farmers belong has characteristics very different from those in the other sample distributaries.

The fixed capital services the farmers in the study area employ are those derived from the 2- or 4-wheel tractors used for land preparation and 'post-harvest operations. As explained earlier, these services for most of the farmers take the fonn of custom service contracted based on area. Usually, the payment for such a contract includes not only the payment for the tractor itself but the wages for tractor operators and the cost of fuel for running the tractor. The value of fixed capital services shown in Table 6.07 is the pure tractor rental per hectare after deducting the wages and the fuel cost by using the respective market rates. For the farmers who used their own tractor, its service is imputed at the market rental rates. The use of fixed capital thus estimated shows remarkable uniformity across the strata for all the categories examined, except for the Dc8 fanners who used it significantly more than others.

As explained so far, there were some differences in the pattern of input uses among the allotments in different strata of the categories examined. Attempts were made to test if these differences could be supported statistically after controlling other factors. The tests were made through regression analyses in which the level of a certain input per hectare was regressed on a set of factors; distributary, location, soil type, tenancy, and salinity. If all independent variables are dummy variables, this is nothing but performing the analysis of variance. Here, all factors are defined as dummy variables, except salinity which is defined both as a dummy and as a continuous variable showing the percentage of area affected by salinity in an allotment. The results are summarized in Table 6.09. Note that an intercept in the table shows the average of dependent variable for the allotments having all of the following characteristics: DC2, head-end, well-drained, free of salinity, and tenant-operated. The following points are confirmed:

1. Seeding rate was higher, other factors being equal, for the farmers in the DC5 and Dc8 areas.

2. Fertilizer use, as the total value of all kind of fertilizers, was higher for the Dc5 and DC8 farmers, and the incidence of salinity lowered it. In terms of nutrient element, the levels of nitrogen and phosphorus were higher in Dc5 and DC8, and lower on the poorly drained allotments.

3. The farmers cultivating poorly drained allotments used more herbicide.

4. Pesticide application was less for the Dc8 farmers and those cultivating the poorly drained allotments.

5. The farmers cultivating poorly drained allotments used less labor. The owner operators used more labor than the tenant farmers, whether leaseholder or sharecropper.

6. The total cost of rice production defined as the total factor payments did not show any factor-specific effect.

Factors Affecting Rice Yield

It was suggested in Table 6.05 that the rice yield on tail-end allotments along the distributaries and on poorly drained allotments was significantly lower than that of other allotments. To test whether this fact is retained after controlling other factors, regression analyses similar to the input regressions in the previous sub-section were attempted. The results are summarized in Table 6.10.

The first two equations are estimated using the yield data on all allotments for which the crop-cut survey was conducted, i.e., all allotments in the DC2 area and the sample allotments in DC5 and DC8. Regression 1 confirms that the yield of poorly drained allotments was significantly lower than other allotments even after the distributary and distributary-location factors are controlled. It also shows that the yield of DC5 allotments was higher than others. The location factors do not show any significant impact on the yield.

Regression 2 in which the salinity dummy is included reveals that the incidence of salinity lowered rice yield by about 800 kg per hectare. The coefficient of poorly-drained dummy is still negative and significant. This implies that, aside from the salinity problem that occurred exclusively on poorly drained allotments, the poorly drained allotments had certain factors that caused the low yield.

The last two equations are estimated with the data obtained from the sample allotments. Regression 3 shows that, although the coefficient of DC5 dummy turns out to be insignificant, essentially the same structure as in Regression 2 is detected in the data from the sample. In Regression 4, tenancy dummy and input variables are added in the linear form. The production inputs are divided into the major nutrient elements of fertilizers and the non-fertilizer cost. The addition of inputs makes the coefficient of poorly-drained dummy insignificant. Salinity dummy, however, remains significant.

These results suggest that the farmers cultivating the poorly drained allotments reduced the levels of inputs accordingly in the course of the production process. As shown in Table 6.09, the level of input use on the poorly drained allotments is significantly less for many production inputs examined. In the case of salinity, since the problem arose in the later stage of production process, its adverse effect on yield is picked up by the dummy variable even after excluding the effect of differences in input use.

In the same regression, the coefficient of DC8 dummy turns to be significant, the sign being negative. This means that there are some factors that explain the low yield of the allotments there other than the inputs and other factors introducedin the regression. As observed in the previous section, the timing of land preparation in the DC8 area delayed by more than one month. This might have caused the low yield. It was also observed that the DC8 farmers exhibited distinct characteristics in their input use pattern, particularly for labor, which seemed to stem from their social structure. One of the unrevealed factors behind the dummy variable could be traits in their society. Or, more specifically, it could be due to a relatively lower level of their rice growing technology as a reflection of such traits.

At least, the following two implications are derived from the regression results above: first, reflecting the fact that water was generally abundant in the this season, the head-tail problem was not serious at all for either the branch canal or for the distributaries. As a matter of fact, the branch canal head-enders, i.e., the DC8 farmers, attained significantly lower yield than others, and the location factors along the distributaries revealed no yield effect.

Second, the problem was how to drain excess water. If the system management could solve this drainage problem under abundant water supply, the productivity of the system would be increased through two routes; first, it is increased directly by reducing the incidence of salinity, and second, it is increased indirectly by letting the farmers cultivate the poorly drained allotments and increase their use of production inputs.

Credit

Table 6.11 shows the sources of credit for farmers in the three study seasons. In the 1987/1988 maha season, 80 percent of the fanners obtained loans either from institutional or from informal sources, or from both. On the average, the amounts borrowed per farmer from institutional and informal sources were 3500 rupees and 2500 rupees, respectively, totaling 6000 rupees. The interest rate of the institutional bank loan was 9 percent per year or 4.5 percent per season. Of the 2500 rupees from informal sources, more than 50 percent was interest-free, while the rest was with interest, the typical rate of which was 120 percent per year or 60 percent per season.

In 1988/1989 maha season, while the percentage of borrowers increased slightly to 84 percent, the amount borrowed per farmer became less than the previous **maha** season; 2200 rupees from institutional and 1820 rupees from informal sources. The decline in the amount borrowed was particularly large in the case of institutional loans, suggesting that the decline might have been due to the unstable security situation which paralyzed for some time many social activities including government and bank services in the study area. Institutional loans per farmer declined even further in the 1989 yala season when the unstable situation continued. However, the amount borrowed from informal sources was more or less the same across seasons. As a result, the share of informal loans became more than twice as much as that of institutional loans in the third season.

It is interesting to note that, whatever the reason for the decline in institutional loans in the last two seasons, it did not affect adversely to the rice production in the system. As shown in the previous section, the yield performance in rice production was much improved in the last two study seasons as compared to the first one. Its economic performance, as will be shown in the next section, was far better in these seasons. These facts suggest that the credit constraint, if any, is not a serious problem in the system as far as rice farming is concerned. It could be said that the availability of informal loans is rather good, which also suggests that modest credit needs of farmers could be dealt with by the local financial market, rather than by the formal credit system. Such experiences in credit in this system cast doubt on a popular premise that farmers must be provided with formal credit systems through which subsidized loans are channeled.

It is difficult to divide these loans to the farmers into production and consumption purposes. This is especially *so* in the case of informal loans, a substantial part of which would have been spent for consumption purposes. Even a part of bank loans, which were made for production purposes in farming, could have been diverted for consumption purposes. In the following section, we assume that all loans were for production purposes in rice farming, and that they were made at the beginning of this season.

Economic Performance

There could be various indicators by which the economic performance of agricultural production in an irrigation system is evaluated. Farmer's average income from particular production, or as it is popularly called, the net returns to farmers, is one of the possible indicators. A few indicators are shown in Table 6.12.

The first set of indicators is the factor payments and the operator's surplus in rice production. Viewed from one side, the factor payments are nothing but the costs of production, counting all factor inputs used in a production process as factor costs. Factor inputs are either purchased in respective factor markets or self-supplied within a farm. Self-supplied inputs are valued at their opportunity costs. The difference between the gross revenue and the total factor payments is, by definition, the profit, or the operator's surplus. Viewed from the other side, the factor payments are nothing but income of owners of the factors. This applies in strict sense to two primary factors, i.e., labor and land, since payments for non-primary factors can further be divided into payments to primary and non-primary factors. The factor payments as such in rice production are presented in the table. Production factors are classified into four categories; current inputs, fixed capital, labor, and land. Self-supplied inputs are valued at respective market prices which are listed in Table 6.13.

The current inputs are such inputs as seeds, fertilizers and chemicals, the value of which is transferred to the output and exhausted during a prcduction cycle. The difference between the gross revenue and the current inputs is the value added, Since the value added is the income that is generated by a production process and distributed among the owners of resources involved in the production, this can be an indicator of economic performance of irrigated agriculture and hence of the system.

The third indicator listed in Table 6.12 is the farmer's income from rice fanning. This indicator is derived from the factor payments. The labor productivity of rice production is also shown in the table as the fourth indicator.

In Table 6.12, these indicators are shown for the three seasons studied. In addition to the figures in nominal value term, those in real value terms are also shown after deflating the nominal values by the rice (paddy) price at the farm gate in each year. The averages over the three seasons are given in the real terms.

Improvements in economic performance from the 1987/88 maha to the 1988/89 maha were enormous; gross revenue, gross value added, and labor productivity increased more than two times. In the case of farmers' income, the rate of increase was nearly four times. In terms of current prices, the economic performance of the 1989 yala was as high as in the 1988/1989 maha, and far better than in the 1987/1988 maha even in terms of paddy equivalent. Such improvements were brought about by two factors: increase in yield and changes in relative prices between the output and inputs.

The increase in rice yield was substantial particularly in the 1988/1989 maha season; it increased by 80 percent from the 1987/1988 maha level. Since this increase in yield was attained without concurrent increases in inputs, it resulted in large increases in gross value added and farmers' income. In contrast, the increase in rice (unhusked, i.e., paddy) price relative to input prices was more important contributor to better performance in the 1989 yala season; it increased by 67 percent from Rs 3.83/kg in the 1987/1988 maha to Rs 6.40/kg in the 1989 yala (Table 6.13). All prices increased substantially between these two seasons, not only for rice output but for all production inputs, but the rate of increase was highest for rice. The impacts of this change in rice price relative to inputs can be observed in the reductions in factor payments in terms of paddy equivalent from the 1987/1988 maha to the 1988/1989 maha, and further to the 1989 yala.

It should be noticed that the performance of rice farming in Kirindi Gya is now one of the best among major rice growing regions in the country (see Tables 6.02 and 6.03). Compared to other productive rice growing regions, such as Uda Walawe, Kalawewa, and Matale, the performance of rice production in the Kirindi Oya 1987/1988 maha was lower in terms of gross value added and farmers' income per hectare. However, the performance in the last two seasons is more or less comparable, or even better. If labor productivity is compared, Kirindi Oya performed best. It can thus be said from these observations that, as far as the performance in a single cropping season is concerned, the rice production in Kirindi Oya has evolved very quickly from a substandard level to one of the best levels in the country.

NON-RICE CROPS FOR DIVERSIFICATION IN KIRINDI OYA

Thus far, we have summarized the results of our surveys on rice production in the Kirindi Oya system. Since the first water issue in the 1986 yala season, there have been five cropping seasons in Kirindi Oya. Despite the intention to make it a 'non-rice' system, the system has *so* far been a 'rice monoculture' system; the farmers in the system have been planting rice in all five seasons, and non-rice crop cultivation has been nil.

It was shown in the previous section that rice production in the system has evolved to a stage which is comparable to the best standard in the country in terms of economic performance. It should be noted, however, that cropping intensity per year in the system has been low; on average for the past four years, it was at best about 1.4 for the old area and 1.2 for the new area developed under Phase I of the Kirindi Oya project (see chapter 2). Moreover, another new area of roughly same extent as the Phase I new area will be developed under Phase II, and the entire command area, including this Phase II new area, will be irrigated with the same source of water now available. Unless the cropping pattern in the system is switched from rice monoculture to diversified cropping with non-rice crops that require less water, cropping intensity per year for the entire command area would become far less than 1.0.

Cropdiversification is thus essential in order for the water-short Kirindi Gya system to be a socially viable irrigation system. Then arises a question as to what non-rice crops are to be grown in the system. Ironically enough, the fact that rice production in the system has become very high and profitable makes it difficult to specify the list of non-rice crops that can substitute for rice with better economic performance. In what follows in this section, we examine the economic performance of non-rice crops that could possibly replace rice.

Production Structure of Major Non-Rice Crops

The list of non-rice crops that can be grown under irrigated conditions may be long, at least biologically. However, the list becomes much shorter in Sri Lanka, when it comes to non-rice crops actually planted in irrigation systems with significant extent. Crops included in such a list are chili., onion, and some kinds of legume, such as green gram, black gram, cowpea, and soybean. Some kinds of vegetable, e.g., cabbage and tomato, may be added to the list, but the extent plantedwith these vegetables in irrigation systems have so far been very limited. Major attention in this section will be directed to these "conventional" non-rice crops. Other crops exotic to irrigated agriculture in Sri Lanka, such as gherkin, asparagus, grapes, and limes, might have a good potential to replace rice. Although farm data on these exotic crops are still scarce, to the extent possible the performance of these crops are compared with rice and other conventional non-rice crops.

For the conventional non-rice crops, production-cost data are available from many sources. In this section, we use two sets of data: first, production-cost data collected by the Department of Agriculture for different regions in the country, and, second, the non-rice crop demonstration trials conducted in the Kirindi Oya system in the 1989 yala season by the same Department.

Department of Agriculture regional data. Data on yield, labor requirement, and costs and returns of selected non-rice crops grown on irrigated fields in some dry zone regions are summarized in Tables 6.14, 6.15, and 6.16 for the yala season in 1985 through 1987, the original data of which are from the Crop Production Cost Survey conducted by the Department of Agriculture (Department of Agriculture 1986, 1987, 1988). Crops included in the tables are chili, red onion, Bombay onion (or big onion), green gram, and soybean. These crops are selected to show a variety of performance of "conventional" non-rice crops.

Close observation of these three tables raises several points that should be noted. First, the gross revenue per hectare, or land productivity, varies tremendously from crop to crop, and so do the gross value added, and farmers' income per hectare. Roughly speaking, however, the crops can be classified into two groups: high performance crops and low performance crops. The former group includes chili and two kinds of onion, and the latter green gram and soybean. Although there were variations for each crop in yield, gross revenue, *gross* value added, and farmers' income across seasons as well as across regions, the performance of the first three crops was consistently higher than that of the last two crops. If compared to rice in terms of income generation per hectare, the crops in the first group perform much better, and the performance of those in the second group and other kinds of legume is more or less comparable.

Second, the classification of crops by performance reflects differences in factor intensity as well. The high performance crops are characterized by high factor intensity. They require more current inputs than the low performance crops. Extremely high current input cost due to high seed and fertilizer costs for red onion is a typical case of high current input intensity, though to some extent, other high performance crops also require more fertilizer and chemicals, generally two to three times, than the low performance crops.

The intensity of fixed capital services does not vary much among the crops in both groups as long as the services consist only of draft power for land preparation. However, it jumps up sharply in case irrigation pumps are used to supplement water. Additional irrigation by pump is popularly practiced in some regions for two kinds of onion and for chili. Such a practice is rarely found for the low performance crops.

The difference in labor intensity between high and low performance crops is also enormous. Among the high performance crops, the lowest labor intensity recorded was for chili in the 1987 yala in Kalawewa, but it was still as high as 360 days per hectare. Labor requirements of low performance crops were much lower than those of high performance crops. It should be noted, however, that the labor intensity of low performance crops is comparable to, or even higher than, that of rice. As compared to rice, these low performance crops are not less labor intensive. As a result, labor productivity of these crops is generally lower than that of rice. For the high performance crops, their extremely high labor intensity makes the labor productivity roughly comparable to rice, in spite of their performance in income generating capacity per unit of land area being far better than rice.

Third, generally applicable to both groups, these non-rice crops are planted on a small scale; in none of the cases presented in these three tables, did they exceed 0.5 hectare. As a result, the actual income per farm from a particular crop cannot be so large in the case of low performance crops.

Fourth, seasonal or yearly variation in costs and returns could be very large for non-rice crops, since two major sources of fluctuation, yield fluctuation due to water and climatic conditions, and output price fluctuation due to market conditions, could both be high. Judging from the data in these tables, the most serious source of fluctuation for non-rice crops seems to be from the output prices. For each crop, yield per hectare varies from one season to another and from one region to another, but the degree of variation seems not too large. For chili, yield ranges between 1.2-1.5 tons/ha; for red onion, 10-12 tons/ha; for green gram, 0.8-1.0 tons/ha; and so on. In contrast, the degree of price variation for some crops was 50 to 100 percent. For instance, the price of green gram varies nearly 100 percent between 1986 in Polonnaruwa and 1987 in Kandy. These observations suggest that, as long as output prices are favorable, there are non-rice crops that will provide a reasonably steady income flow.

Table 6.17 gives the same set of information for some non-rice crops under rainfed conditions in the maha season. Future options for diversified cropping in Kirindi Oya include planting of semi-rainfed non-rice crops in the maha season. This table is prepared to provide some data on possible profitability of non-rice crops under such a condition. Only 'low performance' crops are shown in the table, since 'high performance' crops are usually planted under irrigated conditions. Compared to the production structure under irrigated conditions, the same crops grown under rainfed conditions have less factor intensity for current inputs and for fixed capital services, and the yield and other performance indicators are accordingly slightly lower than under irrigated conditions.

Kirindi Oya non-rice crop demonstration. The Department of Agriculture launched, in the 1988/1989 maha season, a field demonstration program of non-rice crops in the Kirindi Oya system using farmers' allotments. The program continued in 1989 yala. About thirty allotments in the new area were selected for demonstration of various kinds of non-rice crops. Seeds, fertilizers, and chemicals were supplied by the Department free of charge, but cultivation itself was carried out by the farmers themselves. The crop harvest from the demonstration plots was disposed of by the farmers, either for their home consumption or for marketing.

We collected crop production data from fifteen allotments covered under this demonstration program in the 1989 yala. Though outside the program, we included in our non-rice crop sample one more farmer who joined the 1988/1989 maha demonstration program and planted some non-rice crops voluntarily on his allotment in this yala season.

The non-rice crops planted by these demonstration farmers and their extent are shown in Table 6.18. Altogether, eight crops were tried. Chili was planted by all the sample farmers. Two kinds of onion, green gram, and okra were each tried by four to six farmers. Only one farmer each planted soybean, long bean, and tomato. In terms of area, chili was planted on a relatively large extent; the average of sixteen sample farmers was 0.452 hectare. The average areas planted with green pram and soybean were 0.100 and 0.194 hectare, respectively. On average, about 0.050 hectare was devoted to two kinds of onion and okra. The area planted with long bean and tomato was very tiny; 40 square meters and 150 square meters, respectively. As both the number of samples for each crop and the extent planted were quite small, we should be cautious in drawing implications from the results of the demonstration cultivation. This is particularly applicable to soybean, long bean, and tomato.

The yields, total labor requirements, and costs and returns of the non-rice crops tried in the 1989 yala are summarized in Table 6.19. Let us first observe the yield performance. The average yield of chili was 1.25 tons per hectare in terms of dry chili equivalent. This can be considered a reasonable yield. The chili yield in other regions shown in the previous tables ranges from 1.2-1.6 tons. Red onion recorded an average yield of about 8 tons per hectare. Compared to the yield level of 10 tons in other regions, the level in Kirindi Oya was a bit low. Bombay onion was successfully cultivated; the average yield of 12.6 tons per hectare is higher than other regions listed in Tables 6.14-6.16. The yield performance of green gram was less than other regions; the yield of 0.65 tons per hectare is even less than the yield under rainfed conditions shown in Table 6.17. Soybean trial apparently failed; the farmer who planted this crop could harvest only 180 kg in terms of yield per hectare.

For other crops, there is no good standard with which to compare their yield. Judging from factor shares, however, the performance of okra seems to have been a bit less than satisfactory. Long bean and tomato performed well in terms of returns, but it is too risky to rely on these data because the sample is too small for both the number of farmers and the size of area planted. We set aside these crops in the following analysis.

Next, let us see the output prices of these crops. Generally speaking, the fanners who planted non-rice crops in Kirindi Oya in the last season enjoyed favorable output prices. The Bombay onion price received by farmers, for instance, was Rs 18.78/kg. This price level is nearly two times the price received by the Bombay onion farmers in Matale in the 1987 yala (Table 6.19 versus Table 6.16). Similarly, the price of green gram in the last season was as high as Rs 27.89/kg. The price range for green gram in the past seasons in the regional data was from Rs 11/kg to Rs 20/kg. The Kirindi Oya farmers received for red onion Rs 9.62/kg, which falls within the price range for this crop in the regional data.

The price of chili in the last season in Kirindi Oya was also good; Rs 67.37/kg. This chili price was the weighted average of three grades of dried chili, using the quantity sold in each grade as weight. As shown in Table 6.13, the price of chili in each grade was Rs 69.10, Rs 44.40, and Rs 35.00, respectively. Since the majority of dried chili sold by the Kirindi Oya farmers in the last season belonged to the first class, the weighted average was very close to the price of the first grade. Aside from dry chili, the farmers sold green chili, the price of which was Rs 11.3/kg. Of the gross revenue for chili, 22 percent was earned in the form of green chili and the rest (88 percent) in the form of dry chili.

The yield performance of the non-rice crops grown by the Kirindi Oya demonstration farmers in the 1989 yala was more or less comparable to other regions, and the output prices received by the fanners were also at least comparable to, or better than, those experienced in other regions during 1985-1987. These facts suggest that the economic performance of these crops in Kirindi Oya would be more or less similar to that in other regions shown earlier in this section. If we compare the production structure in Kirindi Oya of chili, red onion, Bombay onion, and green gram with other regions, it is essentially the same; the first three crops belong to 'high performance', 'high input intensity' group, and green gram to 'low performance', 'low input intensity' group.

The factor shares, value added ratio, and fanners' income ratio for the non-rice crops in Kirindi Oya in yala were roughly on the same order as in other regions, which indicates that the production structure of these crops in Kirindi Oya is basically the same as in other regions. The value added and farmers' income per hectare was quite high for chili, red onion, and Bombay onion, though they require a huge amount of labor, more current inputs, and more fixed capital services. Compared to this group of crops, green gram requires less labor, current inputs, and fixed capital services, and generates less value added and fanners' income per hectare accordingly. However, even with the yield which was less than expected, the income generated in green gram production was as high as Rs 14,460/ha and Rs 6,210/ha for gross value added and fanners' income, respectively. As an extensive crop, this level of income generating performance may be considered 'good'.

It should be emphasized that these results in Kirindi Oya were attained by the farmers who had less experience in the cultivation of non-rice crops. The demonstration program thus exhibited good potential for non-rice crop production in the system not only in terms of such physical conditions as soil, water, and climate, but also in terms of farmers' technological capability as well. It would be fair to say that, should the farmers in the system be provided with appropriate extension services as to cultivation techniques of non-rice crops to be grown, their performance in the production of 'conventional' non-rice crops would be as good as farmers in other regions in this country.

Sugar cane. Sugar cane is a 'conventional' crop which can be grown successfully under irrigated conditions, and could thereby replace rice in some irrigation systems. It is indeed a candidate crop for diversification in the Walawe system. Let us examine here its economic performance based on the data obtained from farmer-allottees in Sevanagala, Uda Walawe.

A big difference between sugar cane and other non-rice crops examined in the previous subsections is that the crop duration of sugar cane is more than one year whereas other non-rice crops usually require less than six months to grow. Moreover, the possibility of ratoon growing for sugar cane makes one cycle of plantation even longer. Since Sevanagala cane farmers grow up to a second ratoon, one plantation cycle takes three years. In Table 6.20, data on yields and factor shares are shown by crop, together with averages per year over three crops.

It should be noted first that cane yields per hectare of Sevanagala farmers are extremely high as compared to other cane growing regions. Whereas the typical yield of planted cane in Sri Lanka under rainfed conditions ranges between 30 to 50 mt and that under irrigated conditions is around 80 mt, it was as high as 154 mt in Sevanagala. Ratoon crops generally give lower yield than planted cane, but, even for the second ratoon, the yield was 120 mt. With such high yields, gross value added was high; on average, 64,000 rupees per hectare per year, or 32,000 rupees per six months which is comparable to chili cultivation.

Since the payments for fixed capital services and hired labor were large, the farmers' income was much lower than gross value added; 38,000 rupees per hectare per year or 16,000 rupees per six months which is at about the same level as, or a bit lower than the level attained in rice production in Kirindi Oya in the last two seasons. It could be said from these observations that sugar cane belongs to the 'high performance' crop group in terms of gross value added and to the 'low performance' crop group in terms of farmers' income.

Exportable non-rice crops. A recent trend in crop diversification in Sri Lanka is to promote the cultivation of exportable crops. Some consultants have recommended such exportable crops as asparagus, gherkins, strawberry, grapes, and limes for crop diversification (e.g., MacDonald Agricultural Services 1987; Irrigation Sub-sector Study Office 1990). It is necessary for us to identify the economic performance of these export oriented crops which can be grown in irrigation systems, relative to 'conventional' crops. However, since these exportable crops are mostly exotic to Sri Lankan farmers, few farm data are available yet to compare their performance with other conventional crops including rice. Here, we try, based on a few examples, to get a rough idea as to the relative economic performance of these exotic crops.

