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Diagnostic Analysis of Minneriya Scheme, Sri Lanka: 1986 Yala Discipline Reports

Water Management Synthesis Project
WMS Report 59

DIAGNOSTIC ANALYSIS OF MINNERIYA SCHEME, SRI LANKA: 1986 YALA DISCIPLINE REPORTS

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TABLE OF CONTENTS

Section		Page
	LIST OF FIGURES	vi
	LIST OF TABLES	viii
	ACKNOWLEDGMENTS	xiv
I.	INTRODUCTION	1
II.	MINNERIYA SCHEME	3
III.	DISCIPLINE REPORTS	7
	A. Main System Engineering	7
	1. Introduction	7
	2. Methodology	8
	3. Results and discussion	12
	a. Adequacy	12
	b. Dependability	19
	c. Equity	19
	4. Conclusion and recommendations	21
	B. On-Farm Engineering	22
	1. Introduction	22
	2. Methodology	23
	3. Results and discussion	30
	a. Relative water supply	30
	b. Spatial variability of delivery	32
	c. Channel conveyance characteristics	36
	4. Conclusions: system performance, problems, and contributing factors	46
	C. Agronomy	50
	1. Introduction	50
	2. Methodology	50
	3. Results and discussion	53
	a. Unit of cultivation	53
	b. Soils	55
	c. Cropping pattern	57
	d. Cultivation season	57
	e. Land preparation	58
	f. Planting	62
	g. Fertilizer application	66
	h. Relative availability of water	71
	i. Weed control	72
	j. Pest control	74
	k. Harvesting	76
	4. Conclusions	78

TABLE OF CONTENTS (continued)

Section | Page

D. Economics 81

1. Introduction 81
2. Methodology 81
3. Results and discussion 82
   a. Land Holdings 83
   b. Livestock 87
   c. Cropping patterns 87
   d. Paddy activities 88
   e. Paddy labor 91
4. Summary and conclusions 116

E. Sociology 120

1. Introduction and methodology 120
2. Results and discussion 121
   a. Socio-economic characteristics of Minneriya farmers 121
   b. Irrigation water supply and distribution 126
   c. Farmer irrigation behavior 129
   d. Irrigation organization, farmers, and farmer associations 136
3. Summary and conclusions 143

F. Women in Development 147

1. Introduction 147
2. Methodology 148
3. Results and discussion 149
   a. Demographic information 149
   b. Activities of Minneriya women 151
   c. Home gardens and permanent tree crops 153
   d. Domestic water 155
   e. Agricultural information 157
   f. Family finances 158
   g. Society membership 161
4. Conclusions 162

IV. LITERATURE CITED 164

V. APPENDICES 167

A. Rice Evapotranspiration in Polonnaruwa Region, Sri Lanka 169
B. Presentation of Reduced Data for Minneriya Scheme 172

TABLE OF CONTENTS (continued)

Section		Page
C.	Regression Analysis of Minneriya Scheme	173
D.	Water Delivery Measurement Sites for Diagnostic Analysis of Minneriya Scheme	174
E.	Rainfall Recorded in Minneriya Scheme	175
F.	Soil Profile Descriptions, Soil Legend, and Engineering and Soil Survey Maps of Selected Fields in Minneriya Scheme	176
G.	Varietal Identification, Planting Method, Sample Yields, and Standard Deviation for Minneriya Study Area	204
H.	Organizational Framework of the Minneriya Scheme	207
I.	List of Field Investigators Involved in the 1986 Diagnostic Analysis of Minneriya Scheme	208
J.	Glossary	209

LIST OF FIGURES

Figure		Page
1	Map of Sri Lanka showing location of Minneriya Tank.....	4
2	Minneriya Scheme, Polonnaruwa District, Sri Lanka.....	6
3	Rice evapotranspiration for Polonnaruwa region, 1986 *yala*...	12
4	Sluice supply rate at Minneriya.....	13
5	Supply rates for various locations along the main channel under study in Minneriya.....	14
6	Supply hydrograph for channel D2.....	15
7	Supply hydrograph for channel D8.....	15
8	Supply hydrograph for channel D17.....	16
9	Supply hydrograph for channel D21.....	16
10	Supply hydrograph for channel D28.....	17
11	Supply hydrograph for channel D31.....	17
12	Supply hydrograph for channel D37.....	18
13	Variation of average weekly supply versus distance.....	18
14	Coefficient of variation for weekly average supply versus distance.....	20
15	The Minneriya Scheme showing location of on-farm engineering diagnostic analysis study sites for 1986 *yala*.....	27
16	Evapotranspiration rate of paddy in Minneriya Scheme.....	31
17	Hydrograph of flow rate delivered to head of field channel LPO 14, canal D21.....	33
18	Hydrograph of flow rate delivered to head of field channel RB4, canal D13.....	33
19	Hydrograph of flow rate delivered to allotment 44/7 on field channel RB2, canal D21.....	34
20	Hydrograph of flow rate delivered to allotment A on field channel RB4, canal D13.....	34

LIST OF FIGURES (continued)