Gleason (1990), based on actual farmers' trials in Mahaweli System B, reported production cost data on gherkins. According to her data, the economic performance of gherkins is quite similar to that of 'conventional high performance crops', such as chili and onion. The gross value added of gherkins is estimated to be 52,000 rupees and the farmers' income to be 41,000 rupees, both per hectare in 1989 prices. It shares the same characteristics with conventional high performance crops: labor intensiveness (800 mandays per hectare) and high capital requirements (35,000 rupees per hectare).

A consultant recommended lime cultivation in a wide scale for the Walawe system (MacDonald Agricultural Services 1987). Though not field tested, he projected that, under the "high production" profile, a full annual income of 62,040 rupees per 0.5 acre will be generated starting from the twelfth year after the first planting (ibid: 42). In terms of per hectare, this means an income of about 300,000 rupees per year, or 150,000 rupees per six months. At a glance, this level of income appears to be twice as high as the income obtained from conventional high performance crops, such as chili and onion. However, if we discount this assuming the discount rate of 20 percent per year (note that the actual interest rate in the local capital market is much higher than this level), its present value is Rs 34,000/ha per year, or Rs 14,000/ha per six months, which is more comparable to rice and other conventional low performance crops than to conventional high performance crops.

These examples suggest that the economic performance of the export oriented crops which are recommended for cultivation in irrigation systems would be similar to the economic performance that the conventional high performance crops have under the present price structure. In the long run, these export oriented crops may perform better than the conventional high performance crops because of their higher income and price elasticities for demand, but, in the short to medium run, it would be reasonable to assume that their performance is as good as that of the conventional high performance crops.

Potential Constraints to Crop Diversification in Study Area

The existence of good potential for non-rice crop cultivation in the system does not necessarily mean that crop diversification in the system is easy to attain. There could exist many potential constraints to crop diversification as well. In this subsection, we briefly review possible constraints to crop diversification in the study system.

Table 6.21 summarizes basic parameters obtained so far in this chapter as to rice and non-rice crop production in the Kirindi Oya system, together with some other information related to the crops. In this table, chili and red onion represent conventional 'high performance' crops, and gherkin exportable 'high performance' crops. As for 'low performance' crops, cowpea is added to green gram and soybean. Other legumes, such as groundnut, are well represented by these crops in terms of parameters shown in this table. Sugar cane is also included in the table. As explained earlier, this crop falls in between; in terms of value added 'high performance", but in terms of farmers' income 'low performance'.

Crop duration. All crops shown in the table, except chili and sugar cane, have a crop duration of around ninety days. Since the duration of these crops is comparable to, or shorter than, that of rice, they would conveniently replace rice as far as the timing of water scheduling is concerned. In the case of chili, crop duration is as long as *200* days, sometimes even longer. To plant such a long duration crop with other shorter duration crops may create difficulties in water delivery schedule within a season as well as between seasons.

Sugar cane is different from other crops in this respect because of its longer crop duration; one production cycle including ratoon cultivation lasts at least two to three years. If sugar cane is introduced in replacement of rice, four to six crops of rice have to be foregone. Since the crop is usually planted on a wide contiguous area, rather than plot to plot mixed up with other various crops, its planting would not entail so much difficultyin water delivery within a cropping cycle. However, if rice and sugar cane are to be planted sequentially in rotation, land as well as water management may become a problem, particularly for rice cultivation after sugar cane.

Crop water requirements. All non-rice crops listed require less water than rice. Note that for sugar cane the water requirement shown in the table is for one year. In this respect, these crops fit well in this water-scarce system. Among the non-rice crops, however, the high performance crops generally require more water than the low performance crops. Moreover, they require much more frequent irrigation than the low performance crops. If water were to be delivered in rotation, rotation intervals for these high performance crops need to be shorter than for low performance crops. In other words, the introduction of high performance crops into the list of non-rice crops to be grown will entail heavier demands for good water management in the system.

Relative profitability. It is often said that there are non-rice crops that generate better income for farmers than rice. Such a statement is true as far as the high performance crops are concerned. It is not necessarily true for the low performance crops. Particularly in productive rice growing areas, it becomes difficult to hold to this statement. Unfortunately from the point of view of promoting crop diversification, the Kirindi Oya system has become a 'productive'rice growing system. Compared to the performance of rice production in the 1987/1988 maha, the low performance crops can compete with rice in terms of profitability, as shown in Table *6.20.* However, compared with the average yield level of rice for the last three seasons in Kirindi Oya and.with the level of rice price of the 1989 yala, the income potentials of the low performance crops are far behind those of rice. Should the risk and uncertainty inherent in non-rice crop production be taken into account, the economic disadvantage of these crops over rice would become even greater.

It may be technically easier to replace rice by the low performance crops (chapter 2). But, given the present price structure and technology of rice and these non-rice crops, crop diversification with these crops would entail a rather serious backward shift in the income position of the farmers who now plant rice in the system. As will be shown in the next section of this chapter, the total benefit in the system or to the society to be generated from this kind of diversification would also be marginal. If the system is to be diversified, and if the low performance crops alone cannot deal with diversification, the only practical solution in the short run is to introduce some high performance crops at least as a part of a mixed cropping pattern, however difficult it is to do so.

Prices and markets. Profitability of non-rice crops of course depends critically on their prices, which in turn depend on the markets of the respective crops. As compared to rice production, non-rice crop production generally involves more risk and uncertainty. An observation in the previous section suggests that price uncertainty is more serious for the performance of non-rice crops than the risk associated with physical production.

It was also shown in the previous section that the farm gate prices of the non-rice crops grown by the Kirindi Oya demonstration farmers were rather favorable. This was partly because the products were sold in a very localized market in and around the system. The farmers marketed the products beyond their home consumption either through private traders or through selling directly to the consumers in their villages or in the town markets located nearby. Since there have not been large sources of local supply for any of these crops in the study area, the farmers had no difficulty in finding the demand for their atomistically small supply of these products. If these crops were to be produced by many farmers in the system at once, the demand for these crops in the localized market would surely not be enough to absorb a large volume of marketed supply from the system. The prices of non-rice crops received by the farmers in the system under such a situation would depend critically on the markets outside the system. Without information on the markets, both national and international, of the non-rice crops, it is impossible to forecast their possible price levels in the future.

We can do nothing for the analysis in this sub-section but to assume that the prices of these crops will continue to be at the present levels or the levels in the recent past, with certain degrees of fluctuation around the levels. In Table 6.20, the impacts of a downward output price fluctuation on value added and farmers' income per hectare are shown, assuming 50 percent decline in the prices of the non-rice crops. If such a decline happens in the very short run so that farmers do not have time to adjust their input levels, the results are disastrous; the farmers' income per hectare of the high performance crops is reduced to a level far lower than that of rice for the three year average case, and it becomes nil for the low performance crops.

Labor requirement. Most non-rice crops require significantly more labor than rice. Labor intensity is especially high for the high performance crops. High labor requirement is in a sense blessing, since more labor, otherwise left underemployed, could be absorbed in agriculture. In fact, the fanners who planted non-rice crops under the demonstration program in the yala season tried to cope with large labor requirements for these crops by mobilizing a part of the family labor force otherwise lying idle or engaging in other job opportunities (Table 6.22). For chili and green gram cultivation, the share of female labor in the total family labor was much more than that for rice. In the case of chili, even child labor was mobilized.

However, a very high labor requirement might create difficulties for the fanners to adopt these labor intensive crops in replacement of rice. Since the average labor force a farm family in the study areas has is less than three members (ARTI 1986: 5), it is difficult for a farmer to meet the labor requirement of these crops solely with its family labor, unless the extent cultivated is extremely small. The large labor requirement can be met by hiring labor from outside. But, it may entail certain transaction costs for a farmer to hire a large number of laborers.

As pointed out earlier, one characteristic of rice farming in the study area is relatively high dependence on hired labor. This means that the labor markets are relatively better developed in the study area. However, since the total labor requirement for rice production is relatively small, the hired labor man-days per hectare do not exceed 100. A sudden increase in labor demand above this level due to the introduction of labor intensive non-rice crops might result in an increase in the wage rate, which further reduces the profitability of the non-rice crops.

It should be noted that seasonal peaks in total labor demand could be very high under a mixed cropping pattern in which labor peaks of different crops coincide with each other. Figure 6.01 shows the cropping calendar of selected crops cultivated during the 1989 yala in Kirindi Oya. In this Figure, the duration of a certain cultivation activity for a particular crop represents the period from the time the first farmer began this activity to the time the last fanner completed it. Water was first issued on 15 March in this season. About ten weeks after the water issue (in early May), three major activities, i.e., land preparation, planting, and crop care, occurred together for all crops including rice. As shown in Table 6.23, these activities each require substantial labor for each crop. If these crops were planted by all system fanners to a significant extent, the total labor demand during this peak season would be enormous.

An indicative order of this seasonal labor demand can be seen in Figure 6.02, in which weekly labor requirements per hectare for selected crops are depicted. For each crop, the labor flow data is represented by a typical farmer who grew the crop in the 1989 yala. In the case of rice, the highest weekly labor peak of about 40 man-days is found during the harvesting season. It may be reasonable to assume that the local labor market in the study area is now organized to accommodate this level of maximum weekly labor demand. For all non-rice crops listed in the Figure, there are weekly peaks that exceed this standard level. The excess is large for the labor intensive crops like chili and red onion, but it is substantial even for less intensive crops like green gram.

In the long run, the labor market could be flexible enough to adjust itself for an increased labor demand due to the introduction of labor intensive crops. In the short run, however, it is quite likely that the introduction of labor intensive crops on a wide scale is constrained by labor availability in the local labor market. In any case, it is sure that the labor requirements of these labor intensive crops could not be met by family labor alone, if they were to be introduced by the fanners on a significant extent.

Capital requirement. It is often said that non-rice crops are more cash intensive than rice. For the high performance non-rice crops, this is true; capital requirement, defined as the summation of costs for current inputs, fixed capital services (tractor and draft animal rentals), and hired labor, is higher for the high performance crops than for rice (Table 6.21). In the case of red onion and gherkins, it is as high as Rs 35,000 per hectare. Such a high requirement of capital funds may be a constraint to introducing high performance crops.

It may be said, however, that the high profitability of these crops makes some credit available to farmers. In this sense, it may be more difficult for farmers to get credit for growing low performance crops, even though capital requirements for these crops are much lower. Judging from the data on informal credit for rice production presented in Table 6.11, however, the problem of credit, if any, would not be so serious. More crucial than credit would be crop insurance; the risk and uncertainty inherent in non-rice crop production makes some kind of crop insuranoe a necessity, particularly for the high performance, capital intensive crops.

ALTERNATIVE SCENARIOS FOR CROP DIVERSIFICATION AND SYSTEM PERFORMANCE

However difficult it is, crop diversification is an imperative need for the water-scarce Kirindi Oya system. With the cropping pattern of rice monoculture, the cropping intensity of the system has been less than 1.3 per year since the first water issue, in which water has been delivered to the old area and the phase I new area. Since the farmers in the old area have been given priority in obtaining water, the phase I new area has suffered from chronic water shortages so that the cropping intensity for this area has been barely above one. With the same water resource, the system is envisioned to irrigate the phase II new area in addition to the areas presently irrigated. Given the rice monoculture pattern with the current rate of irrigation water consumption, it is simply impossible to irrigate the phase II new area. Such conditions make it essential for the system to be a diversified one.

Based on the data presented so far in this chapter on rice and non-rice crop production in Kirindi Oya, we briefly examine in this section possible changes in the income generating performance of the system under different possible scenarios as to cropping pattern and cropping intensity. The result of the analysis which follows is based on many heroic assumptions, and should, therefore, not be taken as more than indicative of possible outcomes. Yet, it will reveal some critical points that should be considered seriously while converting the system into a diversified one.

Alternative Cropping Patterns

As to cropping pattern and cropping intensity, we set forth seven possible scenarios including the present situation (Table 6.24). The following four factors are taken into consideration in devising alternatives: the availability of water in the system; relative crop water requirements for rice and non-rice crops; the rate of irrigation water consumption; and the distinction between old and new areas. The last factor is introduced because of the privileged status given to the fanners in the old area for water delivery.

For each alternative cropping pattern except for scenario VII, both type of crop to be planted and cropping intensity for the maha season are predetermined for each area. Assuming the relative crop water requirement between rice and non-rice crops of 2: 1 and the present level of water consumption rate, the cropping intensity of yala season for pre-specified type of crops is determined so as to fully utilize the total available water. The total water availability in the system is assumed at the level that allows the present cropping pattern and intensity per year. Our research indicates that the present water delivery practice tends to supply more water than required. Scenario VII assumes that a 40 percent water saving is possible compared to the present water use in the system and the cropping pattern is determined so as to keep the yearly cropping intensity at *2.0* while delivering 1.4 times more water than before to the entire system, including the phase II new area, and allocating it among maha rice, and maha and yala non-rice crops.

Crops are broadly grouped into rice and non-rice crops (other field crops; OFC). There can be numerous possibilities as to the crop-mix for non-rice crops to be planted in the system. Here, we assume only two kinds of non-rice crop-mix.

The first one (OFC cropping pattern A) consists of 50 percent soybean and 50 percent green gram. This pattern represents crop diversification with only 'low performance' non-rice crops. Since the economic performance of these low performance crops does not vary so much from one crop to another, any combination of different crops with different shares gives a similar macro performance.

The second pattern (OFC cropping pattern B) includes two crops each from 'high performance' and 'low performance' crop groups; chili, red onion, green gram, and soybean, with 23 percent, 7 percent, 25 percent, and 45 percent of relative planting share, respectively. The planting share of each crop is determined as inversely proportional to the peak weekly labor requirement of the respective crops. No difference in yield, output price, and gross value added ratio are assumed within the system for a particular crop. Assumed levels of these variables are shown in Table 6.25.

It should be noted that we do not take into account, in setting out these scenarios, some important technical aspects inherent in the system. For example, there exists diversity in soil types in different locations within the system; some soil is suitable only for rice and some others are amenable both for rice and non-rice crops. Scenario VI, which assumes that the entire system goes for non-rice crops, may be technically infeasible, or not desirable, under such a condition, or it may entail certain costs to implement such a scenario. All these details are abstracted from the analysis here.

Income Performance

For each alternative cropping pattern, the expected level of gross value added for the system as a whole is estimated as an indicator of system performance. The results are presented in Table 6.26. The total income generated from the present cropping pattern is treated as the base for comparison in the table, and changes are expressed as the difference between the income level of alternative scenarios and this base.

The first alternative scenario (scenario II) is presented to show that, if the rice-rice pattern is adhered to, no water is available for the phase II new area. Even if the present inequitable water distribution between the old and phase I new areas is rectified, the total income for the system will not change much. Inequity between the two areas will be reduced, but the total cropping intensity will remain as low as 1.2 with no water available to the phase II area. If the yala season is diversified, while omitting the phase II new area, sixty percent of the existing area could be planted with non-rice crops (scenario III). Although cropping intensity is higher, the total income in the system remains the same, if OFC cropping pattern A is adopted.

The next four scenarios assume water delivery to the phase II new area. Rice is still retained as a crop €or the old area, in scenarios IV and V, owing to the privilege given to them in water supply; in scenario IV, as yala season rice; and in scenario V, as maha season rice. Scenario IV assumes rainfed non-rice crops for the maha with supplementary water supply at 50 percent of the required level. Because of water saving by rainfed non-rice crop cultivation in maha, cropping intensity for this scenario is high; 1.9 for the old area, and 1.7 for the new areas. In contrast, it is 1.2 and 1.3 for the old and the new areas, respectively, in scenario V in which irrigated non-rice crops are assumed for the maha in the new areas. In scenario VI, withholding the privilege given to the old area. the entire command area is planted with irrigated non-rice crops in both seasons, in which case the cropping intensity becomes 1.55.

The income performance ranking among these three scenarios varies according to the non-rice cropping pattern. If OFC cropping pattern A is adopted, scenario IV with maha rainfed non-rice crops (green gram and soybean with 1:1 planting ratio) gives the best result; the total income for the system is increased by about 20 percent over the current situation. There will be no change in the total income for either scenario V or VI. These two cases become therefore a zero-sum game in which the phase II new area gains at the loss of the other two areas. In both scenarios, both the old and the phase I new area lose, but the latter loses more in scenario V. This means that the inequity between the old and the new area will become more pronounced in this scenario. This inequity problem is solved in scenario VI, but it raises another question whether the fanners in the old area will accept such a plan that entails for them about a 40 percent loss in their income from the present situation. A similar problem exists in scenario IV in which only the farmers in the phase I new area lose so that the inequity relative to the old area becomes even more greater.

If OFC cropping pattern B (which is a mix of "high" and "low" performance crops) is adopted, the situation is different. First of all, the increase in the total income for the system as a whole becomes quite large for all three scenarios. Of these, scenario VI (non-rice crops in the entire system) gives the highest income, and scenario IV the lowest. Except the old area for scenario V, no area loses in shifting away from the present pattern.

Scenario VII assumes a 40 percent saving in water use. With this saving, rice can be grown in forty percent of the total command area in one of the seasons. It is assumed that rice is planted in the two new areas as well as in the old area. Even with OFC cropping pattern A, the income performance of the system under this scenario is more than 50 percent higher than the present situation. If OFC cropping pattern B is adopted, the total system income becomes nearly three times as much as the present level.

In summary, this exercise indicates the following points: first, the income performance of the system under diversified cropping heavily depends on the non-rice crop mix. If the mix consists of only 'low performance' crops, such as green gram and soybean, given the present rate of water consumption, the total income to be generated in the system, including the phase II new area, would be roughly the same as that now being generated under rice monoculture pattern without the phase II area. If some 'high performance' crops, such as chili and onion, are included in the non-rice crop mix, however, the income performance of the system will be drastically improved, given the present structure of technology and prices for these crops.

Second, given the low performance crop mix and the present rate of water consumption, scenario IV, in which rainfed non-rice crops are grown in the maha season for the entire command area, performs best in terms of income performance for the system as a whole. However, from an income equity point of view between the old and new areas in the system, scenario VI, in which the system is converted fully to a non-rice system, may be considered better.

Third, such an equity question would be less important, if the crop mix is with high performance non-rice crops: each area in the system could receive an income as much as, or even better than, the income it is now receiving. Should these scenarios be 'politically' feasible, it would be essential to establish a crop mix that includes high performance crops.

Fourth, if water use efficiency in the system were improved through better management, its impact upon improving income performance would be very large. If the system performance were to be improved while reducing the inequity without entailing any loss to any group of farmers within the system, the only way would be through crop diversification with high performance crops while saving water by better management.

CONCLUSIONS

1. As far as the performance in a single season is concerned, rice farming in the Kirindi Oya System has evolved to a level that is comparable to the best standard in the country within five years since the project's commencement. The yield level in the last two seasons exceeded the target yield set for the system.

2. Such a good yield of rice was attained by consuming water in excess of the crop's need. In none of the last three seasons, was water a constraint to rice production, except for some allotments which had salinity problems due to poor drainage. There is ample scope for saving water in the system.

3. The price of rice at the farm gate went up by nearly 70 percent from the 1987/1988 maha to the 1989 yala. This, coupled with the increase in physical productivity, made rice production in the system highly lucrative relative to non-rice crop production.

4. As a result of wasteful water use during each cropping season, the system's performance in terms of cropping intensity has been very poor; it has been around 1.3 for the old area, and barely above one for the new area developed under the phase I project since the first water issue in the 1986 yala season. Given the present pattern of rice monoculture and the rate of water consumption in the existing areas, there is no room to irrigate the new area that will be brought in under phase II. In order for the system to be socially viable, it is necessary to get out of the rice monoculture patternand to introduce non-rice crops that require lesswater than rice.

5. The on-farm demonstration program carried out in the system during the 1989 yala season clearly indicates that a good potential exists to grow 'conventional' non-rice crops which have been popularly cultivated under irrigated conditions in other regions of the country. The yield performance of non-rice crops tested in the system was as good as in other regions.

6. Conventional non-rice crops can be classified into two groups according to economic performance; 'high performance' and 'low performance'. Crops in the former group, such as chili, red onion, Bombay onion, and gherkin, generate income per unit of area planted at least as high as, or generally higher, than rice does. In contrast, the economic performance of crops in the latter group, such as green gram and soy bean, is at best at the level of rice. With the high productivity of rice production in the system, the performance level of these crops is far lower than rice. Under the present price regime, the performance of such exportable crops as gherkins and limes which have recently been recommended as high value crops to replace rice is comparable to the "conventional" high performance crops.

7. A common characteristic of high performance crops is high input intensity; they require more current inputs, more fixed capital services and more labor per unit of land cultivated than rice does. Their labor intensity is particularly high. Since the scarcity of labor is relatively high in the study area, this characteristic may create a constraint to introducing these crops into the system on a wide scale.

8. Though much less than rice, high performance crops also require more water than low performance crops, and the type of irrigation they need is intermittent irrigation with much higher frequency. This means that high performance crops are more demanding for precise water management and therefore more difficult to adopt in the cropping pattern than low performance crops. Deliberate planning and distribution of water delivery by which fine tuning to meet water requirements of various crops planted in different sections of the system is made possible becomes a necessity in the system management.

9. Non-rice crop production generally involves higher risk and uncertainty than rice production. Whereas well-managed irrigation could reduce the risk of crop failure, fluctuation of output prices in the markets is unavoidable. High performance crops are more vulnerable in this respect. Under the price structure in the 1989 yala season, the high value crops

examined in this report perform, in terms of value added and farmers' income per hectare, twice as good as rice. A sudden decline in their prices by 50 percent reduces their performance far more than proportionally.

10. Through diversification away from rice, in both the old and new areas, it is possible, in principle, to increase yearly cropping intensity of the system, including the phase II new area, to nearly 2.0. But, if the non-rice crop mix to be adopted in the system consists only of low performance crops, the total income the system as a whole could generate would not be so different from the level it now does with rice monoculture pattern. In order to increase the total income significantly beyond the present level, it is necessary to adopt a cropping pattern that includes at least some high performance crops, while improving water use efficiency significantly by better water management.

Table 6.01. Population and sample allotments in distributary canals under study in Tract 5 of Kirindi Oya, by location along distributary canal and by soil type.

Soil type	Location along DC			
	Head	Middle	Tail	Total
	------ Number of sample/Population ------			
DC 2:				
Well drained	1/10	10/16	3/ 3	20/29
Intermediate	0/ 8	0/15	0/ 6	0/29
Poorly drained	5/ 8	7/11	6/10	18/29
Total	12/26	17/42	9/19	38/87
DC 5:				
Well drained	1/ 1	0/ 1	2/ 4	3/ 6
Intermediate	0/ 5	0/ 4	0/10	0/19
Poorly drained	4/13	0/ 8	7/17	11/38
Total	5/19	0/13	9/31	14/63
DC 8:				
Well drained	1/ 1	0/ 0	1/ 6	2/ 7
Intermediate	0/ 2	0/ 1	0/ 6	0/ 9
Poorly drained	3/ 6	0/ 2	7/19	10/27
Total	4/ 9	0/ 3	8/31	12/43
Total:				
Well drained	9/12	10/17	6/13	25/42
Intermediate	0/15	0/20	0/22	0/57
Poorly drained	12/21	7/21	20/46	39/94
Total	21/54	11/58	26/81	64/193

Note: Canceled and uncultivated allotments are excluded.

Table 6.02. Output, inputs, and factor payments per hectare, farm income per hectare and per farm, and prices, in irrigated rice production in selected regions in Sri tanka and study area,

	1986181 Maha[1]					Xiriodi Oya[2]	
Region	Kalawewa	Matale	Kegalle	Udawalawe	Hambantota	1987/88 oaha	1988189 maha
Yield (kg)	4 748	4 663	3 623	4 512	4 323	3 747	6 876
Seed[3] (kg)	120[B]	95[T]	104[T]	160[B]	133[B]	131[B]	128B
Fertilizer							
Total value (Rs)	1 112	1 282	1 151	1 035	1 182	831	704
N (kg)	77	98	90	84	100	82	62
P (kg)	28	45	42	41	42	21	8
K (kg)	29	40	45	37	41	30	22
Herbicide (Rs)	383	-	-	948	751	184	236
Pesticide (Rs)	351	175	400	483	577	927	438
Labor(days)							
Family	88(64)	111(70)	189(84)	59(50)	30(37)	58(45)[14]	37(35)
Hired	49(36)	49(30)	37(16)	60(50)	52(63)	70(55)	70(65)
Total	137(100)	160(100)	226(100)	119(100)	82(100)	128(100)	107(100)
Gross revenue (Rs)	17 046(100)	16 368(100)	14 202(100)	16 064(100)	16 086(100)	14 351(100)	32 473(100)
Factor payoent(Rs):							
Current input[4]	2 510(15)	937(121	2 117(15)	3 200(20)	3 127(19)	3351 231	2 631(8)
tabor: Family	3 3431 20)	662(221	6 290(44)	2 646(161	1 557(10)	636(18)[14]	2 674(8)
Hired	1 856(11)	4831 91	1 241(91	2 721(17)	2 519(16)	373(24)	4 4911 14)
Total	5 199(31)	1451 31)	7 531(53)	5 367(33)	4 076(26)	009(42)	7 171(22)
Fixed capital')	2 576(15)	606(10)	I 518(11)	2 454(151	2 1291 131	672(12)	1 694(51
Land & surplus[6]	6 761(40)	6801 47)	3 0361 21)	5 043(31)	6 754(42)	335(23)	20 651(64)
Value added[7](Rs)	14 536(851	14 431(881	12 0851 851	12 864(80)	12 959(81)	11 016(77)	29 847(92)
Farmers'income[8](Rs)	10 104(59)	11 342(69)	9 326(66)	7 689(48)	8 311(52)	5 971(42)	23 651(73)
Area cultivated (ha)	0.86	0.56	0.11	0.98	1.25	1.19	0.93
Actual farmers' income[9] (Rs/farm):	8 689	6 352	7 181	7 535	10 389	7 105	21 995
Price:							
Paddy rice[10](Rs/kg)	3.59	3.51	3.92	3.56	3.72	3.83	4.72
Seeds (Rs/kg)	5.53	5.05	5.44	4.58	4.63	5.80	6.36
Nitrogen[11] (Rs/kg)	9.3	6.6	6.5	6.3	6.4	6.5	8.3
Wage rate[12](Rs/day)	37.9	32.1	33.3	45.0	49.6	48.9	66.6
Labor productivity[13](Rs/day)	124	102	63	135	196	112	303

Note: 1) Data are from Departoent of Agriculture. Clioatic-geographical specification of the regions: Kalawewa; Dry Zone, North-Central, Matale; Wet-Dry Intermediate Zone, Central, Kegalle; Wet Zone, Central, Udaualawe; Dry Zone, South, Haobantota; Dry Zone, South.

2) Data are for the sample farmers in our survey.
3) Superscripts B and T stand for broadcasting and transplanting, respectively. Although both methods coexist in all regions listed, only major one is reported in this table,
4) Seed, fertilizer, herbicide, pesticide and fuei. Fuel for tractor is not included for the data from DA.
5) Fixed capital services such as Craft animal and tractor. For DA data, fuel is included here. Qor Ririndi Opa data, the returns to services for fixed capital owned by farmers are ioputed using the market rate, but not for DA data.
6) Grass revenue - (current input t labor t fixed capital].
7) Gross value added {Gross revenue - current input].
8) Family labor t land & surplus. Assuoe that all farmers are owner-operator.
9) Farmers' income per ha x area cultivated.
10) Farm-gate price of rice output.
11) Based on urea price.
12) Average far all operations.
13) Grass revenue/total labor days.
14) Includes exchange labor.

Source: Department of Agriculture (1988)

Table 6.03. Output, inputs, and factor payments per hectare, farm income per hectare and per farm, and prices, in irrigated rice production in selected regions in Sri tanka and study area.

	1986 gala'!				1989 yala
Region	Kalawewa	Kurunegala	Hambantota	Udawalawe	Kirindi Oya²⁾
Yield (kg)	3 184	3 443	4 235	4 123	4 697
Seed (kg)	118ᴮ	103ᶠ	113ᴮ	179ᴮ	147B
Fertilizer:					
Total vaiue (Rs)	1 165	1 104	1 286	1 121	783
N (kg)	85	82	116	93	65
P (kg)	42	47	41	40	10
K (kg)	32	41	42	38	22
Herbicide (Rs)	541	210	649	835	346
Pesticide (Rs)	316	335	551	388	246
Labor(days)					
Family	63(61)	113(601	19(22)	561 46)	26(29)
Hired	411 39)	75(40)	69(181	651 54)	641 71)
Total	104(100)	188(100)	88(100)	121(100)	30(100)
Grass revenue (Rs)	10 85111001	11 25911001	14 611(100)	13 276(100)	30 202(100)
Factor payment(Rs):					
Current input	2 591(23)	2 193(19)	2 998(21)	3 2311 24)	2 702(91
tabor: Family	2 2981 211	3 503(31)	865(6)	2 626(201	1 855(6)
Hired	I 590(15)	2 185(19)	3 087(21)	3 048(17)	4 709(16)
Totai	3 888(36)	5 688(51)	3 952(27)	5 674(43)	6 5641 22)
Fixed capital	1 731(16)	9931 91	1 268(91	1 507(11)	i 758(61
Land & surplus	2 647(24)	2 3851 21)	6 403(43)	2 8581 22)	19 178(631
Value added (Rs)	8 266(76)	9 066(81)	11 613(191	10 039(161	27 500(91)
Faraers'income (Rs)	4 945(461	5 888(53)	1 268(50)	5 4841 41)	21 033(101
Area cultivated (ha)	0.51	0.62	1.34	0.87	0.92
Actual farmers' income (Rs/farm):	2 802	3 610	9 13Y	4 111	19 350
Price:					
Paddy rice (Rs/kg)	3.41	3.27	3.45	3.22	6.13
Seeds (Rs/kg)	4.82	4.10	4.48	4.99	5.11
Nitrogen (Rs/kg)	6.7	6.5	6.4	6.4	8.5
Wage rate (Rs/day)	37.4	30.3	44.8	47.0	14.6
tabor productivity (Rs/day)	104	60	166	110	336

Note: 1) Data are from Department of Agriculture. Climatic-geographical specification of the regions: Kalaueua; Dry Zone, North-Central, Kurunegala; Wet-Dry Interoediate Zone, Central, Udawalaue; Dry Zone, South, Hanbantota; Dry Zone, South.

2) Data are for the saaple farmers in our survey,

3) For variable definitions and other notes, see Table 6.02.

Source: Departaent of Agriculture (1987).

Table 6.04. Average rice yield per hectare in the three seasons under study, by location and by soil type, Kirindi Oya, based on crop-cut survey.',

	1987/1988 maha	1988/1989 maha	1989 yala
Location along BC			
Head (DC 8)[2]	3047"	6483	4632
Middle (DC 2)	3699	7010	4854
Tail (DC 5)	4026	7254	4354
Location along DC			
Head	3826	6576	4433
Middle	3716	7238	4960
Tail	3468	6814	4711
Well drained	4021"	7112	5002
Intermediate	3658	-	-
Poorly drained	3431	6696	4489
Average	3675	6876	4697

Note: 1) Yields with * are statistically different from others at the 5% significance level.
2) For 1987/1988 maha, crop-cut survey was conducted for all allotments in DC 2.

Table 6.05. Average rice yields (kg/ha) in the DC2 allotments in the 1987/1988 *maha* season, Kirindi Oya, by location along the distributary and by soil type, based on the 100% crop-cut survey.[1)]

	Location along DC			
	Head	Middle	Tail	Average
Soil type				
Well drained	4110 (11)	3808 (16)	4609 (3)	3999 (30)
Intermediate	3596 (8)	3111 (12)	3619" (5)	3658 (25)
Poorly drained	3168 (8)	3569 (8)	2973**+ (10)	3413** (28)
Average	3851 (27)	3116 (38)	3424 (18)	3699 (83)

Note: 1) Figures in parenthesis are the number of allotments in each category. Yields with * and ** are statistically different, at the 5% and 1% significance levels respectively, from the largest yield in the same column. Yields with t are statistically different, at the 5% significance level, from the largest yield in the same row.

Table 6.06. Rice yield per water supplied at different locations of the sub-system under study, Kirindi Oya, 1989 yala.

Location[1]	Yield per hectare[2] (kg/ha) (1)	Total irrigation water supplied (mm/ha) (2)	Yield per water supplied (kg/mm) (1)/(2)	Effective rainfall (mm) (3)	Total water available (mm/ha) (4)=(2)+(3)	Yield per water available (kg/mm) (1)/(4)	Yield per minimum water supply[3] (kg/ha)
Branch Canal No. 2	4696	2482	1.89	220	2702	.74	3.66
DC 2	4844	2398	2.02	220	2618	.85	3.78
FC 9	4135	3596	1.32	220	3816	1.24	3.70
FC 10	4777	1861	2.57	220	2081	2.30	3.73
FC 15	5159	2918	1.77	220	3138	1.64	4.03
FC 11	5312	2283	2.33	220	2503	2.12	4.15
FC 12	4665	2087	2.24	220	2307	2.02	3.64
FC 14	5104	2736	1.87	220	2956	1.72	3.99
FC 13	4541	1673	2.71	220	1893	2.40	3.55
DC 5	4354	2203	1.98	220	2423	1.80	3.40

Note: 1) Water is measured at the head of respective location.
2) Average rice yield of the sample allotments fallen under respective location, based on crop-cut survey.
3) Yield per minimum water supply of 1,280 mm/ha which is the difference between the minimum crop water requirement (1,500 mm) and the effective rainfall (220 mm).

Table 6.01, Yield and inputs per hectare in rice production for sample allotments in Tract 5, 1987/1988 maha, by distributary canal, by location along distributary canal, and by soil type[1].

	Total Average	DC			Location			Soil type	
		2	5	8	Head	Middle	Tai!	Wel! drained	Poorly drained
Yield[2] (kg)	3 141	3 850	4 026	3 047*	3 852	3 833	3 604	4 057	3 538*
Current inputs:									
Seeds (kg)	131	119*	153	147	135	112*	142	124'	137
Fertilizer;									
Total value (Rs)	831	763	1138*	812	831	800	913	918	813
Nitrogen (kg)	82	76	103	79	82	78	86	86	80
Phosphorus (kg)	21	16	36*	20	19	19	25	25	19
Potassium (kg)	30	28	38*	27	29	28	32	32	29
No. of appl.	3.3	3.2	3.9'	3.0	3.5	3.4	3.2	3.6	3.2*
Herbicide:									
Totai value (Rs)	184	165	290'	116	210	139	193	86	248*
No. of appl.	.86	.87	1.0	.64	.91	.82	.84	.60	1.D'
Pesticide;									
Total value (Rs)	921	1050	915	519'	985	1117	750*	1173	166'
Ha. of appl.	4.5	5.1'	4.1	3.2	4.9	5.1	3.8'	5.4	3.9'
Fuel[3] (Rs)	633	621	684	602	615	607	662	635	631
tabor (days[4]):									
Family	50	51	51	26'					
Kxchange	8	8	12	0					
Hired	10	61	63	87*					
Total	128	132	126	113	126	134	126	144	117*
Fixed capital[5] (Rs)	1 612	I 636	1 666	1 801*	1 616	1 668	1 125	1 668	1 616

Note: 1) in each characteristics group, a figure with * is statistically different from the other(s) at the 5% significance level or higher.

2) Data are from crop-cut survey.

3) Fuel for tractor.

4) One labor day = 8 hours.

5) Fixed capital service for tractor use in land preparation and post-harvest activities. In the study area, no draft animal is used. Costs for fuel and operator are not included. Service from owned capital is imputed at the market rental rate.

Table 6.08. Labor use per hectare in rice production for sample allotments in Tract 5, 1987/1988 maha, by distributary canal, by location along distributary canal, and by soil type[1].

	Tatal Average	DC 2	DC 5	DC 8	Location Head	Location Middle	Location Tail	Soil type Well drained	Soil type Poorly drained
	----------------	-------	-------	days/ha	-------	-------	-------	-------	-------
Land preparation:									
Family	26.7(49)	28.0	33.6	13.3'	21.8	28.2	24.7	30.3	23.8*
Exchange	1.41 3)	1.7	1.8	0'	1.5	2.1	0.9	2.4	0.8'
Hired	26.2(48)	26.2	21.4	32.1'	26.0	24.9	21.3	31.8	22.6'
Total	54.3(100)	55.9	56.8	45.6'	55.3	55.2	52.9	65.1	47.2*
Crop establishment:									
Family	2.51 18)	1.9*	3.5	3.2	3.1	2.1	2.3	1.6	3.1'
Knchange	2.7(20)	2.1	4.8	0'	2.4	3.0	2.7	4.6	1.5'
Hired	8.5162)	8.1	1.6	10.9'	9.7	6.9	8.5	7.7	9.0
Total	13.7(100)	12.7	15.9	14.1	15.2'	12.0	13.5	13.9	13.6
Crop care[2]:									
Family	13.7(79)	18.8*	6.6	5.1	11.8	19.6'	11.3	18.0	10.8'
Exchange	0.8(4)	1.2	0.4	0	0.4	2.2'	0.3	1.4	0.5*
Hired	2.9(17)	2.6	3.2	3.3	2.8	2.4	3.2	2.9	2.8
Total	17.4(100)	22.6'	10.2	8.4	15.0	24.2'	14.8	22.3	14.1'
Harvesting and post harvesting:									
Family	5.61 14)	6.7	5.6	1.9'	6.2	6.5	4.5	6.7	4.9
Exchange	2.7(7)	2.8	4.5	0	2.5	2.5	2.9	3.6	2.0
Hired	32.0(79)	30.2	31.0	39.3	30.2	31.0	34.3	31.2	32.5
Total	40.31100)	39.7	41.1	41.2	38.9	40.0	41.7	(1.5	39.4
Channel clearing:									
Family	1.6(84)	1.4	1.8	2.2	1.3	1.6	1.9	1.2	1.9'
Exchange	0 (0)	0	0	0	0	0	0	0	0
Hired	0.3(16)	0.3	0.2	0.8	0.1	0.2	0.1	0.4	0.3
Total	1.9(100)	1.1	2.0	3.0	1.4	1.8	2.6'	1.6	2.2
Total:									
Family	50.1(39)	56.8	51.1	25.1'	50.2	58.0	44.7	58.4	44.5*
Exchange	7.6(6)	8.4	11.5	0'	6.8	3.8	6.8	12.0	4.8*
Hired	69.9(55)	67.4	63.4	86.6'	68.8	65.4	14.0	14.0	67.2
Total	127.6(100)	132.6	126.0	112.3	125.8	133.2	125.5	144.4	116.5*

Note: 1) In each characteristics group, a figure uith * is statistically different from the other(s) at the 5% significance level or higher. One labor day = 8 hours.

2) Fertilizer-chemical applications, aanual weeding, and fencing.

3) Threshing, winnowing, and hauling,

Table 6.09. Factors affecting input uses per hectare, 1987/1988 maha: Summary of regression analyses[1]).

Regression No.	1	2	3	4	5	6	7	8
Dependent-variable	Seeds[3])	Fertilizer(value)	N	P	Herbicide	Pesticide	Total labor	Total cost[2])
Sample size	63	63	63	63	63	63	61	61
D-canal dummy:								
DC 5	27.1***	432***	31.3***	23.1***	66.3	28.1	4.5	550
DC 8	20.7**	187**	6.4	12.1**	-91.1	-308*	-2.1	27.6
location dummy:								
Middle	-12.1	53.2	3.7	4.0	-44.2	21.1	-1.6	-94.7
Tail	0.9	63.0	2.2	4.8	-37.2	-138	7.2	166
Soil-type dummy:								
Poorly drained	1.8	-175	-12.8**	-10.8**	171***	-300**	-25.5***	-738
Salinity:								
Dummy			1.5		16.7	-42.6		
% affected		-9.5*		-0.5			-0.4	-13.1
Tenancy dummy:								
Owner operator	0.6	-54	-5.9	-1.3	-91.4	-107	18.3*	1101
Intercept	124	829	80.2	18.9	123	1231	115	13320
R^2	0.340	0.442	0.266	0.318	0.219	0.301	0.241	0.161
R^2 (adjusted)	0.279	0.311	0.172	0,299	0.120	0.212	0.141	0.050
F-value	4.99	6.22	2.85	4.11	2.21	3.38	2.41	1.45

Note: 1) Regression coefficients with *, **, or *** are statistically significant at the 10%, 5%, or 1% level, respectively.
2) Total factor payments,
3) Salinity dummy is not included.

Table 6.10. Factors affecting rice yield per hectare, 1987/1988 maha: Summary of regression analyses[1].

Regression No.	1	2	3	4
Sample size	108	108	62	62
D-canal dummy:				
DC 5	527*	507"	271	-157
DC 8	-435	-141	-465	-676*
Location dummy:				
Middle	-140	-203	-226	-381
Tail	-261	-243	-130	-123
Soil-type dummy:				
Intermediate	-332	-284		
Poorly drained	-564***	-423"	-385'	-191
Salinity:				
Dummy		-792**		
% affected			-38"	-36*
Tenancy dummy:				
Owner operator				-209
Fertilizer:				
N				7
P				29**
K				-42
Non-fertilizer cost[2]				0.01
Intercept	4110	4121	4211	4497
R^2	0.147	0.201	0.252	0.352
R^2 (adjusted)	0.096	0.145	0.170	0.193
F-value	2.90	3.60	3.09	2.22

Note: 1) The yield data are from the crop-cut survey. Regression coefficients with *, **, or *** are statistically significant at the 10%, 5%, or 1% level, respectively.

2) Total factor cost less fertilizer cost.

Table 6.11. Sources of credit for and amount borrowed by sample farmers.[1]

	Institutional (bank loan)	Informal		Total
		With interest	Without interest	
1987/1988 maha:				
Sample size 61(100)				
Non-borrower 12(20)				
Borrower	43(70)	19(31)	24(39)	43(70)
Average amount borrowed per farmer (Rs)	3495	1095	1389	2484
Typical interest rate (%/season)	4.5	60.0	0	
1988/1989 maha:				
Sample size 32(100)				
Non-borrower 5(16)				
Borrower	18(56)	7(22)	10(31)	17(53)
Average amount borrowed per farmer (Rs)	2234	845	975	1820
Typical interest rate (%/season)	4.5	63.0	0	
1989 yala:				
Sample size 55(100)				
Non-borrower 17(31)				
Borrower	15(27)	14(25)	16(29)	28(51)
Average amount borrowed per farmer (Rs)	1148	989	1555	2544
Typical interest rate (%/season)	4.5	60.0	0	

Note: 1) Figures in parenthesis are percentage of the total samples.

Table 6.12. **Cross** revenue, factor payments and gross value added per hectare, farm income **per** hectare, and labor productivity in rice production, 198111988 maha and average for three seasons studied, Kirindi Oya.[1]

	1987/88 maha		1988189 maha		1989 yala		Average
	Current prices (Rs/ha)	Paddy equivalent'! (kg/ha)	Current prices (Rs/ha)	Paddy equivalent[2] (kg/ha)	Current prices (Rs/ha)	Paddy equivalent': (kg/ha)	Paddy equivalent[2] (kg/ha)
Gross revenue	14 351	3 747	32 410	6 816	30 202	4 h91	5 107
(Output)	(100)	(100)	(100)	(100)	(100)	(100)	(100)
Factor paynent:							
Current input	3 335	871	2 631	551	2 702	420	616
	(23)	¡ 23)	[8)	(8)	(9)	(9)	(12)
Fixed capital	1 612	437	I 694	359	1 758	273	356
	(12)	(12)	(5)	(51	(6)	(6)	(7)
tabor: Family[3]	2 636	688	2 674	561	1 855	288	514
	(18)	(18)	(8)	¡ 8)	(6)	(6)	(10)
Hired	3 313	881	4 491	951	4 709	732	855
	1241	(24)	(14)	(14)	(16)	(16)	(17)
Total	6 009	1 569	*1* 171	1 519	6 564	1 021	1 369
	(42)	(42)	(221	(221	(22)	(22)	(27)
Land[4]	3 214	839	I 530	324	3 976	618	594
	(22)	(22)	(5)	(51	(13)	(13)	(12)
Operator surplus	121	32	!9 444	4 119	15 202	2 364	2 172
	(1)	(1)	I 60)	(60)	(50)	(50)	(43)
Gross value added	11 016	2 876	29 841	6 324	*21* 500	4 277	4 491
	(77)	(77)	(92)	(921	(91)	(91)	(88)
Farmers' income[5]:							
Unadjusted	5 971	I 559	23 651	5 011	21 033	3 271	3 280
	(42)	(42)	(731	(73)	(70)	(70)	(64)
Interest adjusted!)	5 151	1 346	23 061	4 886	20 143	3 133	3 122
	(361	(361	(611	(61)	(67)	(67)	(61)
tabor productivity	112	29	303	64	336	52	48

Note:1) The factors owned by farmers are imputed at the respective market prices. Figures in parenthesis are factor shares or percentage of the gross revenue.
2) Nominal value deflated by rice (paddy) price at the farm gate.
3) Includes exchange labor after imputed at the market wage rates.
4) Land rent, paid or imputed.
5) Assume that farmers are owner-operator. Family labor t Land t Operator surplus.
6) Interest payments for production loans are deducted, assuming the production loans from institutional and informal sources and respective interest rates as shown in Table 6.11.

Table 6.13. Market prices used for analysis.

1987/1988 maha		Interest rate (%/season)	
		Institutional	4.5
Rice(paddy) price (Rs/kg)	3.83	informal	60
Seed(paddy) price (Rs/kg)	5.80	Wage rate (Rs/day):	
Fertilizer (Rs/50kg bag):		Land preparation	41
V1	150	Planting	41
Urea	150	Fertilizer application	40
TDM	150	Weeding: Male	62
Tractor rental rate (Rs/ha):		Female	34
Land preparation	1168	Harvesting Male	49
Post harvest	503	Female	43
Land rent (Rs/ha)	3214	Post harvest	64

1987/1988 maha		Interest rate (%/season)	
		Institutional	4.5
Rice(paddy) price (Rs/kg)	4.72	informal	63
Seed(paddy) price (Rs/kg)	6.36	Wage rate (Rs/day):	
Fertilizer (Rs/50kg bag):		Land preparation	66
V1	192	Planting	65
Urea	192	Fertilizer application	76
TDM	199	Weeding: Male	85
Tractor rental rate (Rs/ha):		Female	64
Land preparation	1657	Harvesting Male	66
Post harvest	780	Female	55
Land rent (Rs/ha)	1540	Post harvest	85

1989 yala		Tomato		1,550
		Soy bean		14.0
Output prices (Rs/Kg):		Long bean		400
		Okra		250
Rice (Paddy)	6.40	Green gram		32.0
Chili; Green	11.1			
Dried; Grade 1	69.1	Fertilizer (Rs/50 Kg):		
Grade 2	44.4	Urea		195
Grade 3	35.0	TDM		190
Red onion	9.62	Mixture for OFC		200
Bombay onion	18.6	Tractor rental rate for land		
Green gram	27.5	preparation (Rs/ha)		I,272
Okra	4.52	Wage rates (Rs/day):		
Tomato	7.29	Land preparation;	Male	51
Soy bean	7.50		Female	42
Long bean	6.00	Planting;	Male	51
			Female	37
Input prices:		Chemical application;	Male	50
			Female.	42
Seeds (Rs/kg);		Harvesting;	Male	50
Chili	380		Female	42
Red onion	12.6		Child	28
Bombay onion	1,000	Land rent (kg in paddy/ha)		1,050

Table 6.14, Yieids, labor requirements, and costs and returns of selected non-rice crops grown under irrigated conditions in the dry zone of Sri tanka in 1985 yala.[1)]

Crop Region	Chili Batticaioa	Red onion Jaffna	Bombay onion Kataie	Green gram Anuradhapura	Soy bean Kalawewa
Yield (t/ha)	1.58	12.16	5.58	0.86	1.58
Price (Rs/Kg)	48.00	6.12	11.18	16.68	7.98
tabor (days/ha)					
Family	166(27)	141(26)	584(83)	165(94)	134(72)
Hire	460(73)	400(74)	120(17)	11(6)	52(28)
Total	626(100)	541(100)	704(100)	176(100)	186(100)
Gross revenue (Rs 1000/ha)	75.84(100)	81.71(100)	62.38(100)	14.30(100)	12.64(100)
Factor payment (Rs 1000/ha)					
Current inputs:					
Seeds	0.301 0)	33.56(41)	0.67(1)	0.49(3)	0.67(51
Fertilizer	2.59(3)	8.12(10)	1.90(3)	0.82(6)	0.28(2)
Chemical	3.00(4)	4.39(51	0.95(2)	0.86(6)	0.46(4)
Total	5.89(8)	46.07(56)	3.52(6)	2.17(15)	1.41(11)
Fixed capital	4.951 7)[2)]	7.37(9)[2)]	6.13(10)[2)]	0.81(6)	1.201 9)
Labor: Family	5.68(7)	5.09(6)	14.86(24)	5.93(41)	4.11(33)
Hired	13.58(18)	12.66(15)	2,891 51	0.41(3)	1.58(13)
Total	19.26(25)	17.75(22)	17.75(28)	6.34(44)	5.691 45)
Land & surplus	45.141 60)	10.52(13)	34.98(561	4.98(35)	4,341 34)
Value added (Rs/1000/ha)	69.95(92)	35.64(44)	58.86(94)	12.13(85)	11.23(89)
Farmers' income (Rs 1000/ha)	51.42(68)	15.61(19)	49.84(80)	10.91(76)	8.45(67)
Area planted (ha)	0.44	0.13	0.11	0.13	0.19
Actual farmers' income (Rs 1000/farm)	22.62	2.03	5.48	1.46	1.61
Labor productivity (Rs/ha)	121	151	88	81	68

Note: 1) For variable definitions, see table 6.02.
2) Include power for irrigation.

Source: Department of Agriculture (1986)

Table 6.15. Yields labor requirements, and costs and returns of selected non-rice crops grown under irrigated conditions in the dry zone of Sri Lanka in 1986 yala.[1)]

Crop Region	Chili hnuradhapura	Red onion Batticaloa	Bombay onion Kalawewa	Green gram Polonnaruwa	Soy bean Matale
Yield (t/ha)	1.46	10.06	7.38	0.92	2.00
Price (Rs/kg)	24.26	9.33	11.09	19.66	9.48
Labor (days/ha):					
Family	417(74)	242(29)	408(74)	174(76)	69(46)
Hired	149(26)	602(71)	144(26)	55(24)	80(54)
Total	566(100)	844(100)	552(100)	229(100)	149(100)
Gross revenue (Rs 1000/ha)	35.35(100)	93.81(100)	81.81(100)	18.12(100)	18.97(100)
Factor payment (Rs 1000/ha):					
Current inputs:					
Seeds	0.43(1)	14.20(15)	1.18(1)	0.55(3)	0.59(3)
Fertilizer	1.96(6)	5.94(6)	2.63(3)	0.61(3)	0.28(1)
Chemical	1.88(5)	2.97(3)	1.46(2)	1.76(10)	0.64(3)
Total	4.26(12)	23.11(25)	5.27(6)	2.92(16)	1.51(8)
Fixed capital	1.54(4)	4.14(4)[2)]	2.01(2)	1.53(8)	2.49(13)
Labor: Family	14.72(42)	8.44(9)	16.48(20)	7.36(41)	1.55(8)
Hired	5.09(14)	20.86(22)	5.89(7)	2.29(13)	2.11(11)
Total	19.81(56)	29.30(31)	22.36(27)	9.65(53)	4.60(24)
Land & surplus	9.74(28)	37.26(40)	52.17(64)	4.02(22)	11.31(60)
Value added (Rs 1000/ha)	31.09(88)	70.70(75)	76.55(34)	15.19(84)	17.46(92)
Farmers' income (Rs 1000/ha)	24.46(69)	45.70(49)	68.65(84)	11.37(63)	13.42(71)
Area planted (ha)	0.23	0.15	0.16	0.21	0.43
Actual farmers' income (Rs 1000/farm):	5.63	6.86	10.99	2.39	5.77
Labor productivity (Rs/day)	62	111	148	79	127

Note: 1) For variable definitions, see the notes to Table 6.02
2) Include power for irrigation,

Source: Department of Agriculture (1987).

Table 6.16. Yields, labor requirements, and costs and returns of selected non-rice crops grown under irrigated conditions in the dry zone of Sri Lanka in 1987 yala.[1]

Crop Region	Chiii Kalaueua	Red onion Puttalan	Bombay onion Matale	Green gram Kandy	Soy bean Anuradhapura
Yield (t/ha)	1.23	10.78	5.44	1.03	1.64
Price (Rs/kg)	35.10	10.54	10.09	10.96	7.54
Labor (days/ha)					
Family	242(66)	99(23)	425(78)	157(79)	141(76)
Hired	122(34)	333(77)	117(22)	41(21)	45(241
Total	364(100)	432(100)	542(100)	198(100)	186(100)
Cross revenue (Rs 1000/ha)	43.17(100)	113.64(100)	54.90(100)	11.26(100)	12.35(100)
Factor payment (Rs 1000/ha)					
Current inputs:					
Seeds	0.42(1)	21.99(19)	1.96(4)	0.71(6)	0.70(6)
Pertilieer	2.25(5)	6.32(6)	2.45(4)	0.61(5)	0.79(6)
Cheoical	2.20(5)	0.65(1)	2.07(4)	0.68(6)	0.55(4)
Total	4.87(11)	28.96(25)	6.48(12)	2.00(18)	2.04(17)
Fixed capital	1.69(4)	6.69(6)[2]	12.71(23)[2]	0.94(8)	2.46(20)
Labor: Family	9.74(23)	4.14(4)	14.54(26)	5.12(45)	5.78(47)
Hired	4.95(11)	13.92(12)	3.92(7)	1.40(12)	1.77(14)
Total	14.69(34)	18.06(16)	18.46(34)	6.52(58)	7.55(61)
Land & surplus	21.92(51)	59.93(53)	17.25(31)	1.80(16)	0.30(2)
Value added (Rs 1000/ha)	38.30(89)	84.68(75)	48.42(88)	9.26(82)	10.31(83)
Farmers' income (Rs 1000/ha)	31.66(73)	64.07(56)	31.79(58)	6.92(61)	6.08(49)
Area planted (ha)	0.30	0.50	0.15	0.23	0.28
Actual farmers' income (Rs 1000/farm)	9.50	31.91	4.77	1.59	1.70
Labor productivity (Rs/day)	119	263	101	57	66

Nate: 1) For variable definitions, see Table 6.02.
2) Include power for irrigation,

Saurce: Department of Agriculture (1988).

Table 6.11. Yields, labor requirements, and casts and returns of selected non-rice craps grown under rainfed conditions during the oaha season in the dry zone of Sri Lanka.[1]

Crop / Region / Season	Green gram Anuradhapura 1985/86 maha	Green gram Anuradhapura 1986/87 naha	Soy bean Matale 1985/86 maha	Soy bean Matale 1986/87 maha	Cowpea Ampara 1985/86 oaha	Cowpea Anuradhapura 1986/87 maha
Yield (t/ha)	0.75	0.80	1.04	1.47	0.15	0.19
Price (Rs/ha)	16.94	14.41	5.93	6.65	11.61	10.28
tabor (days/ha):						
Familg	1501 911	165(94)	60(54)	61(59)	191(83)	166(91)
Hired	14(9)	11(6)	52(46)	42(41)	40(17)	16(9)
Total	164(100)	176(100)	112(100)	103(100)	231(100)	182(100)
Gross revenue (Rs 1000/ha)	12.74(100)	11.59(100)	6.16(100)	9.78(100)	8.74(100)	8.07(100)
Factor payment (Rs 1000/ha):						
Current inputs						
Seeds	0.51(4)	0.53(5)	0.58(9)	0.55(6)	0.24(3)	0.23(3)
Fertilizer	0.96(8)	0.96(8)	0.06(1)	- (-)	0.24(3)	0.36(4)
Chemicals	- (-)	- (-)	- (-)	- (-)	0.15(2)	- (-)
Total	1.47(12)	1.49(13)	0.64(10)	0.55(6)	0.63(7)	0.59(7)
Fixed capital	- (.)	- (-)	1.37(22)	1.05(11)	0.84(10)	- (-)
tabor: Family	5.31(42)	6.15(53)	1.84(30)	2.11(22)	5.73(66)	6.21(77)
Hired	0.47(41	0.41(4)	1.58(26)	1.47(15)	1.20(14)	0.58(7)
Total	5.78(45)	6.56(57)	3.42(56)	3.58(37)	6.93(79)	6.79(84)
Land & surplus	5.491 431	3.54(31)	0.73(12)	4.60(47)	0.34(4)	0.69(9)
Value added (Rs 1000/ha)	11.27(88)	10.10(87)	5.52(90)	9.23(94)	8.11(93)	1.481 93)
Farmers' income (Rs 1000/ha)	10.80(85)	9.69(84)	2.57(42)	6.71(69)	6.07(69)	6.90(86)
Area planted(ha)	0.14	0.23	0.73	0.65	0.35	0.45
Actual farmers'income (Rs 1000/farm)	1.51	2.23	1.88	4.36	2.12	3.11
Labor productivity (Rs/day)	78	66	55	95	38	44

Note: 1) For variable definitions, see Table 6.02

Source: Department of Agriculture (1987 and 1988).

Table 6.18. Area planted with non-rice crops of selected demonstration farms, by crop and by farm, Kirindi Oya, 1989 yala.

Farm No.	Chilli	Red onion	Bombay onion	Green gram	Okra	Tomato	Soy bean	Long bean
	(ha)							
1[a]	0.215	0.025						
2	0.176	0.089			0.042			0.004
3	0.362							
4	0.346							
5	0.319		0.027	0.143	0.055			
6	0.230							
7	0.749							
8	0.357				0.030	0.015		
9	0.554	0.009	0.003		0.037			
10	0.437							
11	0.326	0.008	0.011					
12	0.654	0.089						
13	0.333							
14	0.338			0.019				
15	1.054		0.231	0.064				
16	0.778	0.061	0.001	0.173	0.082		0.194	
Total number of farmers								
	16	6	5	4	5	1	1	1
Average area planted (ha)								
	0.452	0.047	0.055	0.100	0.049	0.015	0.194	0.004

Note: a) This farmer was out of the demonstration program in the 1989 yala season, but he was in the 1988/89 maha demonstrations.

Table 6.19. Yields, labor requirements, and costs and return of selected non-rice crops under irrigated condition in Kirindi Oya in 1989 yala. a)

	Chili	Red onion	Bombay onion	Green gram	Okra	Soy bean	Long bean	Tomato
Yield (t/ha)	1.25c)	7.65	12.64	0.65	1.67	0.18	18.57	27.0
Price (Rs/kg)	67.37d)	9.62	18.78	27.89	4.52	7.50	6.00	1.29
Labor (days/ha):								
Family e)	473(65)	416(61)	509(88)	138(51)	1501 74)	44(31)	3881 98)	7371 86)
Hired	258(35)	261(39)	70(12)	135(49)	53(26)	99(69)	9(2)	116(14)
Total	731(100)	677(100)	580(100)	273(100)	203(100)	143(100	397(100)	853(100)
Gross revenue (Rs 1000/ha)	85.33(100)	73.79(100)	237.4(100)	18.19(100)	7.55(100)	1.35(100)	111.411001	193,511001
Factor payment (Rs 1000/ha):								
Current inputs:								
Seeds	0.561 1)	14.61(20)	13.13(6)	2.89(16)	1.05(11)	0.50(37)	1.14(1)	3.04(21
Fertilizer	3.221 4)	0.77(1]	1.02(0)	- (-)	0.09(1)	- (-)	3.75(3)	4.18(21
Chemical	2.68(3)	1.21(2)	2.61(1)	0.48(31	0.59(6)	0.231171	2.37(2)	1.531 1)
Fuel	0.36(0)	0.31(0)	0.331 0)	0.37(2)	0.23(3)	0.18(13)	0.241 0)	0.14(0)
Total	6.82(8)	16.90(23)	17.09(7)	3.74(21)	1.821 2Ci	0.92(681	7.50(7)	8.69(4)
Fixed capital	1.961 21	1.18(2)	1.94(1)	1.40(81	0.521 6)	0.77(511	1.38(1)	0.69(0)
Labor: Family	21.76(25)	20.78(28)	25.34(11)	6.48(36)	9.14(99)	2.23(165)	19.46(17)	35.841 19)
Hired	14.521 17)	13.211 18)	3.50(1)	6.84(381	0.50(5)	5.18(383)	0.40(0)	5.71(3)
Total	36.281 42)	34.06(46)	28.84(12)	13.32(73)	9.64(105)	7.41(548)	19.86(18)	41.55(21)
Land & surplus	40.27(47)	21.701 291	189.5(80)	-0.261 -1)	-2.79(-30)	-7.74(-573)	82.70(74)	142.6(74)
Value added (Rs 1000/ha)	18.511 92)	56.811. 77)	220.31 931	14.46(79)	1.371 80)	0.43(32)	103.9(93)	184.3(96)
Farmers' income (Rs 1000/ha)	62.03(73)	42.48(58)	214.9(91)	6.21(341	6.35(69)	-5.51(-408)	102.2(92)	178.4(92)
Labor productivity (Rs/day)	111	109	409	67	46	9	281	227

Note: a) For variable definitions, see Table 6.02.
c) Dry chili equivalent.
d) Dry chili price; weighted average for three grades
e) Include exchange labor.

Table 6.20. Yields and factor shares in irrigated sugar cane production, Sevanagala, Uda Walawe, 1986-1989.

	Plant cane	1st ratoon	2nd ratoon	Average
Yield (mt/ha)	154	143	120	139
Price of cane (Rs/mt)	500	500	500	500
Gross revenue (Rs/ha)	77 000(100)	71 500(100)	60 000(100)	69 500(100)
Factor payment (Rs/ha):				
Current inputs	8 603(11)	4 882(7)	3 799(6)	5 560(8)
Fixed capital	15 752(21)	8 423(12)	7 393(12)	10 425(15)
Labor: Family	4 974(6)	3 243(5)	1 591(3)	3 475(5)
Hired	16 192(21)	17 436(24)	14 051(23)	15 985(23)
Total	21 166(27)	20 679(29)	15 642(26)	19 460(28)
Land and surplus	31 474(41)	37 516(52)	33 166(55)	34 055(49)
Gross value added (Rs/ha)	68 397(89)	66 618(93)	56 201(94)	63 940(92)
Farmers income (Rs/ha)	36 448(47)	40 759(57)	34 757(58)	37 530(54)
Area cultivated (ha)	0.73	0.73	0.75	0.73
Actual farmers income (Rs/farm)	26 607	29 754	26 068	27 397
Labor requirement (days/ha)	332	230	209	260
Labor productivity (Rs/day)	232	299	287	267

Source: Data are from Sugarcane Research Institute.

Table 6.21. Comparison between rice and selected non-rice crops; profitability, and requirements for irrigation, labor and capital.[a]

	Chili	Red onion	Gherkin	Sugar cane[b]	Green gram	Soybean	Cowpea	Rice Kirindi Oya 87/88 maha	Rice Kirindi Oya Average[k]
Crop duration [c] (days)	200	90	100	300-400	85	90	85	90 - 120	
Irrigation frequency [c] (days)	6	3-4	3-4	-	7-10	10	7-10	-	
Number of irrigation [c]	20	20	20	-	7	7	5	-	
Water duty [d] (mm)	500-700	600-800	700	1000-1500	250-450	250-450	200-400	600-1500	
Yield [e] (mt/ha)	1.2	10.00	6.5	139	1.0	1.5	1.0	3.7	5.0
Price [f] (Rs/kg)	67.00	9.00	11.7	5.00	20.00	8.00	12.10	3.83	6.40
Value added [g] (Rs 1000/ha)	72	72	52	32	17	11	11	11	27
Farmers' income [g] (Rs 1000/ha)	56	54	41	19	12	7	7	6	21
With 50% price decline [h]:									
Value added	32	27	14	29	7	5	5	-	-
Farmers' income	16	9	11	3	2	1	1	-	-
Labor requirement [i] (days/ha)	700	600	800	260	220	170	290	128	108
Labor productivity	115	150	95	267	91	71	42	111	296
Capital requirement [j] (Rs 1000/ha)	23	35	35	16	7	3	3	8	12

Note: a) Except gherkin, data are from Tables 6.12, 6.18, and 6.20. Data on gherkin are from Gleason (1990).

b) Averages for plant cane, 1st and 2nd ratoons. In order to make the data comparable to other seasonal crops, for the rows on and below "value added", figures shown are in terms of average for six months.

c) Data are from Somasiri (1981).

d) Rough estimates based on Dimantha (1987) and Somasiri (1981).

e) Average or typical yield, from previous tables in this section and Table 5.11 of the Interim Report.

f) For non-rice crops, typical prices in the 1989 yala season.

g) Obtained assuming typical value added ratio and farmer income ratio for the crops.

h) Value added and farmers' income per hectare when the output prices declined 50%.

i) Average or typical labor requirements.

j) The summation of costs of current inputs, fixed capital services, and hired labor.

k) Average yield over the past three seasons and 1989 yala prices are assumed.

Table 6.22. Labor use for hectare for selected crops by type of labor, Kirindi Oya, 1989 yala.

	Male	Female	Child	Total
Chilli				
Family	277(59)	178(37)	18(4)	473(100)
Hired	178(69)	74(29)	6(2)	258(100)
Total	455(62)	252(34)	24(3)	731(100)
Red Onion				
Family	384(92)	32(8)	-(-)	416(100)
Hired	207(79)	37(14)	17(7)	261(100)
Total	591(87)	69(10)	17(3)	677(100)
Bombay onion				
Family	462(91)	48(9)	-(-)	510(100)
Hired	69(99)	1(1)	-(-)	70(100)
Total	531(92)	49(8)	-(-)	580(100)
Green gram				
Family	89(64)	49(36)	-(-)	138(100)
Hired	135(100)	-(-)	-(-)	135(100)
Total	224(82)	49(18)	-(-)	273(100)
Okra				
Family	115(77)	35(23)	-(-)	150(100)
Hired	49(92)	4(8)	-(-)	53(100)
Total	164(81)	39(19)	-(-)	203(100)
Rice				
Family	49(85)	8(14)	1(1)	58(100)
Hired	59(85)	11(15)	0(0)	70(100)
Total	108(84)	19(15)	1(1)	128(100)

Table 6.23. Labor use per hectare (days/ha) in non-rice crop production, Kirindi Oya, on-farm demonstration, 1989 yala.

	Chili	Red onion	Bombay onion	Green gram	Okra	Soy bean	Long bean	Tomato
Land preparation								
Family	51(50)	70(50)	92(76)	21(33)	48(57)	27(44)	40(82)	67(37)
Hired	50(50)	69(50)	29(24)	43(67)	36(43)	35(56)	9(18)	116(63)
Total	101(100)	139(100)	121(100)	64(100)	84(100)	62(100)	49(100)	183(100)
Crop establishment								
Family	22(61)	89(51)	143(89)	43(69)	16(89)	7(39)	9(100)	41(100)
Hired	14(39)	87(49)	18(11)	19(31)	2(11)	11(61)	0(0)	0(0)
Total	36(100)	176(100)	161(100)	62(100)	18(100)	18(100)	9(100)	41(100)
Crop care								
Family	166(65)	78(70)	151(87)	49(51)	58(79)	10(20)	98(100)	82(100)
Hired	91(35)	34(30)	23(13)	48(49)	15(21)	40(80)	0(0)	0(0)
Total	257(100)	112(100)	174(100)	97(100)	73(100)	50(100)	98(100)	82(100)
Harvesting								
Family	178(64)	178(71)	124(100)	17(40)	28(100)	0(0)	241(100)	547(100)
Hired	98(36)	71(29)	0(0)	26(60)	0(0)	13(100)	0(0)	0(0)
Total	276(100)	249(100)	124(100)	43(100)	28(100)	13(100)	241(100)	547(100)
Post harvesting								
Family	56(90)	0(0)	0(0)	8(100)	0(0)	0(0)	0(0)	0(0)
Hired	6(10)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Total	62(100)	0(0)	0(0)	8(100)	0(0)	0(0)	0(0)	0(0)
Total								
Family	473(65)	416(61)	510(88)	138(51)	150(74)	44(31)	388(98)	737(86)
Hired	258(35)	261(39)	70(12)	135(49)	53(26)	99(69)	9(2)	116(14)
Total	731(100)	677(100)	580(100)	273(100)	203(100)	143(100)	397(100)	853(100)

Table 6.24. Current and alternative cropping patterns in Kirindi Oya.[a]

		Cropping intensity		
		Maha	Yala	Total
I.	Current situation			
	Old area[b]	Rice 90%[c]	Rice 40%	1.3
	New area I[d]	Rice 90%	Rice 20%	1.1
II.	Rice-rice with equal water distribution between old and new areas			
	Old area	Rice 90%	Rice 30%*	1.2
	New area I	Rice 90%	Rice 30%*	1.2
III.	Rice-OFC[e] for old and new areas			
	Old area	Rice 90%	OFC 60%*	1.5
	New area I	Rice 90%	OFC 60%*	1.5
IV.	OFC-OFC for the entire new area and OFC-rice for old area[f]			
	Old area	OFC(rainfed) 100%	Rice 90%	1.9
	New area I+II[g]	OFC(rainfed) 100%	OFC(irrigated) 70%*	1.7
V.	OFC-OFC for new area and rice-OFC for old area			
	Old area	Rice 90%	OFC 30%*	1.2
	New area I+II	OFC 100%	OFC 30%*	1.3
VI.	OFC-OFC for the entire system			
	Old area	OFC 100%	OFC 55%*	1.55
	New area I+II	OFC 100%	OFC 55%*	1.55
VII.	With 40% water saving, OFC first and then rice if water available[h]			
	Entire system	Rice 40%; OFC 60%	OFC 100%	2.0

Note:

a) For each alternative cropping pattern, the cropping intensity in the yala season (marked with *) is determined so as to utilize the quantity of water being consumed under the current situation, assuming that the water requirement of rice is twice as much as non-rice crops. Alternative II and III assume no cultivation in the new area which is forthcoming under phase II, whereas IV through VII assume that water will be diverted to the new area. For all alternatives except VII, water supply rate is assumed to be the same as under the current situation.

b) Old area; the area where irrigated paddy fields have existed since even before the phase I project; about 3,700 ha.

c) The maha season cropping intensity for rice is assumed to be 90% at the highest, based on the probability that it fails one out of ten years.

d) New area I; the area created by the phase I project; about 4,200 ha.

e) OFC; other field crops = non-rice crops.

f) Under this option, non-rice crops in the maha season assumed to be grown with rain and supplementary irrigation water at 50% of the full supply level for non-rice crops.

g) New area II; the area to be created under the phase II project; about 4,200 ha.

h) It is assumed that the irrigation water is over supplied at least 40% under the current situation, and that this excess water can be saved and diverted to irrigate additional area in the system. Such water saving makes it possible to plant rice in some parts of the system while keeping the yearly cropping intensity of 2.0.

Table 6.25. Assumptions for assessing returns from different cropping patterns and cropping intensity, Kirindi Oya.[a]

	Rice	Soy bean	Green gram	Chili	Red onion
Yield (t/ha):					
Irrigated	5.0	1.5	1.0	1.2	10.0
Rainfed (maha)	-	1.3	0.8	-	-
Price (Rs/kg)	6.40	8.00	20.00	67.00	9.00
Value added ratio:					
Irrigated	0.85	0.90	0.85	0.90	0.80
Rainfed (maha)	-	0.90	0.90	-	-
Value added (Rs 1000/ha)					
Irrigated	27.2	10.8	17.0	72.4	72.0
Rainfed	-	9.4	14.4	-	-
OFC cropping pattern:					
A. Soy bean-green gram		50%	50%		
B. Mixture[b]		45%	25%	23%	7%

Note:

a) Based on data in the previous section. The prices are for 1989.

b) The share of each crop is set assuming that the size of area planted with a certain crop is constrained by labor availability in the study area as indicated by the peak weekly labor requirement per hectare for rice production; one hectare allotment is divided into four clops according to the ratio of the rice weekly peak labor requirement to the weekly peak labor requirement of these crops.

Table 6.26. Changes in the total agricultural income generated in the Kirindi Oya System by alternative cropping patterns and intensity, at 1989 prices.[a]

	OFC cropping pattern A				OFC cropping pattern B			
	Old	New area		Total	Old	New area		Total
	area	Phase I	Phase II		area	Phase I	Phase II	
	---------- Rs million ----------							
I. Current situation (control)								
Total income	131	126	-	257				
II. Rice-rice with equal water distribution between old and new areas								
Total income	121	137	-	258				
Change	-10	11	-	1				
(% change)	(-8)	(9)		(0)				
III. Rice-OFC for old and new areas								
Total income	121	138	-	259	159	180	-	339
Change	-10	12	-	2	28	54	-	82
(% change)	(-8)	(10)		(1)	(21)	(43)	-	(32)
IV. OFC-OFC for new area and OFC-rice for old area[b]								
Total income	135	91	91	317	135	141	141	417
Change	4	-35	91	60	4	15	141	160
(% change)	(3)	(-28)		(23)	(3)	(12)		(62)
V. OFC-OFC for new area and rice-OFC for old area								
Total income	106	76	76	258	125	168	168	461
Change	-25	-50	76	1	-6	42	168	204
(% change)	(-19)	(-40)		(0)	(-5)	(33)		(79)
VI. OFC-OFC for the entire system								
Total income	80	90	90	260	177	201	201	579
Change	-51	-36	90	3	46	75	201	322
(% change)	(-39)	(-29)		(1)	(35)	(60)		(125)
VII. OFC-first and rice if water is available, with 40% water saving								
Total income	123	139	139	401	223	253	253	729
Change	-8	13	139	144	92	127	253	472
(% change)	(-6)	(10)		(56)	(70)	(101)		(184)

Note: a) Assumed cropping patterns and cropping intensities for alternative scenarios are given in Table 6.24. The rates of agricultural income (gross value added) to be generated are assumed as in Table 6.25.

b) For non-rice crops to be grown in the maha season under the semi-rainfed condition, soy bean (50%) and green gram (50%) are assumed.

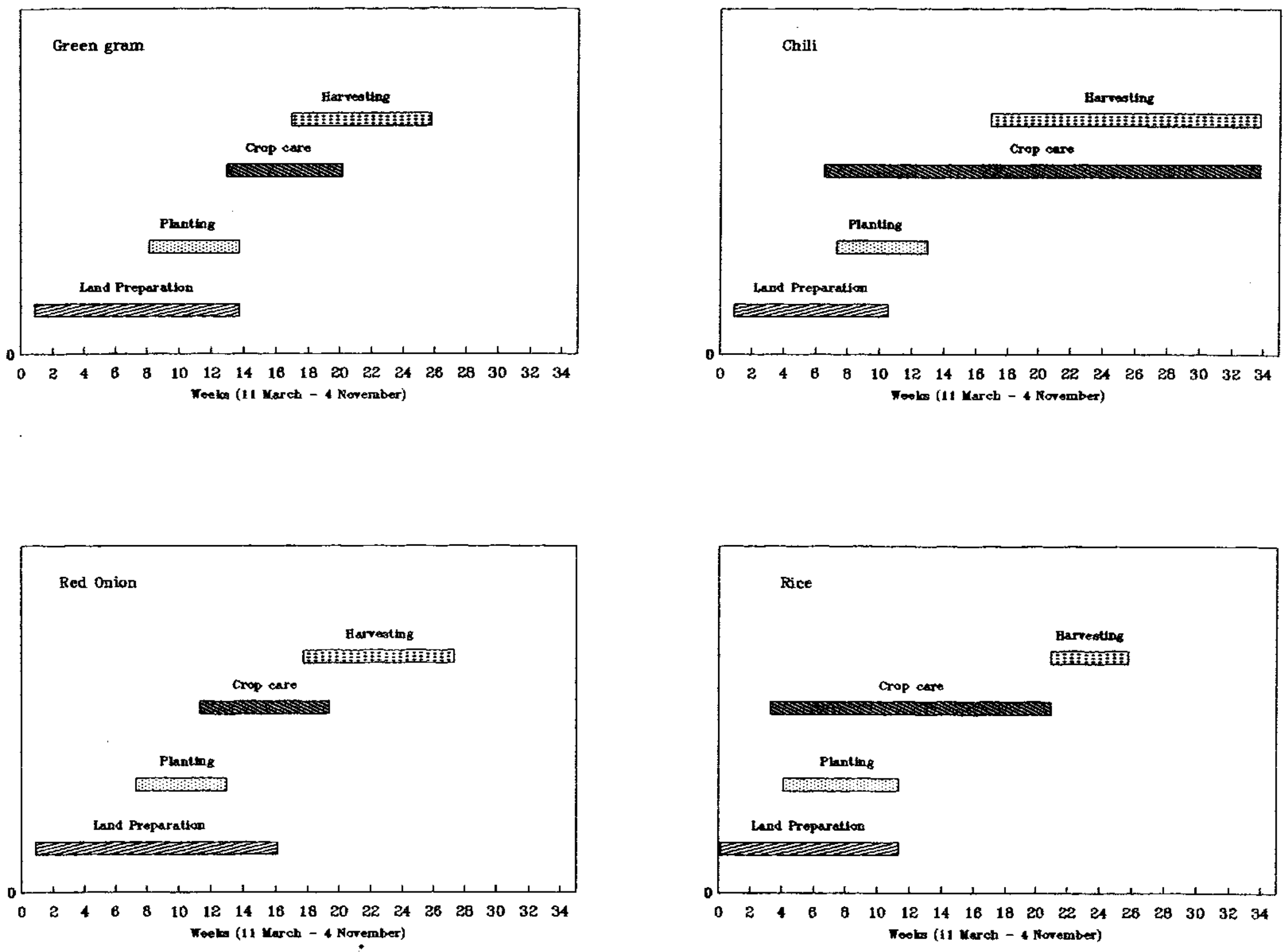


Figure 6.01 Crop calendar for rice and non-rice crops in 1989 yala, Kirindi Oya

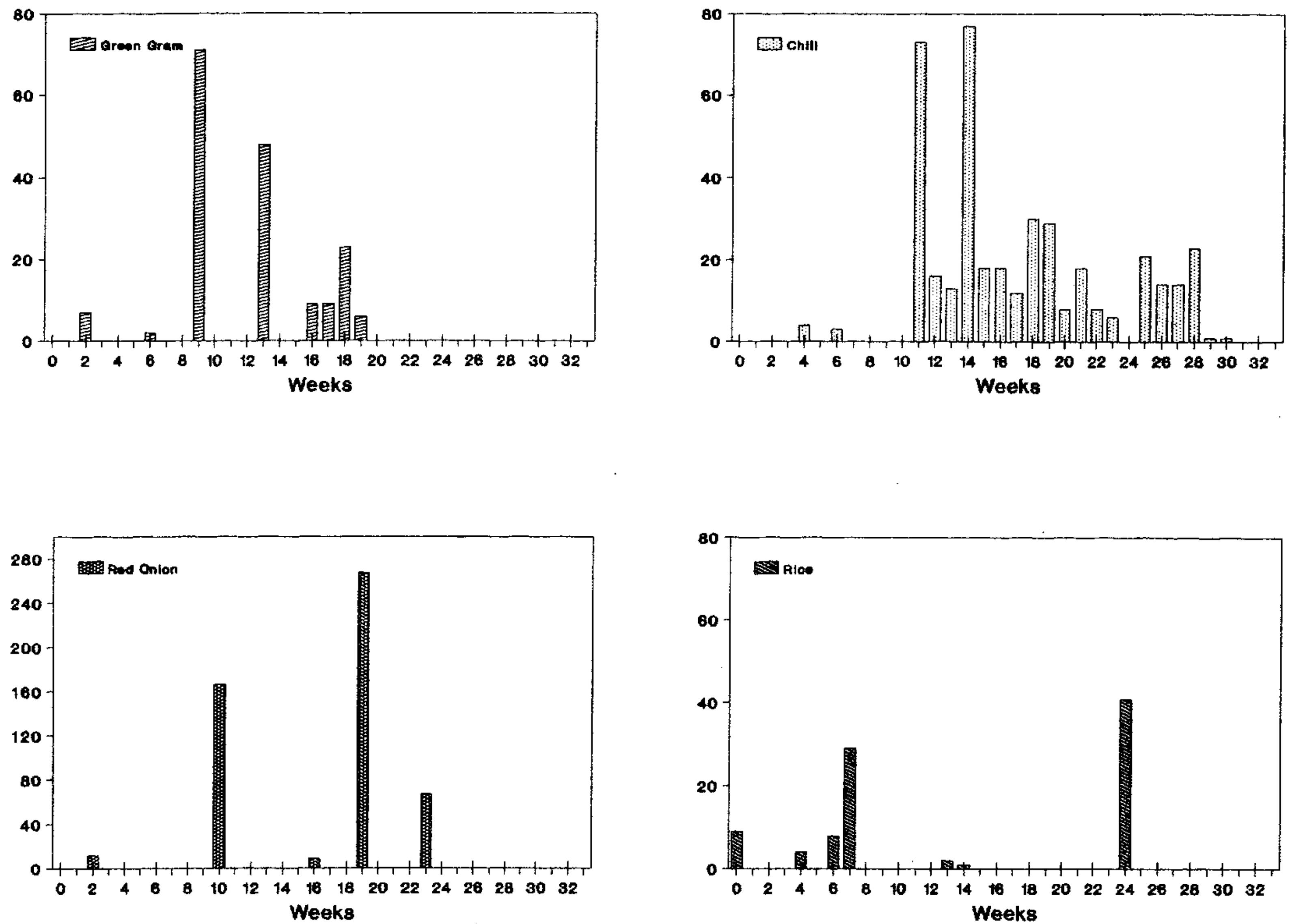


Figure 6.02 Weekly labor requirements per hectare, for rice and non-rice crops in 1989 yala, Kirindi Oya

CHAPTER VII

DEVELOPMENTS DURING MAHA 1989/1990

INTRODUCTION

This chapter discusses IIMI's findings during **maha 1989/1990 and** adds vigour and precision to the conclusions arrived at in our Draft Final Report. This season had some specific features compared to the previous seasons studied. The officers of the Irrigation Department, confronted again with the problem of allocation of water to various subsystems of the project, wanted to discuss with farmers their plans for water issues for the season beforehand. With this intention in mind a pre-kanna meting was summoned, as decided by the Subcommittee of the District Agricultural Committee, with the participation of the farmer representatives of the old and new systems in the project.

The Department's plan was to issue water to these systems in a way that guarantees maximum utilization of drainage water originating from tracts 1 and 2 left bank and tract 1 right bank. But this was not acceptable to fanners in the old area as they believed it would undermine their priority right to water and would tend to develop salinity in their paddy fields. Under the circumstances the meeting ended with the decision of prior water issues to farmers of the Ellegala system, who claimed that they had cultivated rice in the entire command area in both seasons without much difficulty before the construction of Lunugamwehera reservoir. The meeting proved counter-productive, as the arguments between farmer representatives of the two systems over water issues created a rift between the two communities, something which did not exist previously.

The water issues for the season commenced in the latter part of October 1989 with priority to Debarawewa and Tissawewa Tanks and subsequently, in the early part of November, to tracts 1 and 2 of the left bank, tract 1 of the right bank, Pannegamuwa and Weerawila Tanks, and later to tracts 2 and 5 of the right bank system and Yodawewa Tank. With the water issues to tract 1 in right bank on 2 November 1989, we undertook a study on the institutional aspect of water management in DC 5, tract 1. We paid particular attention to this canal because the O&M responsibilities had been handed over to a farmer organization, the first such attempt in the Kirindi Oya Project.

In the case of tracts 2 and 5 right bank, there was no likelihood of water issues as the water level in the reservoir was very low, at 49.40 m. (164.4 ft.) by first of November. But there was a demand for water issues for the season from the fanners in tracts 2 and 5 right bank after some rains marginally increased the water level in the reservoir. Though the risk involved in undertaking rice cultivation with a low reservoir was adequately informed to the farmers at the kanna meeting by Irrigation Department officials, farmers proposed to start the seasonal activities with water issues on 15 November 1989. According to the kanna meeting decision, water issues to these two tracts were made on 18 November 1989. Therefore, we continued with our research activities in DC 2 in tract 5 in addition to the research undertaken in DC 5 in tract 1.

However, since the expected inflow was not received in the reservoir, the water issues to tracts 2 and 5 right bank were stopped on 30 November after a discussion between the Government Agent, Hambantota and farmer representatives. About 50 percent of the farmers in tract 5 had completed first plowing as indicated in Figure 7.01 at the time when water issues to the area were stopped. *As* a result we could not continue our research activities in tract 5. Our research concentrated on DC 5 in tract 1.

BASIC FEATURES OF DC 5

DC 5 has a design capacity of 310 liters per second (l/s) (eleven cusecs). It had originally been designed to feed eleven field channels, eight originating from the distributary and three originating from a branch of the distributary (sub DC). However it was realized at the construction stage that the design is defective; hence the number of field channels under the canal was increased to twelve from the original eleven, but without increasing the design capacity of the distributary. FC 46A is the canal not included in the original design. The allotments presently under FC 46A had originally been designed to be fed from FC 46. In addition, the number of allotments under *some* field channels in the original design have either been increased or decreased after the construction of the canal system because some could not be fed from the planned field channel. Three allotments designed to be fed from FC 45 and four from FC 48 have now been included under FC 46 and FC 49 respectively. The number of allotments under *some* field channels has increased as a result of redefining the boundaries and allocating excess land to settlers. Since a new blocking out plan with all these modifications and additions has not yet been prepared, it is extremely difficult to know the extent of the command area with accuracy. Based on field observations *the* number of allotments under each field channel served by DC 5 and the extent of the command area as per the Irrigation Department schedules are given in Table 7.01.

The entire command area of 174.1 ha under DC 5 is considered as poorly drained (LHG soil) in the design even though about 50 percent is highland, i.e., well drained, with RBE soils according to our general field observations. Since the design duty for a distributary serving 100 percent LHG farms would be far less than one serving 50 percent LHG and 50 percent RBE soils, the canal design indicates a serious capacity constraints as discussed in chapter 4. In addition, the distributary serves eight very long field channels (serving more than 15 allotments); three of these serve 19 or more allotments.

In addition to these design defects, the field channels are poorly maintained; and some are highly deteriorated. Field channel bunds and reservations have been encroached by fanners to extend their allotments. Water losses in these field channels are very high and create problems for the tail-end farmers who are in a very disadvantageous position because of reduction of supply through leaks occurring at farm turnout gates in the up-stream even when they are closed. Another problem in the tail-end part of some canals, especially in FCs 49, 50, 52 and 53, is the existence of a very deep drainage canal known as Weerawila Ara. As a result of this deep drainage channel, the farmers are not able to retain water in their allotments because of the high rate of seepage.

Though the distributary as well as some field channels have capacity constraints resulting from poor design, there are location specific characteristics which minimize the impact of water shortage and scarcity in some canals, mainly in those which originate direct from the distributary. The command area of field channels located below the distributary and right bank main canal tend to develop high water tables by seepage contributions from the two canals. However, the field channels under the branch distributary running along a different ridge is not compensated much by seepage from the distributary or main canal.

A single bank canal like DC 5 located at a higher contour than its command area is subject to other problems. Highland runoff tends to damage the canal bunds, and increases canal seepage losses. In the case of DC 5, water losses occurring at drainage undercrossings at several places in the canal reduce the supply to tail-end field channels. However, the farmers under field channels originating directly from the distributary are benefited from this seepage water.

THE FARMING COMMUNITY IN DC 5

The farmers in DC 5 are relocatees who lived in the reservoir area prior to its construction. They have been settled in two hamlets located some 3 kms from each other. The land under FC 44 and 45 in the head have been allocated to settlers in Hamlet 2 while the land under FC 46 is owned by farmers in Hamlets 2 and 3. The land under the other 9 field channels is owned by farmers in Hamlet 3, located very close to the DC 5 command area. The agro-distance of settlers in Hamlet 2 is nearly 3 kms along the main highway, the only access to their fields after the commencement of cultivation.

Since 99 percent of the settlers had lived in adjacent localities in the Tissamaharama area and knew each other well before coming to settle, the pattern of social interaction among the settlers is similar to that of a purana village. A significant nunber of farmers under some field channels have close kinship relations. Almost all the fanners under DC 5 are permanently settled and have close interactions with the people in Tissamaharama, Pannegamuwa and Lunugamwehera.

CLIMATIC DATA

The daily rainfall and computed evapotranspiration (ET), based on measured pan evaporation data this season at Lunugamwehera in Tissamaharama for the period of 11 January to 30 March 1990 are given in Figure 7.02. The total rainfall for the study period in maha 1989/1990 is 334.6 mm. The long term average rainfall of the project area for the period of 1 November 1989 to 30 March 1990 is 257 mm.

The month-wise rainfall, number of rainfall occurrences per month and highest recorded monthly rainfall are presented for 1988, 1989 and 1990 seasons along with long terms averages in Table 7.02, Monthly rainfall occurrences for the season indicate a high variability with high monthwise rainfall in January and March. On the other hand, computed ET values as per Table 7.03 remain more or less the same as in the previous seasons studied.

SEEPAGE AND PERCOLATION

The measured average value of seepage and percolation over the season in tract 1 varied from 18.3 mm/day to 6.5 mm/day as indicated in Table 7.04. Allotment No. 751 showed high values ranging from 35.1 mm/day to 63.3 mm/day, while it was 0.3 mm/day to 18.1 mm/day in the lowland allotments studied. As in the case of DC 2 in tract 5, the measurements in DC 5 indicate wide variation and location specific nature.

INSTITUTIONAL FRAMEWORK FOR WATER MANAGEMENT

The organizational structure of the Department of Irrigation remained the same. As the construction work under phase II had been suspended the resident engineers were somewhat relaxed and could contribute more to O&M work in the respective canal system than in the past. DC 5 had been officially turned over to the farmers' organization: hence the Department expected it to take more responsibility for O&M. However, farmer leaders as well as farmers were not very aware of the new responsibilities bestowed on them by the turnover. In addition, about 60 percent of the farmers did not even know that DC 5 had been handed over to the farmers' organization; therefore they went to the office of the work supervisor to solve their irrigation problems; but he could not help as it was supposed to be managed by the president of the farmer organization.

To both the farmer representatives and the field level minor staff of the Irrigation Department, "handing over" mant that the president of the farmer organization is responsible for doing what was previouslydone by the Irrigation Department field level staff. The president, the key person of the organization, expected the Department to take action to pay him for the operational work he was doing "voluntarily" for the organization. In addition, there existed a tension between the work supervisor and the president of the farmer organization at the beginning; hence the president, who lacked technical knowledge of system operation, could not get the necessary guidance from him. The irrigators who are temporarily hired laborers felt that the handing over of canals would lead to the termination of their employment.

Because of the political and social disturbances prevailing during the land preparation period and for some time thereafter, the higher level officers of the Irrigation Department and the Irrigation Management Division project manager could not pay much attention to the incidents at the newly handed over canal, though they did intervene when the tension between the work supervisor and the president, and the president and farmers, became a problem for water management in the DC 5 area. The president had threats from the farming community who believed that the water shortage during some periods of land preparation occurred as a result of canal closures by Irrigation Department officials on wrong information given by the president. Though Department officials intervened and explained to fanners the reasons for the canal closure, the incident led to the leader's giving up all operational and other tasks he performed on behalf of the organization. After his resignation in early December, there was a period of nearly one mnth in which neither the Irrigation Department nor the organization was responsible for the operation of the canal. With the implementation of rotations in mid-January, the Irrigation Department assigned an irrigator to attend to the operation of this canal.

WATER MANAGEMENT DURING THE LAND PREPARATION PERIOD

Though IIMI started research on the institutional aspects of water management in DC 5 with the water issues to tract 1 on 2 November 1989, it was not accompanied by water measurements in the turnout areas because we expected to continue research on DC 2 in tract 5. We started water measurements only after the water issues to tract 5 were stopped. We did collect data on the progress of land preparation in all the field channels under the canal. In addition, we carried out an indepth study on the progress of land preparation in three field channels, FCs 44, 49 and 52, located in the head, middle and tail of the canal respectively, to identify the constraints associated with the delay in the progress of land preparation.

According to the cultivation calendar agreed upon at the kanna meeting, the first day of water issue was 2 November, while the last day for sowing was 2 December 1989. The Irrigation Department normally issues a limited supply to the right bank main canal at the beginning, instead of the full supply quantity of 2,256 l/s (80 cusecs) for land preparation in tract 1; it issues the full requirements based on field observations and the demand of fanners. In this season discharges from the right bank main sluice from 2 to 7 November was below 1,128 l/s (40 cusecs). This was increased to 2,256 l/s by 8 November.

In the case of DC 5, water did not reach the branch of DC 5 because it had not been cleaned by the day of water issues. The delay in canal cleaning occurred because the canal had been handed over to the farmers' Organization and the Department expected the organization to do canal cleaning. Though the president of the organization had arranged canal cleaning by hiring farmers for direct payment by the Department, they failed to clean the canal by the due date. The rest of the canal was cleaned both by hiring the farmers and through self-help campaigns organized by the president of the farmers' organization and the fanner representatives. As a result, there was a three day delay in supplying water to the branch of DC 5.

The discharge into the right bank main canal was reduced from 2,256 l/s to 1,128 l/s on 13 November to remove the coffer dam across the main canal below the cross regulator at the boundary of tracts 1 and 2, to issue water to tracts 2 and 5 for the season. This created a water shortage in DC 5 for two days. Similarly, the discharge was reduced to 479 l/s (17 cusecs) on 2 December and the canal was completely closed on 3 December. The discharge was again increased to 2,538 l/s (90 cusecs) on 5 December. DC 5 fanners experienced a shortage of water for a period of 5 days because of the reduction of discharge. Since the reduction was just after stopping of water issues to tracts 2 and 5, the farmers thought that the Irrigation Department had not put sand bags below the cross regulator between tracts 1 and 2 to stop leaks. In their view the rain received was insignificant. The rainfall figures for 2 and 3 December are

2.0 mm/day and 1.81 mm/day respectively. On this basis it can be argued that there was a shortage of water to DC 5 for a period of 10 days during the land preparation period.

Our interviews with farmers and farmer representatives revealed that the problems they encountered during the land preparation period were aggravated by the irregular canal operation by the canal leader. According to farmers and farmer representatives, the leader was particularly worried only about the shortage to his own canal and tried to solve the problems of those farmers on his canal. When the Irrigation Department operated the gate, the farmers were able to contact the work supervisor or irrigator and get the discharges to field channels increased if necessary. But the leader was busy with his own and other various community work, meetings, etc.; hence fanners could not meet him and get solutions to their water problems.

Our interviews with the leader also revealed that he did not know how to operate the distributary and field channel gates to maintain adequate water levels in field channels. The capacity constraints of the field channels, and lack of skills by the leader for operating the canal gates promoted a feeling among the farmers that the farmers' organizations cannot handle operation work. Since the distributary organization in Hamlet 3 did not hold regular meeting for security reasons, the management capacity of the organization in handling the new responsibility was further reduced.

FINDINGS ON THE PROGRESS OF LAND PREPARATION

The land preparation progress in maha 1989/1990 in DC 5 tract 1 right bank and FCs 44, 49 and 52 are shown in Figures 7.03 and 7.04. The following are the major observations:

1. A typical farmer in DC 5 takes about 3.0 to 4.0 weeks for completing land soaking and preparation from the day he receives water in his allotment to sowing, against 4.0 to 5.0 weeks by a typical farmer in tract 5.

2. The average number of days required by a farmer between the receipt of water and first plowing, between the first plowing and second plowing, between second plowing and puddling, and between puddling and sowing are 4 to 5 days , 9 to 14 days, 13 to 16 days, and 1 to 3 days respectively.

3. The total time required for 90 percent completion of sowing in DC 5 is 6 weeks from the date of first water issue. However 100 percent completion took nearly 7.5 weeks.

4. The rainfall received during the land preparation period (in November and December) was about 118 mm while rainfall in October just prior to the beginning of land preparation was 137.5 mm.

Our interviews with 77 percent of the farmers, 47 out of 61, in the three sample field channels have brought out the following as shown in Table 7.05:

1. Nearly 75 percent of the farmers (35 out of 47) reported that they have water problems. Four farmers out of the twelve who claimed that they have

no problem with water were found to be depending solely on drainage water for irrigating their allotments. The other eight fanners who had no water problem are from FC 44 in the head-end. Farmers of FCs 49 and 52 located respectively in tho middle and tail of the distributary complained of insufficient supply to the head of the field channels. It could be seen however that out of the 21 farmers interviewed in FC 52, 14 (67 percent) had access to drainage water, a significant factor compensating for scarcity. In the case of FC 49, only one out of 15 interviewed has access to drainage water. Both these canals (FCs 49 and 52) have more than 18 allotments under them and the canals are long and poorly maintained. Water leaks through the farm turnout gates even when they are closed reduce the supply to the tail allotments. In addition, canal losses by way of seepage are very high in FC 49 because of the dilapidated condition of the canal bund which has been encroached by fanners to extend their allotments.

2. We observed farmers in long field channels such as FCs 49 and 52 practicing rotations even during the land preparation period. The rotation in FC 49 was a three hour issue to each allotment twice a week. In FC 52 each farmers was allowed six hours issue for land soaking, reduced to four hours after first plowing. The entire flow in the canal is utilized by one farmer under these rotational arrangements initiated by field channel leaders. There were no rotational issues in FC 44 during the land preparation period. The fanners in FCs 49 and 52 adhered to these rotations as they cannot practice simultaneous sharing, as done by farmers of FC 44, because of the canal capacity constraints.

3. However, our data on the progress of land preparation do not indicate a significant variation between the water short and water abundant canals (Figure 7.04). Though water is a real constraint for farmers under FC 49, it was not by itself the major cause of delays. Other constraints, such as lack of farm power, credit, and labor imposed a stagger which overshadowed the impact of the canal capacity constraint. The data collected from 47 farmers in these three field channels on these aspects show that 41 farmers (87 percent) had to delay land prepration due to one or a combination of factors such as shortage of tractors, credit and labor. There are 35 cases (74 percent of the total sample) reporting delay due to lack of credit, 30 cases (64 percent) due to shortage of tractors, and 17 (36 percent) due to shortage of labor.

Over half, 24 out of 47, were not entitled to bank loans as they had failed to settle loans taken in previous seasons. A majority of farmers who had failed to settle loans are from FC 49; they attribute this to low yield due to scarcity of water. It should be noted, however, that two out of the six farmers who had no problem with input supply and farm power have still taken more than one month for land preparation. They are tail-end fanners of FC 52 who depend solely on the field channel for irrigating their allotments.

4. It is also noteworthy that there is a significant difference in farmers' perceptions about the duration of the lard preparation period, which ranges from 17 to 40 days under constraint free conditions, but is within

a period of one month in 90 percent of cases. But in actual practice it ranges between 22 to 41 days. Only 29 percent complete land preparation within 30 days. The Department of Agriculture recommends completion of land preparation within 20 to 25 days, but our data show that it is not possible because of various constraints faced by fanners.

WATER MANAGEMENT AFTER COMPLETION OF LAND PREPARATION

According to the Irrigation Department, the irrigation schedule was implemented from 29 November 1989. The implementation of the schedule implies a reduction of discharge to the distributary and field channels compared to the issues made during the land preparation period. Iherefore, the implementation of the schedule needs to be accompanied by field channel rotations. However, our field observations and interviews with field level officers of the Irrigation Department substantiate that the rotations were not implemented in any of the field channels under DC 5. When interviewed in the first week of January 1990, these field level officers informed us that operation of the canal is being handled by the president of the farmers' organization; hence they were not involved in operational activities in the distributary below the offtake. However, the leader had given up his responsibilities by 6 December 1989 as a result of conflicts with fanners over shortage of water.

Since our field level observations cannot be substantiated with water flow measurements at the time of implementation of the schedule, we cannot provide precise data on water deliveries. Our general field level observations, however, show that the Department continued to issue bankful discharges until 13 January 1990. As shown in Figure 7.03, the progress of land preparation in DC 5 up to the end of November 1989 is only 10 percent; hence we strongly doubt the schedule could have been implemented by this day without affecting the progress of land preparation.

The field channel rotations in DC 5 commenced on 14 January 1990 with the involvement of an irrigator hired by the Department. The Irrigation Department also started current metering and measuring S&P in the DC 5 area during this period under the supervision of the senior irrigation engineer (water management). Our water flow measurement starting on 10 January 1990 indicates a reduction of supply from 13 January 1990 as shown in Figure 7.05. However Figures 7.05 and 7.06 on target and actual deliveries do not indicate the implementation of rotations in the strict sense, though reduction of discharges to some field channels are observable.

With the exception of some tail-end fanners on long field channels serving more than 18 allotments, the other fanners did not complain about shortage of water during this period. It is observed that head-enders too face water problems at intervals of closing and opening of the right bank main canal after rains. It should also be indicated that the Irrigation Department officers including the senior irrigation engineer paid special attention to water management activities in DC 5 after implementation of rotations and made regular field visits to the tract 1 area. Though some fields still required water, the water issues to the tract were stopped by 19 March 1990 because of rains.

Conveyance Losses

Our water measurements in DC 5 substantiate high conveyance losses occurring at various levels of the canal system. Table 1.06 indicates canal losses between the branch distributary and FC 52 resulting from seepage, overtopping of canal bunds and leaks from undercrossings.

Target and Actual Discharges at Heads of DC 5, its Branch, and FCs 44, 53, 54

Figures 7.05 and 7.06 indicate the actual daily deliveries at the heads of DC 5, the branch of DC 5, and FCs 44, 52, 53, and 54 from mid-January to 18 March 1990, the last date of water issue for the season. It can be concluded from these figures that DC 5, FC 44 and FC 54 were oversupplied most of the time while the other three canals were undersupplied. The actual discharges to DC 5 from 10 January 1990 to 8 February 1990 are very much higher than the target.

The non-compliance with the scheduled operation is also observable from the daily flow hydrographs for FC 44, the branch distributary, and FC 54. FC 54 at the tail, which is supposed to be closed completely on certain days, is kept open throughout. Since this canal is in the extreme tail it has not been provided with a gate and discharges to this canal are supposed to be controlled by interventions at other field channel gates and at the DC 5 offtake. However, because of a defect in a check structure, the discharges to the canal cannot be fully controlled.

The figures indicate that in actual operation rainfall was not accounted. If the rainfall had been accounted for, the supply would have run below the target. Nevertheless, the Department had closed or reduced the supply to the main canal whenever there was sufficient rainfall. For example, DC 5 was closed for 6 days in January (between 2nd to 8th January) due to heavy rainfall of 106 mm during this period.

Adequacy of Supply

The weekly RWS values for this season at the heads of DC 5, FC 44, the branch distributary, FC 52, FC 53 and FC 54 are presented in Figures 7.07 and 7.08. In DC 5 the RWS values were above 1.15 throughout the period studied. FC 44 at the head of DC 5 shows high RWS values ranging from 1.5 to 2.4 while in FC 54 in the tail it was 2.5 to 3.5. FC 52 and 53 indicated an inadequate supply most of the season.

Following the Department's irrigation schedule and the design assumption for DC 5 which classifies the entire command area under the canal as lowland, we have adopted measure S&P values applicable to lowland in calculating RWS for the canals. However, our field observations reveal that nearly 50 percent of the land is highland. If we calculate RWS adopting values applicable to lowland and highland on a 50 percent basis, the RWS values indicated in the figures would be reduced roughly by two-thirds. The figures throw light on the real water crisis faced by the farmers under the branch distributary, FC 52 and FC 53 which had an inadequate supply even with the RWS calculated adopting values applicable to lowlands. It appears from these observations that the Department purposely oversupplies the distributary in order to avoid severe water problems associated with the defective canal design.

Water Delivery Performance

Table 7.07 indicates the mean RWS, maximum and minimum RWS as well as Water Delivery Performance (WDP) for the season. As indicated in chapter 5, the mean RWS and WDP are almost the same. These values are higher than 1. The supply in DC 5 is not equitable as WDP varies between 1.02 to 2.76 in FCs 53 and 54 respectively. The table demonstrates a decline in supply from head to tail along DC 5. However, FC 54 in the extreme tail does not represent this tendency due to a construction defect in the canal mentioned earlier.

Equity of supply

As indicated in Figure 7.09, mean RWS is higher than 1.0 in all the field channels and DC 5 except in FC 53. FC 54 in the tail recorded a high value exceeding 2.5 because water issues to the canal were continuous and could not be controlled due to a defect in a check structure.

Discussion

It is evident from the daily flow hydrographs of the long canals such as FCs 52 and 53 that the total requirements after crop establishment cannot be provided by them even by overloading DC 5. This indicates the gravity of capacity constraints of DC 5 during land preparation period. However the serious water problems in many of the field channels have been alleviated by their favorable location which compensates for scarcity by seepage from the distributary and main canal, drainage water and higher groundwater table.

The farmers generally start land preparation late because of social and economic constraints and therefore capacity constraints of the canal do not form a major obstacle. However, if the farmers had fewer constraints with respect to input supply, credit and farm power, then the capacity constraint of the canal would become the dominant factor affecting land preparation. With the canal capacity constraint, the total land preparation period for rice in the canal cannot be shortened and might take roughly one and a half months.

IRRIGATION MANAGEMENT DIVISION ACTIVITIES

The higher level officers of the Irrigation Management Division had arranged several training programmes for project managers, institutional development officers and irrigation engineers this season. In addition, several Irrigation Management Division officers came to meet the project managers and made field visits to identify field level problems. Though the Division showed improvement in its activities such as providing training to officials, it failed to bring to an end the conflicts of the fanners in the old and new systems. The farmers of the old area were seen organizing themselves to avoid being "deprived" of 200 percent cropping intensity. They had serious arguments with farmers of the new system over water whenever project management brought them together for a discussion of water allocations. Tensions worsen between the farmer leaders of the old and new areas whenever a joint meeting of these farmers is called for. The old area farmers have also developed a dislike for certain officers in the new area of the project as a result of these conflicts over water.

Institutional Organizer Program

The Irrigation Management Division selected 18 institutional organizers and fielded them after two weeks training this season. We closely studied the institutional organizer program in the right bank area to which 11 institutional organizers had been assigned. Those assigned to tracts 2 and 5 of the right bank could not implement the program as instructed because the farmers were faced with severe water scarcity and poverty, and could not be organized for *any* purpose. However, the institutional organizers in tract 1 right bank and tracts 1 and 2 left bank could work with the farming communities and initiate self-help campaigns for field channel maintenance work. Though it is too early to comment on this program definitively, the following key problems could be identified:

1. Some of the institutional organizers were not well versed with the key concept of the program and viewed their role as being to help fanners to find solutions to problems by active involvement just like an officer. The farmers and farmer leaders too expected institutional organizers to solve their problems. Some institutional organizers were seen working very hard with this idea in mind. This syndrome has been observed under the Irrigation System Management Project in Polonnaruwa, where there is better supervision (see TEAMS 1990).

2. Though some institutional organizers were knowledgeable about the key concepts, they were biased towards the farmers' views. Most of them in tracts 2 and 5 expressed views and ideas against the crop diversification program planned for yala 1990 in tracts 2 and 5, as did the fanners. They too believed that water issues are not made for rice even though sufficient water is available in the reservoir. The institutional organizers thought that farmers can grow rice in both seasons. They did not know the project plans and objectives. This raises questions about project specific training for institutional organizers.

3. Most of the field level officers of line agencies did not understand the role of institutional organizers. They expected them to do certain administrative tasks such as distribution of applications for agricultural loans. The institutional organizers at times could not refuse these requests as it would affect the fanner community. However, involvement in such activities may lead to a wrong identification of their role by the farming community. This suggests the necessity of training of middle and field level officers on the Irrigation Management Division's program and the role of institutional organizers.

4. The institutional organizers in the field were confronted with certain problems which discouraged them from attending to their duties effectively. The major problem was the failure of farmer organizations to find solutions to certain problems such as stray cattle grazing and to take action against those who do not attend to canal cleaning and fencing. The institutional organizers who tried to encourage farmers to find solutions to such problems found that they cannot be solved without some legal support to farmers' organizations. Even the leaders whom we interviewed expressed the view that farmers' organizations need sane legal authority to deal with such problems if they are to survive and to be valued by people.

5. In *many* hamlets, the institutional organizers were discouraged by the leading men of the farmer organizations who took them as a threat to their role as patrons to the farmer community. There were *many* occasions in which **some** leaders created problems for institutional organizers to bring them into conflict with farmers. Some organizers faced this challenge successfully while others were highly discouraged. On the directives of Irrigation Management Division head office, institutional organizers were recently instructed to inform field channel groups that the leaders once selected can hold office only for a period of two years. When this was intimated to leaders they got annoyed and viewed it as an attempt to expel them from their positions. Since **some** of these leaders are well accepted in the comity, holding new elections must be done tactfully or the organizers will face tremendous resistance from these leaders.

6. Institutional organizers felt that they need much more training and guidance to tackle field level problems. The organizers in tracts 2 and 5 had this feeling when confronted with the challenge of changing farmers' attitude to cultivating non-rice crops.

In general, the institutional organizer program was well received by the farming communities in tracts to which water issues had been made last maha. In other tracts, the fanners are experiencing severe poverty and are therefore more concerned about making a living than forming organizations. The institutional organizers working in these tracts found it difficult to meet fanners and organize group meetings. The organizers assigned to these two tracts had to face resistance from fanners after the kanna meeting in which all project level higher officers including the Irrigation Management Division project manager requested the farmers to grow non-rice crops to put an end to the water crisis in the project. The farmers had come to the meeting with the expectation of water issues to cultivate rice: they were very angry with all the officers including those attached to the Irrigation Management Division. The organizers could not get any farmers to attend field channel group meetings after the kanna meeting; in addition, farmers started to criticize the attempts to organize them when there is no water to share.

STRATEGIES FOR TURNOVER OF DISTRIBUTARIES TO FARMER ORGANIZATIONS

Operation and maintenance responsibilities for DC 5 were handed over to the farmer organization in Hamlet 3 a few months prior to the commencemant of this season. Some improvement work in the canal was contracted out to the organization. When the water issues for the season started, the O&M responsibilities of the canal were supposed to be handled by the farmers' organization. As discussed above, the **farmers'** organization failed to handle these responsibilities during the land preparation period, and as a result, the Irrigation Department had to take over the responsibilities again. The failure of the organization to handle these responsibilities are associated with the following problems:

1. Farmers' lack of understanding of the responsibilities bestowed on them by turnover.

As our interviews with the farmers reveal, they are not clear about what is meant by the turnover of the canal. To **many** of them it **means** that the president of the organization will take over the canal operation. In the case of maintenance, their view is that the Irrigation Department should employ farmers on daily pay basis for maintenance work.

2. Too much dependence of the organization on one or two individuals.

The farmers' organizations in Kirindi Oya have an inherent defect of depending too much on one or two leading men in the organization. We pointed out in our earlier reports how the resignation of such leading men affected the activities of the organizations in tract 5. The same arguments hold good not only for the organizations in tract 1 but in the entire project area. As far as the handing over of DC 5 is concerned, it had been handed over to a single individual who used to run here and there to solve fanners problems with the desire of being a leader of the community. However he later told us that he expected a payment **from** the Irrigation Department for operational work done by him. When he got frustrated with the members of the community he gave up operational responsibilities and the Department had to takeover the canal again.

3. Design defects of the canal.

The distributary leader initiated the turnover of the *canal* to the farmers' organization because of the serious problems encountered by farmers in irrigating their allotments when the Department was handling the operation. The leader realized that the problem were due to capacity constraints, but he believed that they could be solved by flexible operation of field channel gates. This flexibility was not possible when the Department was operating it; therefore he wanted to take over the responsibility on behalf of fanners.

4. Lack of support from the field level staff to the turnover program.

Though the turnover of O&M responsibilities is the Government's policy, the field level minor staff of the Irrigation Department is not aware of it and therefore is not able to help the organizations or assist them in taking over such responsibilities. As we saw in DC 5, the field level officers appeared to have the misconception that the farmers' organization has intruded into their territory by taking **O&M** responsibilities into their hands.

5. Lack of training for leaders on O&M.

We observed in DC 5 during the land preparation period that the leader lacked technical know-how and skill to adjust the field channel gates to distribute water; hence ***some*** canals received too much water while others were faced with scarcity. This could have been avoided by giving proper training to leaders on canal operation.

Turnover must be a slow process in Kirindi Oya, in view of the weakness of the farmers' organizations. The Irrigation Management Division has to identify first of all which organizations are capable of taking larger responsibilities by careful monitoring of the progress of the organizations. On the other hand the Irrigation Department needs to give a lot of assistance and guidance to the organizations to prepare them to take over O&M responsibility. At the same time the Department should also find solutions for technical problems impeding smooth operation of canals like DC 5 constraints before turnover of such canals.

PROGRESS OF YALA 1990 CROP DIVERSIFICATION PROGRAM

The initiatives taken to assist the Department of Agriculture research staff at the Weerawila Agriculture Research Station in developing the station for conducting on-farm water management experiments were described in the Interim Report (IIMI 1989a). The limited progress on the on-farm research during the yala season of 1989, as well as the progress made on observational trials in farmers fields by the extension staff were briefly reported in the Seasonal Summary Report (IIMI 1989).

The process by which an action plan for crop diversification in yala 1990, and IIMI's role in this process, is described in this section. The plan includes proposed cropping patterns, cropping calendar, irrigation delivery scheduling and land preparation methods. Initial developments during yala 1990 are also described,

Preparation of the Action Plan for Diversified Crops in Yala 1990

The project authorities headed by the project manager (settlement) were engaged in the preparation of the action plan for the cultivation of non-rice crops in yala 1990 during the last quarter of 1989. The main line agencies responsible for preparing this plan consisted of the Irrigation Department, Department of Agriculture, Land Commissioner, and Irrigation Management Division, together with the Department of Agrarian Services, Marketing Department and the regional banks. None of the officials representing the above agencies had much prior first hand experience in implementing a program of diversified cropping under irrigation during a dry yala season in a major irrigation settlement project; the planning exercise was therefore an important and useful learning exercise.

A first preliminary draft of an action plan was prepared by the senior field staff of the project, based mainly on the irrigation delivery computations made by the consultants (Water Management Consultants 1989). Drawing on IIMI's three years of experience in its studies on irrigation management for crop diversification in the North Central Province of Sri Lanka, IIMI's senior staff were able to make a substantial input into the draft action plan in the three broad areas of cropping patterns, irrigation scheduling and cropping calendar, and farmer participation and organization.

<u>Cropping Patterns</u>. It was suggested that crops with a sowing-to-harvest duration of less than 90 days be given priority in view of the restricted water supply; and that crops which need a similar irrigation frequency of one-in-seven days be selected. On the foregoing consideration the main crops would be green

gram, cowpea, soybean end black gram. Since these crops fall within the category of low productivity crops, provision was made for small extents of high productivity crops such as onion and chillie to be permitted in order to enable fanners to reap a better income. It was, however noted that farmers who grow onion and chillie would have to adopt the same irrigation frequency as for the grain legume crops, and that farmers growing chillie would do so at their own risk beyond the 90 to 100 days permitted.

It was agreed that the major focus of activity should be in right bank tracts 2 and 5, taking into consideration the probable average inflow into the reservoir and also the fact that these two tracts were deprived of a maha rice cultivation.

Irrigation Scheduling and Cropping Calendar. Since the irrigation staff had no prior experience of irrigation delivery scheduling for non-rice crops during the dry season, IIMI's interventions in this area baaed on its experience proved useful. Apart from what quantities should be issued for the land preparation period and the subsequent rotational deliveries for the crop growth period, the more complex management problems of rotational deliveries between distributaries, field channels and farm allotments were the more important issues on which considerable guidance was needed.

Following discussions with staff of the key departments, the following framework for irrigation scheduling and cropping patterns was adopted:

1. Irrigation deliveries to commence in the first week of April with two to three deliveries of 70 mm each to be made within a 14 day period. This would enable farmers to prepare their seed beds and drill the seed by mid-April. Maximum use of the rainfall was to be made during this period and also a cutting down of the amount of planned delivery according to the amount of rainfall received. Land preparation to be encouraged soon after the maha rice crop was harvested and minimum tillage practices to be encouraged such as burning of rice straw in the field to reduce weed load.

2. After crop establishment, the irrigation delivery schedule to be strictly once in seven days with a 70 mm issue for each delivery. Ten such deliveries will be adequate for grain legumes. Any delivery beyond 90 days if needed for chillie will be made according to availability of water in the reservoir, and farmers would, therefore, be growing chillie, which takes more than 120 days, at their own risk.

3. While the foregoing delivery schedules would inhibit the growing of rice, it was recognized that farmers located in the poorly drained soils end at the end of the field channels will make use of the night flows of irrigation water to grow rice. Again, drawing on IIMI's research experience, it was decided to permit farmers located on poorly drained soils to grow rice, but with the strict understanding that the water delivery schedule will be only once in seven days and that they would have to rely on the seepage from the adjacent uplands to augment the water needs of a rice crop, and also be content with lower rice yields.

4. The rotational scheduling between distributaries and field ohannels to be worked out by the Irrigation Department according to the command area falling under the respective distributary and field channels. However, a measure of flexibility to be retained in order to make mid-course modifications. In respect of the delivery schedule within the field channels, the management staff opted for each farm allotment using the full stream of 1 cusec (28.3 l/s) for a period of 5-6 hours rather than two farmers sharing a stream of half cusec each.

Farmer Participation and Organization. The need for a strong and effective coordinating mechanism supported by a good communication system between farmers and officials was stressed at all meetings and discussions, in order that the recommended cropping patterns and delivery schedules could be properly implemented. While this was tacitly accepted by the agency staff, there was no clear outcome of how this could be achieved. The Irrigation Department staff who had a good understanding of the physical make up of the irrigation system showed a high degree of confidence in managing the proposed irrigation delivery schedules. However, the other line agencies responsible for developing effective farmer organization and communication between farmers and agency staff were not able to match their activities to the same degree. Moreover, the present fragmented nature of the organizational structure in the project was a further constraint to developing affective farmer-agency collaboration.

Serious staff constraints were also experienced by the Department of Agriculture consequent on the transfer of the field level extension staff to the poverty alleviation program. Approval was obtained to recruit temporary staff to fill this gap in time for the yala season, and the limited staff resources of the training division of the Department were also to be utilized for the farmer training activities.

IIMI was, on the whole, not in a position to help out on the above problems, except to bring to the attention of higher level authorities at the Ministry level the shortcomings and the adverse effect these would have in the implementation of the action plan in yala 1990. On the other hand, IIMI was able to influence the thinking of the agency staff in the field to pay sufficient attention for developing a good communication and feedback mechanism during and after each water delivery since this was one of the crucial management areas recognized in IIMI's research in the North Central Province.

Monitoring of Progress in Planning and Implementing of the Program

A senior IIMI staff member, together with IIMI field research staff, have been attending the meetings held every month (except February 1990) since December 1989 at the chief resident engineer's office Debarawewa or at the training center at Weerawila. These meetings were held mainly to review progress in planning for implementing the yala 1990 Action Plan, and to identify problems arising from a frequently changing scenario in the water supply situation in the main Lunugamwehera reservoir, coupled with farmers going back on decisions arrived at in the earlier kanna meetings. Faulty decisions at higher political levels (e.g., diversion of water to Bandagiriya reservoir) have further complicated the situation, and the original plans have had to be frequently modified at each successive meeting.

Progress on Crop Diversification Plan for 1990

Although the earlier plans for diversification in yala 1990 were based on a very tight water supply situation in the main reservoir, the above normal March-April rains coupled with above average inflows have resulted in a better-than-normal water supply situation. This has posed its *own* set of problems where farmers who earlier agreed to grow non-rice crops, now desired to grow rice.

With good inflow to the reservoir towards the end of maha 1989/1990, the project management had a meeting with the fanner representatives of both the old and new systems to discuss plans for water issues to the various subsystems. The Irrigation Department proposed an issue of 24.7 million m^3 (20,000 ac.ft) to Ellegala system, and 6.2 million m^3 (5,000 *ac.* ft) to Badagiriya to start rice cultivation, and 12.3 million m^3 (10,000 ac.ft) to tracts 2 and 5 to cultivate non-rice crops on a <u>bethma</u> basis, each farmer cultivating 0.5 ha. Most of the farmer representatives in tracts 2 and 5 informed officials that the farmers cannot undertake other crops for economic reasons. Though the project authorities attempted to implement the other field crop program as per the action plan developed by project officials, it could not be implemented in tracts 2 and 5. At the kanna meeting for tracts 2 and 5 the farmers requested water for rice. The Irrigation Department explained to them that the water available in the reservoir was not sufficient for rice cultivation, but its explanation was not accepted by many farmers.

The reasons for the failure of the crop diversification program in these tracts are:

1. The poverty of the farming community; there had been no maha cultivation because of the lack of water.

2. The temporary residence of farmers in settlement areas due to lack of livelihood.

3. Lack of credit facilities for about 75 percent of farmers. Though the Central Bank of Sri Lanka has agreed to provide credit for non-rice crops undertaken even on a bethma basis, nearly 75 percent of farmers as defaulters on previous loans are not eligible for bank loans. The money lenders and others who lend for rice on high interest rates are not prepared to provide credit for cultivating non-rice crops.

4. Threats of powerful farmers against those who were prepared to cultivate other crops.

5. Stray cattle problems and threats from cattle owners against fanners ready to cultivate other crops.

6. The decision to issue water to Badagiriya for rice. Many new area farmers view the program for promoting other field crops as a pretext for issuing

water to Badagiriya for rice, bypassing tracts 2 and 5 where project management expects farmers to cultivate other crops[1].

The earlier plan to confine non-rice crop cultivation to right bank tracts 2 and 5 had. to be abandoned because of fanner unwillingness at the latter stage to grow other crops. Instead, plans were modified to grow other crops on about 1200 ha on bethma basis in left bank tracts 1 and 2 and right bank tract 1 soon after the maha rice crop was to be harvested. The area planned was shortly afterwards reduced to 400 ha, with water issues to begin on 5 May for land preparation. By 25 May, it was reported that land preparation for about 200 ha of non-rice crops had been completed.

The Irrigation Department staff worked on developing feasible delivery operational procedures and schedules for bethma cultivation. The Department of Agriculture in late April had to address a new problem of heavy weed load in the fields consequent on the extra rainfall received over several weeks, and the land preparation problems that would arise as a result of this excessive weed load. They later reported that they were able work out a satisfactory technique using herbicides to control the weed load and thus enable timely land preparation.

There has been a continuous delivery of water to the above extents since 5 May. This will continue up to 5 June. However, both distributary and field channel turnout gates are closed between 6:00 PM and 6:00 AM by Irrigation Department turnout attendents. At night the water is sent to Ellegela and Badagiriya. This is a new innovation in management of turnout deliveries for this project aimed at preventing night irrigation of rice.

Despite reservations expressed earlier, the farmers in the above 200 ha have been able very successfully to complete the land preparation within 20 days. The tractor power available within the project area has just sufficed for this extent. There will definitely be a constraint of farm power if a larger extent of land preparation is undertaken. The beds for planting of onions (shallot) have been very well prepared, while the most popular crop is groundnut, which needs a less well prepared seed bed.

The main problems highlighted by fanners are shortage of seed onions, uncontrolled cattle trespass, and lack of cheap and readily available fencing materials.

The importance of coordinating the various activities of the respective line agencies in water delivery, land preparation, seed and input supply had been stressed at the 24 April meeting. The senior staff of the line agencies working in the project, especially the Irrigation Department and Irrigation Management Division, have shown a high degree of confidence, motivation and coordination in planning and implementing this season.

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1. A decision not to issue water to Badagiriya was later reversed, apparently due to some political pressure. Thus, farmers in tracts 2 and 5 right bank, who had no maha crop, watched water pass through their tracts to Badagiriya for those farmers to grow rice.

Progress of On-Station Research at Weerawila and Angunukolapelessa

Water management research for Kirindi Oya has to recognize the basic issue of shortage of water which results in having to spread the **water** "thinly" over the **maximum** extent if the project is to bring irrigation benefits to the largest number of farmers. Therefore, a key research goal for Kirindi **Oya** must be to support the development of technologies to assist serving the largest number of farmers profitably. The research has to therefore generate a series of water-related recommendations for non-rice crops.

Important among these will be one which deals with irrigation requirements in relation to rainfall and time of planting. Faced with perennial water shortages, especially during yala, agency staff must make recommendations for planting dates and irrigation schedules which maximize production and minimize water release. In addition to the on-station research outlined in the Inception Report (IIMI 1988a), experiments on irrigation requirements in relation to rainfall and time of planting were therefore initiated for yala 1990 with four crops green gram, soybean, cowpea and sesame with the following dates of planting:

30 March with rainfall
10 April with rainfall
20 April with rainfall
30 April with pre-soaking with one irrigation

Because of the uncertainty of water issues in yala at Weerawila, these experiments were located at the Angunukolapelessa Agricultural Research Center. A limited trial to demonstrate the feasibility of establishing these crops with the early yala rains was also initiated at Weerawila Agricultural Research Center.

During the last IIMI visit to these locations on April **24**, there **was** clear evidence that non-rice crop cultivation for the yala season is best commenced with the early yala rains and this could, therefore, effect a major saving in irrigation requirements. A similar time of planting trial with six crops including cotton and maize will be conducted during the forthcoming maha season at both locations.

THE **IMPACT OF** THE **DRAFT FINAL REPORT**

The Central Coordinating Committee for the Kirindi Oya Irrigation and Settlement Project met on 15 February 1990 and discussed IIMI's Draft Final Report **as** one of the agenda items. In that meeting, the State Secretary for Irrigation was requested to visit the Kirindi Oya project and submit a report containing his suggestions for remedial measures to improve the management of the project. His recommendations for institutional changes and remedial measures were framed following discussions with the Land Commissioner, Director (Irrigation), Director (Irrigation **Management** Division), Government Agent (Hambantota), the present fanner representatives of both the old and new areas, senior and field level staff of the Irrigation Department, Department of Agriculture, Land Commissioner's Department, and Department of Agrarian Services. His recommendations are briefly summarized here.

Institutional Changes

The present institutional arrangements which were principally intended for the construction phase of the project are no longer appropriate for the present operational phase. There should be one project manager from the Irrigation Management Division for the whole project including both the new and old areas. This project manager would coordinate all activities within the project with the help of a new project management committee for the entire project. This committee would comprise farmer representatives from the old and new areas of the project and the key officials at the project level. Water allocations for each season are to be decided by the committee subject to approval by the Government Agent, Hambantota.

A "Special Task Force" of the Central Coordinating Committee comprising State Secretary (Irrigation), Land Commissioner, Director (Irrigation), Director (Irrigation Management Division) and Director (Water Resources Development) would provide necessary guidance and instructions to the project manager. The project coordinating committee and the District Agricultural Subcommittee of Hambantota District, presently existing, will continue to oversee coordination of all departments and agencies and give direct assistance to the project manager and the project management committee.

Four separate subproject management committees for Badagiriya scheme, Ellagala system, right bank new area, and left bank new area constituted with farmer representatives and department officers would coordinate all water management and related activities within their areas of operation.

The chief resident engineer will take full responsibility for all O&M works; the remaining construction work will come under the administrative and technical control of the deputy director of irrigation, Hambantota.

Farmer Organizations

In any major irrigation project, rational and successful water distribution cannot be achieved without effective farmer organizations, an appropriate institutional arrangement to coordinate the work of all government agencies, and an appropriate mechanism where the farmers' organizations are able to participate in the project and water management activities.

As documented in previous chapters as well as this one, the fanners' organizations formed by the Irrigation Management Division have been found to be weak and ineffective in performing the tasks expected of them in the participatory management approach. Their leaders are not successful in representing the farmers' views or communicating agreements back to farmers when seasons are planned. And the one attempt to "turn over" a distributary to fanners was aborted because the organization was not yet ready for managing their subsystem.

The Irrigation Management Division has to revamp the existing farmer organizations, form new field and distributary canal organizations and give proper training to farmer representatives. In this endeavour, the project manager and his staff require guidance and assistance from Colombo.

Crop Diversification

The cropping patterns planned in the past could not be implemented on the ground for many reasons. These include the farmers' organizations not being strong and effective, the lack of fanner participation in the decision-making process, ineffective extension services and institutional support arrangements, lack of adequate credit and marketing facilities, and lack of strong overall project leadership. Strong project leadership is required to overcome these problems; improved credit and marketing facilities would help create incentives for farmers to organize and respond by adopting more profitable cropping patterns. In view of the water shortage in the project, farmers must be given incentives to shift from growing rice to non-rice crops.

The Government has proposed to set up a "pilot area" of 400 ha in left bank tract 3 where the first 400 families to be newly settled could be brought into an experimental crop diversification program. This pilot area will be jointly managed by the representatives of these 400 families and a selected team of project staff headed by the project manager. It would include special training, and support to reduce risks of growing non-rice crops. Based on the success of the project in the pilot area, the program of crop diversification will be extended to the neighboring areas of the project on a planned basis.

Joint Management of the System

It is proposed to bring the Kirindi Oya project under the participatory management policy of the Government. Under this arrangement, the Irrigation Department would operate and maintain the main canals, and all distributary and field canals would be operated and maintained by the fanners' organizations. This change will be effected through the medium of the project management committee and the subproject committees. One of the essential pre-requisites for the turning over strategy is that the fanners' organizations should be fairly strong and effective. This is not presently the case in Kirindi Oya. Therefore, turning over of distributary and field channels to farmers' organizations will have to follow the implementation of proposals for reconstituting and strengthening farmer organizations.

At the project level, the following changes have taken place:

1. The Irrigation Management Division has taken initiatives to train its project managers, institutional development officers and the officers of the Department of Irrigation, after the submission of the Draft Final Report. Irrigation Management Division officers from headquarters have made regular field visits subsequently and tried to identify field level problems.

2. The Department of Irrigation has realized the necessity of adopting realistic S&P values and climatic data in their water delivery schedules; therefore, they initiated some field measurements during maha 1989/1990 which have provided results similar to our own

findings. In addition, Irrigation Department officials took action to collect more reliable data from the weather stations in the project.

Therefore, to conclude, it is clear that the Government has given greater priority to improving the management of Kirindi Oya and has taken concrete measures to implement improvements.

Table 7.01 Command area of field canals in RB Tract 01 distributary canal 5.

DC	SDC	FC	Area (Ha) Upland	Lowland	TOTAL (Ha)	Number of Allotments
Dc-5		FC-44	0.0	15.2	15.2	15
		FC-45	0.0	11.1	11.1	11
		FC46	0.0	13.2	13.2	15
		FC-46A	0.0	9.1	9.1	10
		FC-47	0.0	17.2	17.2	19
	S1DC-5	FC-51	0.0	15.2	15.2	16
		FC-48	0.0	6.1	6.1	6
		FC-49	0.0	27.3	27.3	24
		FC-50	0.0	10.1	10.1	18
	'OTAL S'	c-5	0.0	58.7	58.7	64
		FC-62	0.0	22.3	22.3	22
		FC-53	0.0	19.2	19.2	19
		FC-54	0.0	8.1	8.1	7
'OTAL DC-5			0.0	174.1	174.1	182

Table 7.02 Rainfall distribution in right bank tract 5 at Weerawila

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall(mm)	-	-	120.4	225.6	3.9	34.9	44.9	17.9	34.0	143.7	249.5	158.2
No. of Occurrence	-	-	11	12	3	6	4	8	7	10	18	11
Highest recorded (mm)	-	-	19.4	79.4	2.4	10.5	35.3	3.7	12.0	65.9	76.0	42.7
1989												
Rainfall (mm)	140.2	28.2	110.1	7.1	62.5	19.1	118.3	7.8	39.4	137.5	87.1	30.0
No. of Occurrence	5	3	3	4	7	2	11	5	5	8	10	4
Highest recorded (mm)	116.7	17.0	55.8	3.3	20.7	18.5	29.0	5.4	17.5	61.2	22.6	18.1
1990												
Rainfall (mm)	106.1	8.9	101.6	161.3								
No. of Occurrence	4	5	10	11								
Highest recorded (mm)	65.7	5.6	399	39.2								

Table 7.03 **A comparison of computed evapotranspiration (ET) based on pan evaporation measurements at Weerawila with evapotranspiration values adopted for the design based on climatic variables at Angunukolapelessa.**

	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Measured ET (mm/day)	1988	-	-	5.8	4.5	3.9	6.1	5.5	5.2	5.7	5.8	6.1	6.0
	1989	2.6	4.1	3.7	4.8	5.5	6.6	5.1	6.4	6.6	6.0	4.6	6.2
	1990	4.8	4.4	4.8									
Design ET (with 26% e.p#) (mmlday)		3.8	4.5	5.1	5.0	5.2	5.8	6.1	6.2	6.3	5.1	3.6	3.7

– exceedance probability

Table 7.04 **S&P values (mm/day) In RB tract** 01.

	Head			Middle	Tail	
llotment No	751	757	779	759	773	774
	35.1	0.3	0.2	**0.5**	0.9	0.3
	39.1	0.3	1.0	1.3	4.3	0.5
	41.0	0.4	1.2	1.5	4.9	0.7
	42.0	0.4	2.7	1.6	5.9	1.3
	57.8	1.0	3.0	1.7	6.0	1.8
	63.3	1.0	3.0	1.9	**6.3**	1.9
		1.3	3.1	1.9	7.0	2.0
		1.3	3.1	2.1	7.5	2.2
		1.4	3.1	2.3	7.7	2.5
		1.7	3.2	2.4	7.9	2.7
		1.7	**3.3**	2.5	8.2	2.7
		2.0	3.5	3.1	8.3	2.7
		2.0	3.9	4.6	9.1	2.8
		2.2	4.0	4.7	10.0	2.8
		2.5	4.4	5.0	10.1	3.0
		2.5	4.7	5.5	10.5	3.1
		3.1	4.8	5.6	12.1	3.1
		3.1	4.9	6.0	12.8	3.4
		3.2	5.0	6.7	17.9	3.4
		3.3	5.0	6.8	19.2	3.5
		3.5	5.1	6.8		3.5
		3.6	5.4	7.2		3.8
		3.8	5.5	7.2		3.8
		3.8	5.9	7.6		3.9
		3.8	6.7	7.8		4.0
		4.0	6.8	8.1		4.0
		4.0	6.8	8.7		4.0
		5.3	7.0	12.1		4.2
		6.5	7.2	12.6		4.3
		6.9	7.5	13.4		4.5
		8.0	8.2	18.4		4.5
		9.1	8.3	19.7		4.8
		12.2	8.6	27.2		4.8
			8.8			5.2
			10.5			5.2
			11.1			5.4
			11.6			5.5
						5.7
						5.7
						6.0
						6.2
						6.2
						11.0
						18.1
Minimum	35.1	0.3	0.2	0.5	0.9	0.3
Maximum	63.3	12.2	11.6	27.2	19.2	18.1
Mean	46.4	3.3	6.4	6.8	8.8	4.1
S.D	10.4	2.7	2.7	5.9	4.2	2.8
COV	0.2	0.8	0.5	0.9	0.5	0.7
Average		18.3		6.8		6.5

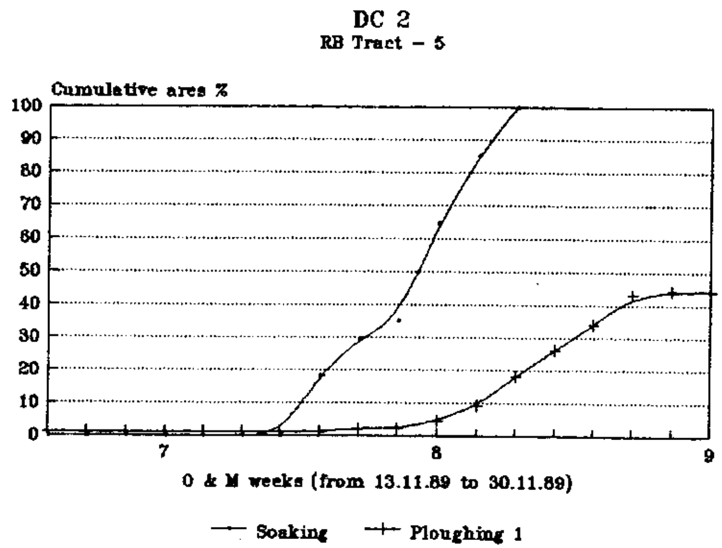
Canal	FC 44 (Head)	FC 49 (Middle)	FC 52 (Tail)	Total
Number of Farmers	16	24	22	61
Number Interviewed	11	16	21	47
Interviewed %	73	63	95	77
Shortage of water	4	14	18	36
Shortage of water %	20	69	82	54
No shortage of water	8	1	3	12
No shortage of water %	63	4	13	23
Access to drainage	0	1	14	15
Access to drainage %	0	4	63	26
Tractor shortage	9	11	10	30
Tractor shortage %	60	45	45	50
Lack of Credit	8	12	15	36
Lack of Credit %	53	50	68	57
Labour shortage	9	6	2	17
Labour shortage %	60	25	9	31
Not entitled to bank loans	6	12	6	24
Not entitled to bank loans %	40	50	27	39

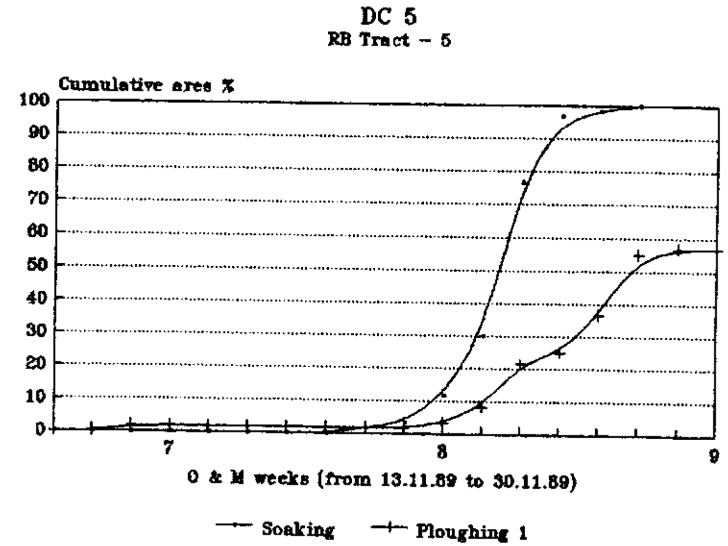
'able 7.06 Canal losses between Sub-DC and FC–62

Date	Losses lit/sec	Date	Losses lit/sec	Date	Losses lit/sec
10–Jan	40.06	01–Feb	4.30	24–Feb	10.86
11–Jan	16.84	02–Feb	14.48	26–Feb	16.86
12–Jan	20.61	03–Feb	12.47	26–Feb	11.73
13–Jan	23.61	04–Feb	10.49	27–Feb	17.66
14–Jan	22.41	06–Feb	12.62	28–Feb	0.76
15–Jan	15.66	06–Feb	6.80	01–Mar	4.46
16–Jan	39.64	07–Feb	6.68	02–Mar	1.22
17–Jan	46.21	08–Feb	10.06	03–Mar	10.01
18–Jan	45.32	09–Feb	10.10	04–Mar	10.93
19–Jan	49.78	10–Feb	26.46	06–Mar	7.64
20–Jan	47.14	11–Feb	16.36	06–Mar	2.79
21–Jan	30.05	12–Feb	18.17	07–Mar	16.19
22–Jan	9.24	13–Feb	12.17	08–Mar	23.48
23–Jan	20.61	14–Feb	7.35	09–Mar	22.99
24–Jan	3.83	16–Feb	8.65	10–Mar	19.10
25–Jan	13.88	16–Feb	9.42	11–MU	22.89
26–Jan	7.92	17–Feb	16.66	12–Mar	20.12
27–Jan	10.09	18–Feb	8.00	13–Mar	9.90
28–Jan	26.13	19–Feb	12.44	14–Mar	14.41
29–Jan	19.24	20–Feb	7.74	16–Mar	2.60
30–Jan	18.96	21–Feb	6.39	16–Mar	4.30
31–Jan	17.00	22–Feb	13.37	17–Mar	4.30
		23–Feb	20.86	18–Mar	6.10

Table 7.07 Relative water supply (RWS) and water delivery performances (WDP) for right bank tract 1 DC 5.

	DC-5	FC 44	SUB	FC 52	FC 53	FC 54
Minimum RWS	1.28	1.22	1.18	0.87	0.78	2.12
Maximum RWS	2.00	2.60	1.88	1.62	1.42	3.63
Average RWS	1.83	1.a5	1.29	1.16	1.00	2.70
WDP	1.63	2.04	I.30	1.16	1.02	2.78





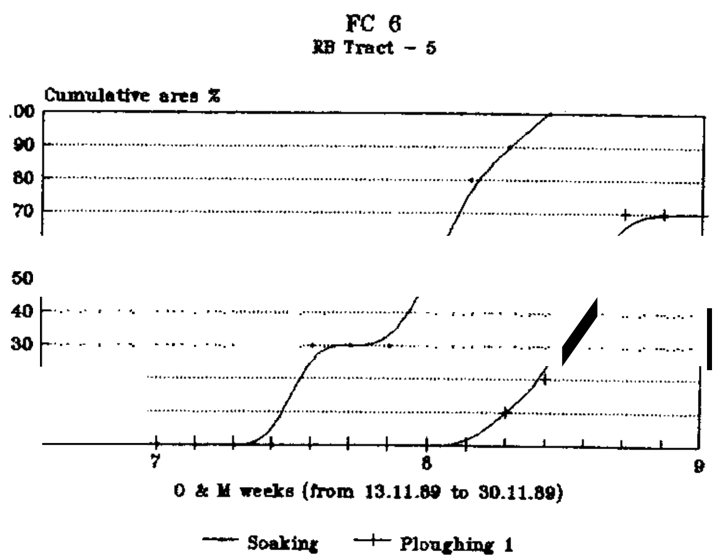


Figure 7.01 Land preparation progress
RB Tract 05.

Figure 7.02 Rainfall & Evapotranspiration
RB Tract - 1
Maha 1989/90

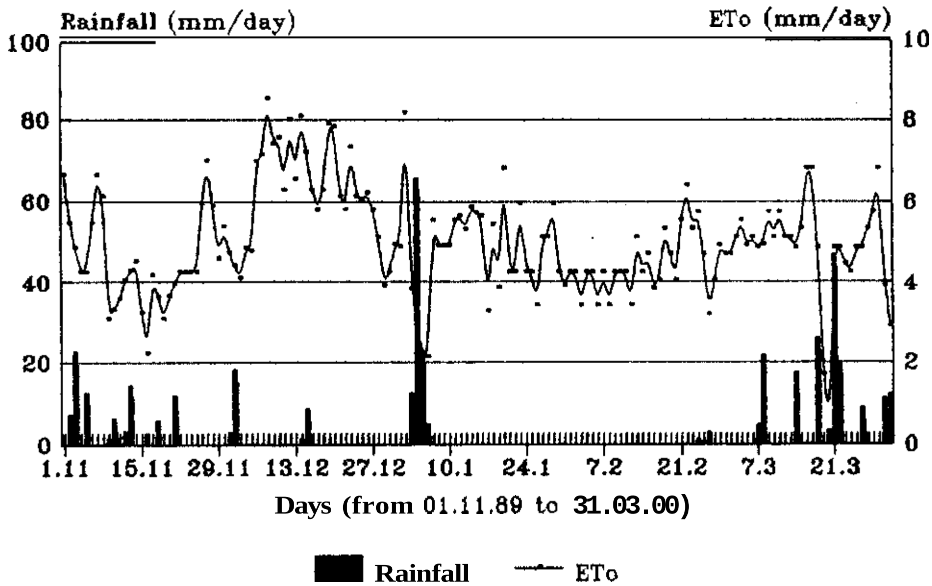
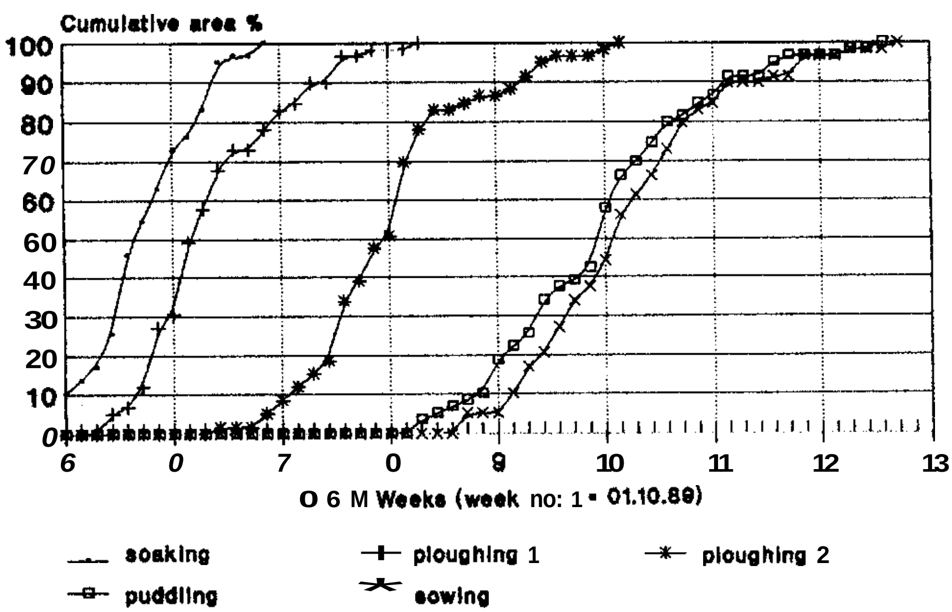
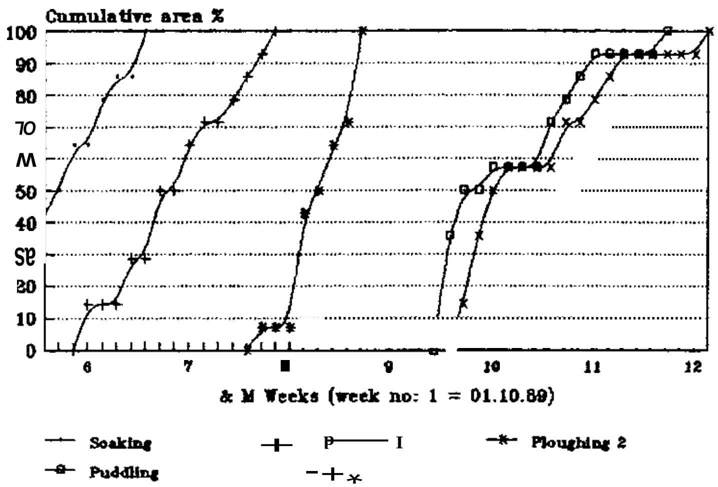


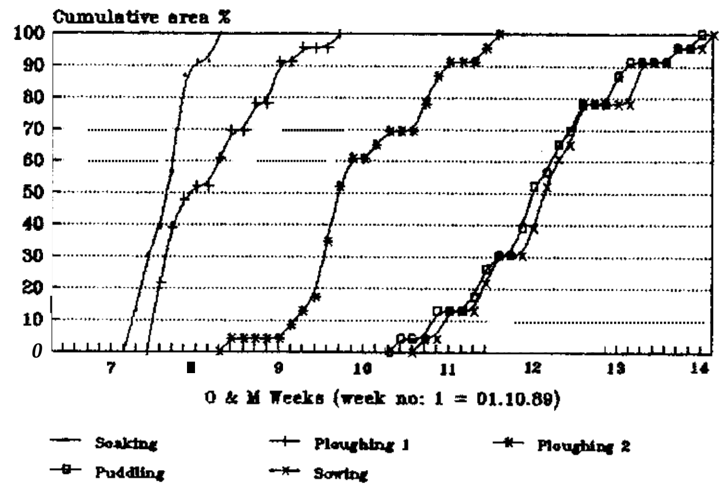
Figure 7.03 Land preparation Progress
DC 6. Tract 01



FC 44



FC 49



FC 52

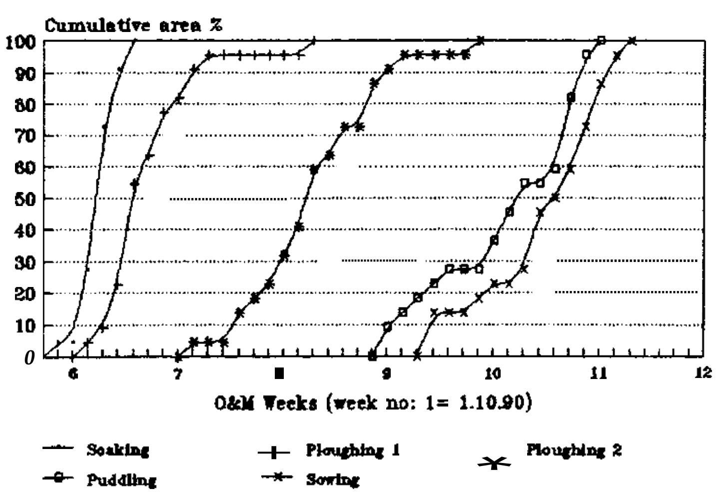


Figure 7.04 Land preparation progress RB Tract 01

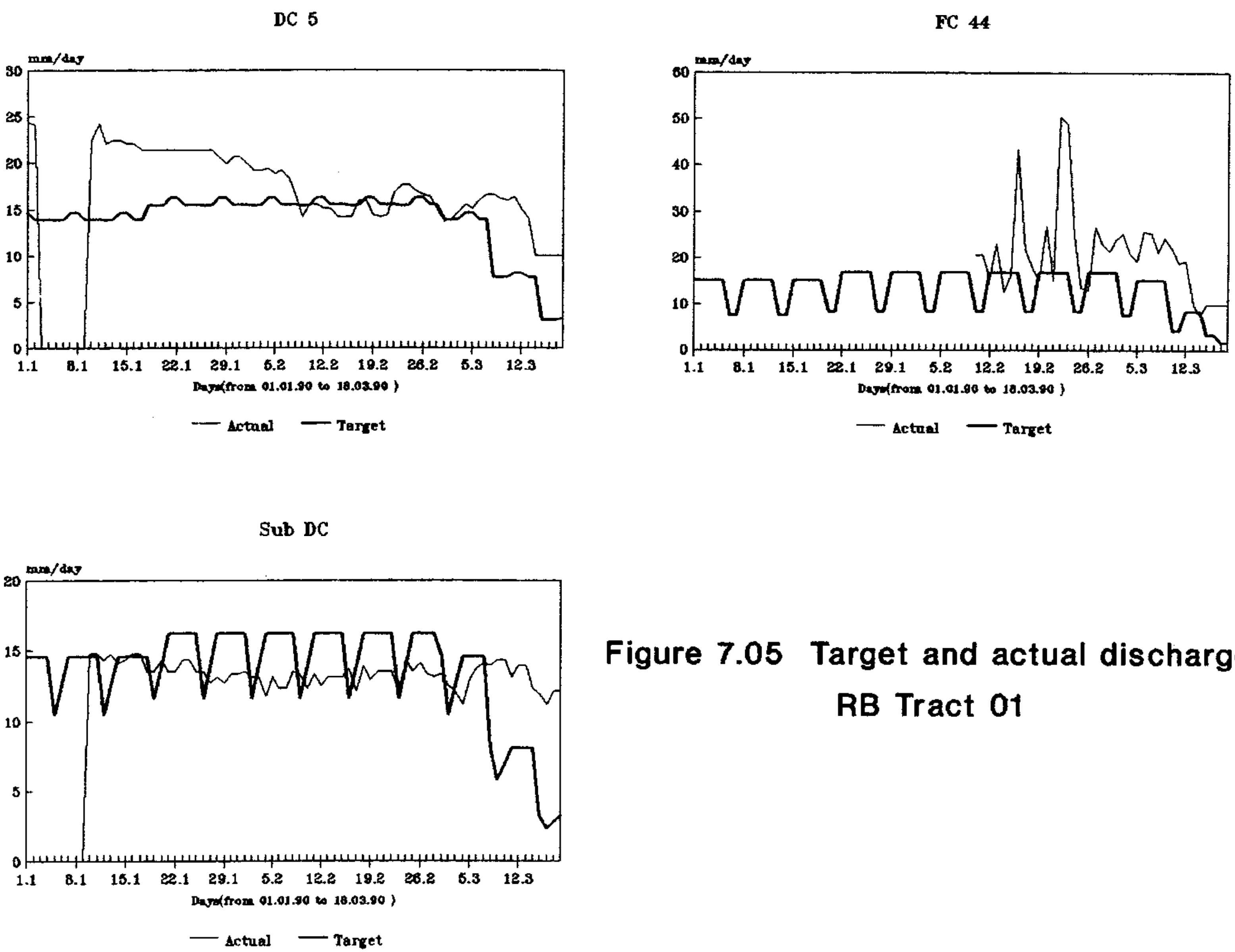
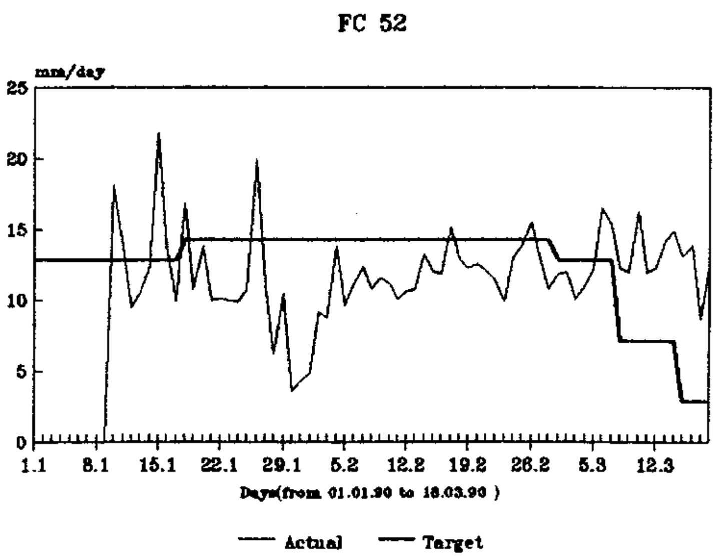
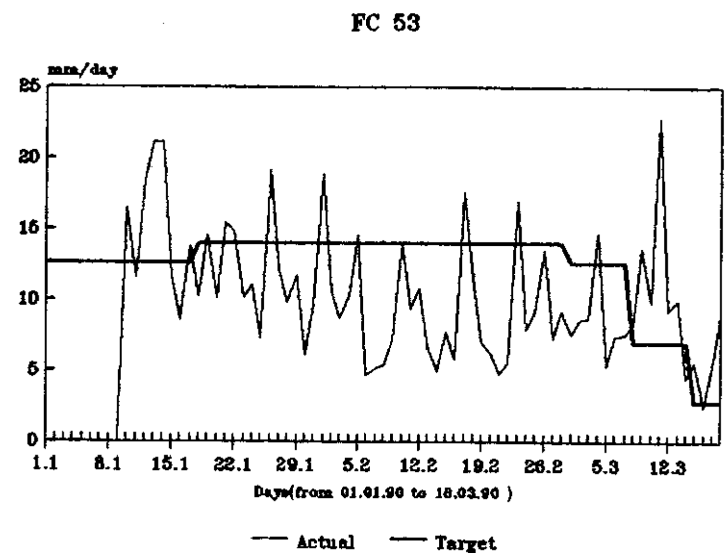


Figure 7.05 Target and actual discharge RB Tract 01





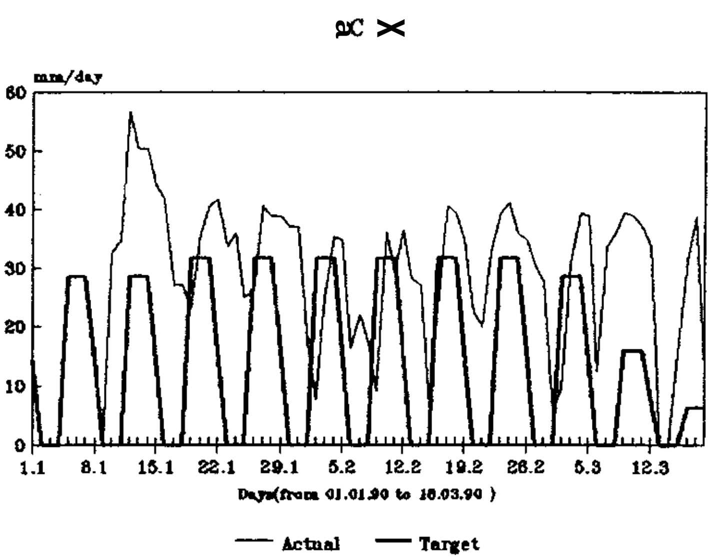
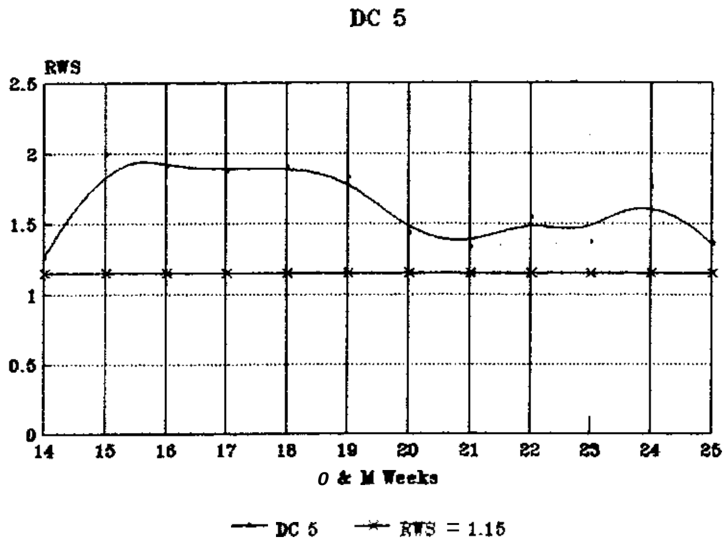
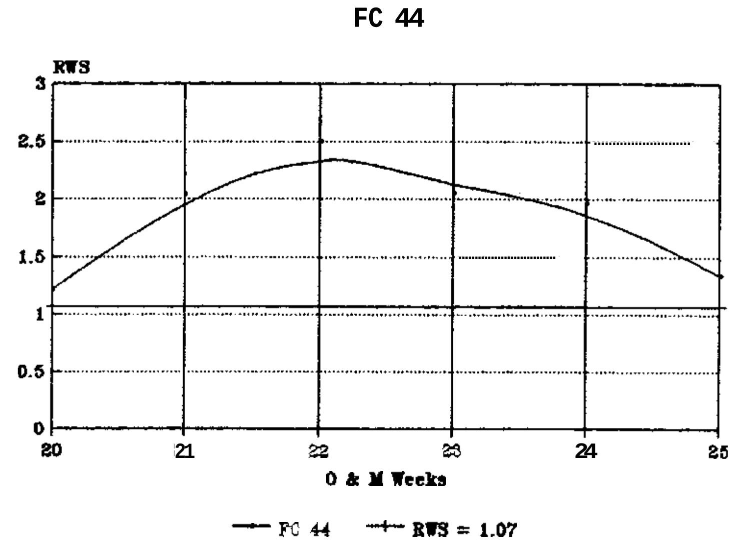


Figure 7.06 Target and actual discharge
RB Tract 01





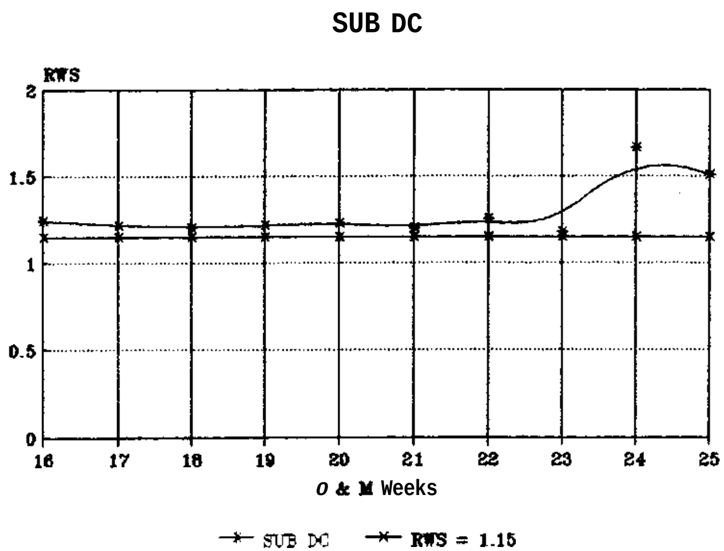
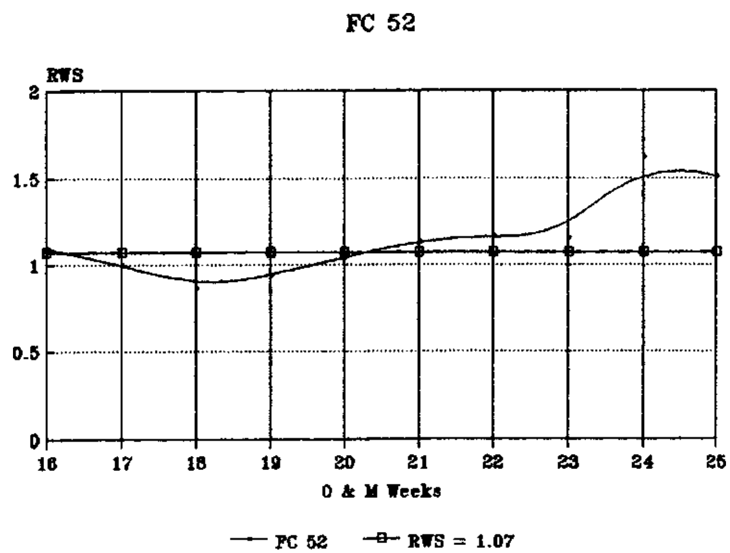
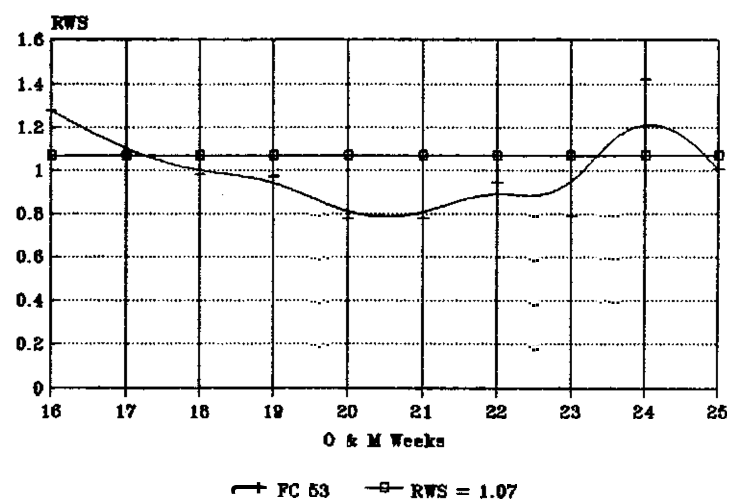


Figure 7.07 Relative water supply (RWS) RB Tract 01





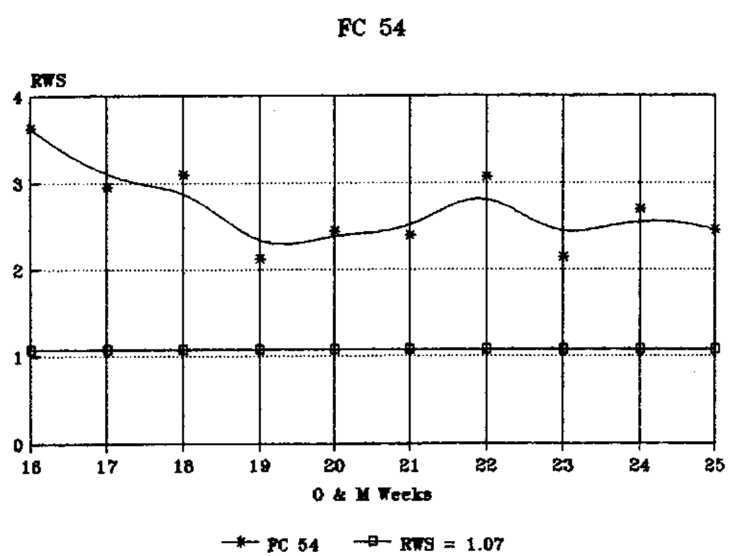
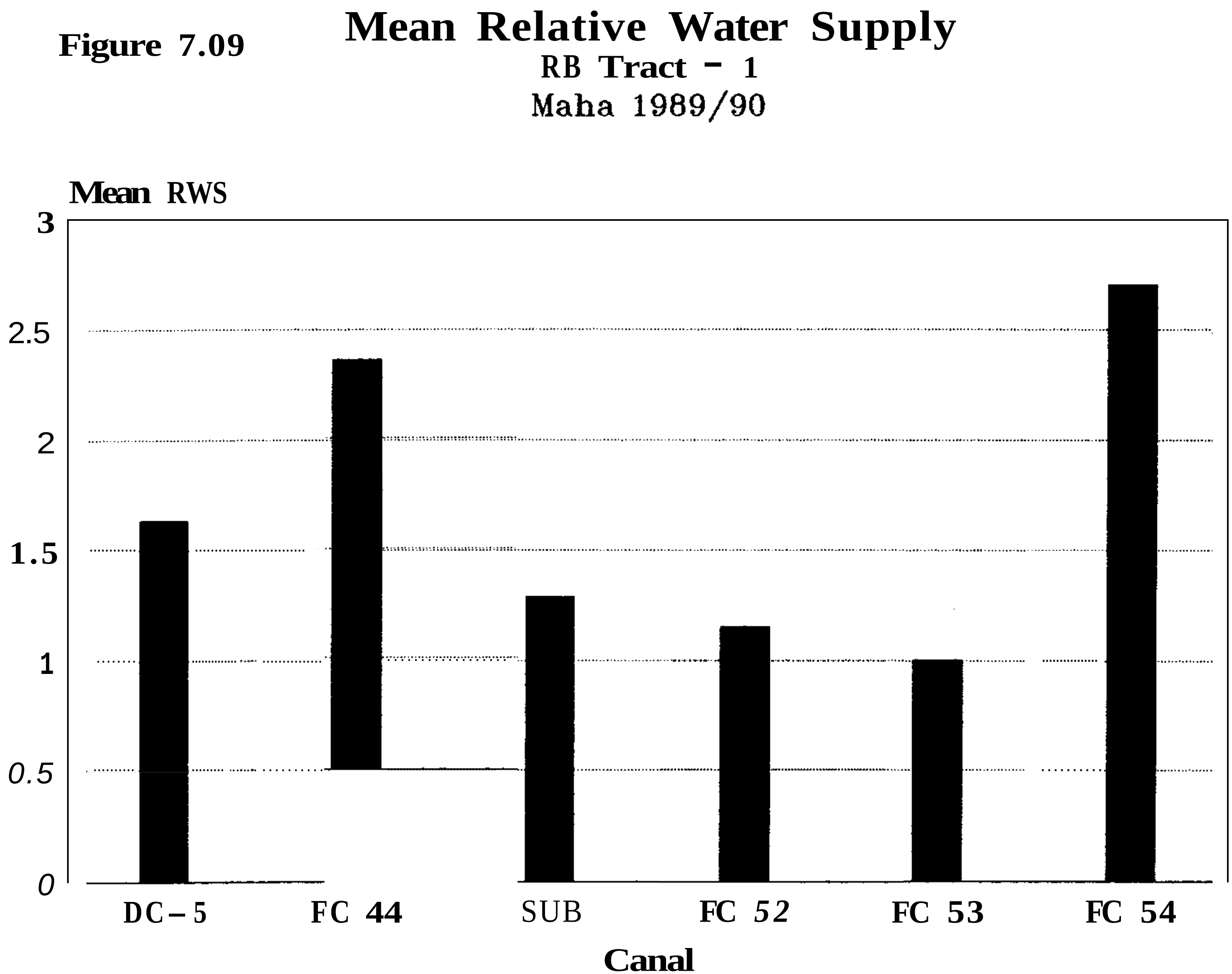
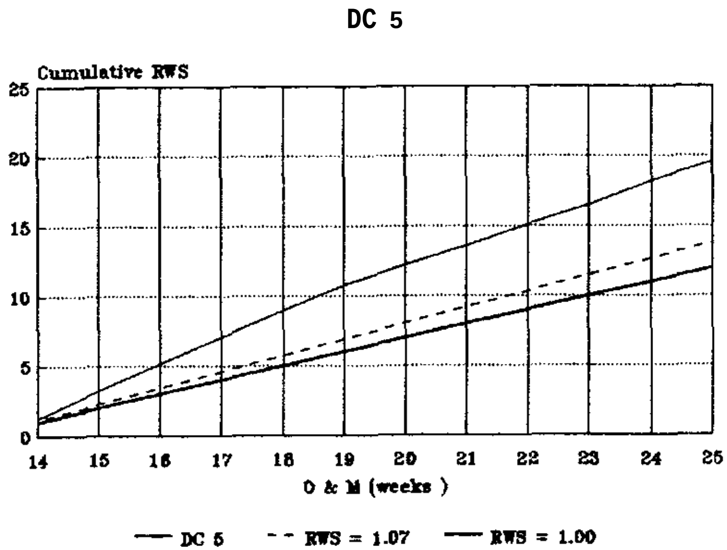
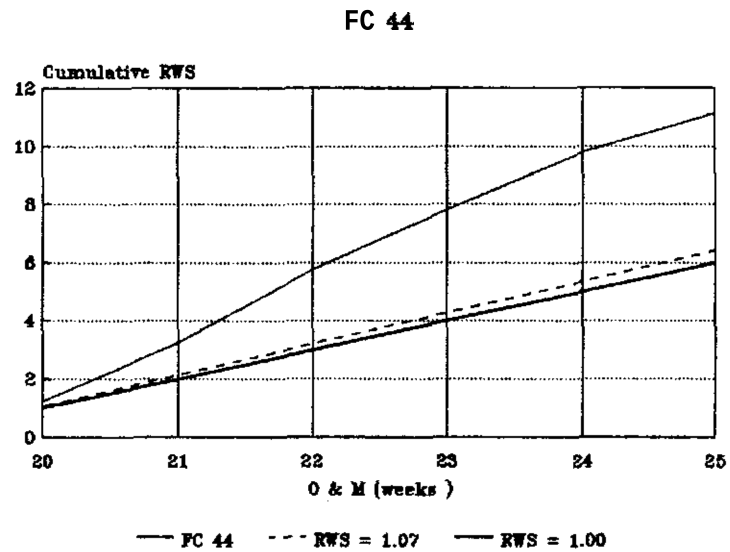


Figure 7.08 Relative water supply (RWS)
RB Tract 01

Figure 7.09


Mean Relative Water Supply
RB Tract - 1
Maha 1989/90
Mean RWS
3
2.5
2
1.5
1
0.5
0
DC-5
FC 44
SUB
FC 52
FC 53
FC 54
Canal





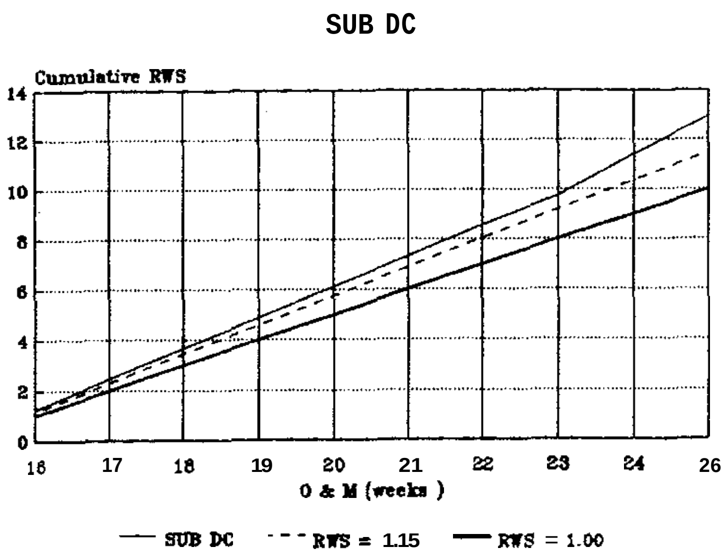
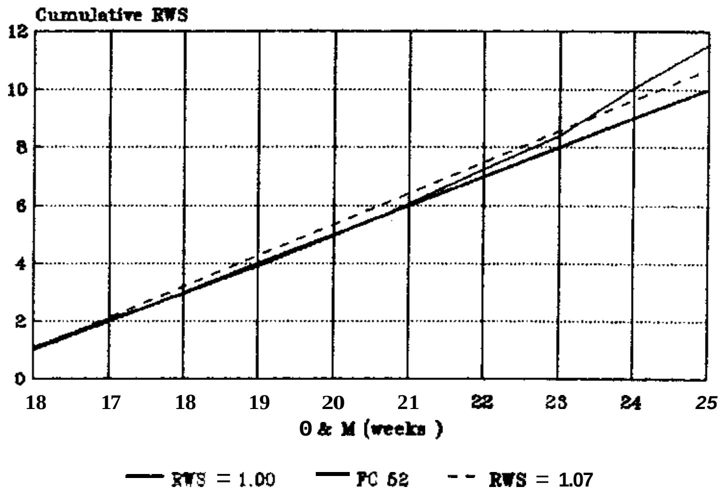


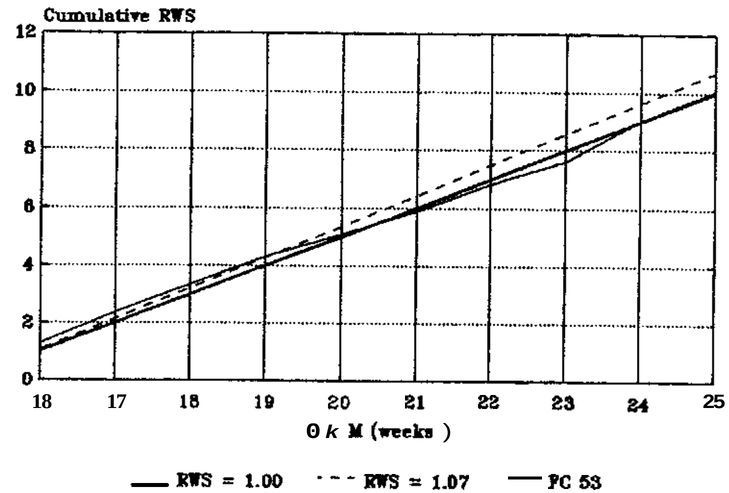
Figure 7.09 (continued)

Cumulative relative water supply RB tract 01

FC 52



FC 53



FC 54

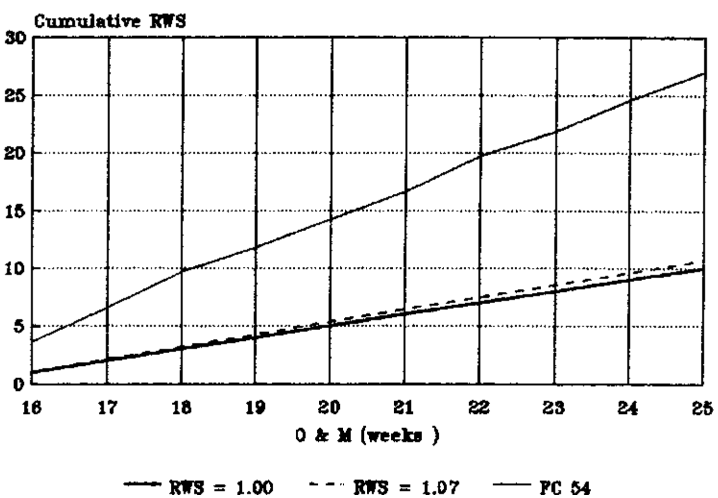


Figure 7.09 (continued)
Cumulative relative water supply
RB Tract 01

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