Figure		Page
21	Relative water supply at sites 1 through 7 of canal D13.....	37
22	Relative water supply at sites 1 through 16 (reach 1) of canal D21.....	37
23	Relative water supply at sites 17 through 23 (reach 1) of canal D21.....	38
24	Relative water supply at sites 24 through 29 (reach 2) of canal D28.....	38
25	Relative water supply at sites 30 through 35 (reach 2) of canal D28.....	39
26	Relative water supply at sites 36 through 41 (reach 3) of canal D28.....	39
27	Relative water supply at sites 42 through 47 of canal D37...	40
28	Seasonal mean relative water supply at sites on canal D13...	40
29	Seasonal mean relative water supply at sites on canal D21...	41
30	Seasonal mean relative water supply at sites on canal D28...	41
31	Seasonal mean relative water supply at sites on canal D37...	42
32	Spatial coefficient of variation in relative water supply among sites on canal D13.....	42
33	Spatial coefficient of variation in relative water supply among sites on canal D21.....	43
34	Spatial coefficient of variation in relative water supply among sites on canal D28.....	43
35	Spatial coefficient of variation in relative water supply among sites on canal D37.....	44

LIST OF TABLES

Table		Page
1	Objectives of the on-farm water delivery system, associated performance indicators, and field data required for determination, Minneriya, 1986 *yala*	24
2	*Liyadda* water balance tests for seepage and percolation	31
3	Statistics of seasonal water supply for Minneriya Scheme.	35
4	Mean excess heights and frequency of occurence in Minneriya study *liyaddas*	44
5	Relationship between water supply and physical features of the canals on Minneriya	45
6	Summary of roughness coefficients for Minneriya study sites	46
7	Elevations of field channel bed and farm with respect to farm pipe outlet sill	47
8	Agronomy field site characteristics for Minneriya	51
9	Degree of fragmentation in Minneriya allotments during 1986 *yala*	55
10	Approximate area of each soil type expressed as a percentage of the surveyed area	56
11	The time between the first scheduled water issue and the initiation of land preparation as reported by Minneriya cultivators	59
12	The time between the first plowing and the completion of land preparation as reported by Minneriya cultivators	60
13	The time between the first scheduled water issue and the completion of land preparation as reported by Minneriya cultivators	61
14	Power sources used by Minneriya cultivators during land preparation	61
15	Land preparation operations used by Minneriya cultivators during the 1986 *yala*	62
16	Visual assessment of the quality of land preparation in paddy fields of Minneriya Scheme	62

LIST OF TABLES (continued)

Table		Page
17	The percentage of each study site planted with different paddy varieties as reported by Minneriya cultivators.....	63
18	The percentage of each study site broadcast or transplanted with either long-season or short-season varieties.	65
19	The number of days between the first scheduled water issue and completion of planting as reported by Minneriya cultivators.....	66
20	Fertilizer recommendations for paddy cultivation.....	67
21	The relative application rate of V-mixture applied by cultivators in the study area.....	68
22	The relative application rates of top dressing 1 applied by cultivators in the study area.....	69
23	Top dressing 2 applied by cultivators in the Minneriya study sites.....	69
24	Top dressing 3 applied by cultivators in the Minneriya study sites.....	70
25	Observations of soil moisture conditions as a relative percent of total observations in selected *liyaddas* in Minneriya study sites.....	72
26	The percent of fields in the Minneriya study area in which herbicides, hand weeding, or no weeding were practiced....	73
27	The percent of fields in the Minneriya study area in which herbicides or hand weeding were effective.....	74
28	The number of fields in each study area where insect infestations were observed and insecticides were applied....	75
29	The number of fields in each study area where one, two, or three or more insecticide applications were made.....	75
30	The number of days required from the first scheduled water issue to the completion of harvest as reported by Minneriya cultivators.....	76
31	The maximum, minimum, and average paddy yields in the Minneriya study area.....	77

LIST OF TABLES (continued)

Table		Page
32	Approximate distance of economic study sites from the main sluice in Minneriya	82
33	Average lowlands owned as reported by the Minneriya sample farmers	84
34	Average highlands owned as reported by the Minneriya sample farmers	84
35	Combined average lowland and highland ownership by size of holdings for the Minneriya sample farmers	85
36	Average net additional lowland transactions and total lowland areas reported by Minneriya sample farmers	85
37	Total acreage farmed as reported by Minneriya respondents.	86
38	Combined lowland and highland areas farmed by the sample farmers in Minneriya	86
39	Average labor requirements for paddy production -- overall and by head, middle, and tail as reported by Minneriya respondents	92
40	Average labor requirements for paddy production by source of supply as reported by Minneriya respondents	93
41	Average labor requirements for paddy production by gender.	94
42	Cultural practices reported by the sample farmers in Minneriya	95
43	Comparison between the most common and the most labor-intensive approaches to paddy production reported by sample farmers at Minneriya	97
44	Average variable cost of producing paddy on 4.27 ac	99
45	Average variable costs of producing paddy for Minneriya farmers who followed the predominant practice	101
46	Average net paddy yields for sample farmers according to their location and method of seeding	103
47	Average disposition of paddy overall and by head, middle, and tail farmers	105

LIST OF TABLES (continued)

Table		Page
48	Average values of paddy production overall and by head, middle, and tail farmers	105
49	Cost difference between transplanting and broadcasting paddy	107
50	Average other income accruing to the sample farmers during 1986 *yala*	108
51	Adjusted average other income	109
52	Combined 1986 *yala* incomes for the sample farmers at Minneriya	109
53	Interest rates reported by Minneriya sample farmers	111
54	Summary of the Minneriya sample farmers' costs that were additional to those involving paddy production	112
55	Net profit for the Minneriya composite farmer	113
56	Average returns to family labor in Minneriya	115
57	Net cash flow for the Minneriya composite farmer for 1986 *yala*	116
58	Distribution of respondents in Minneriya by hydrological position within the system	120
59	Location of respondents by field channels in Minneriya	121
60	Age distribution of respondents in Minneriya	122
61	Settler status of Minneriya respondents	122
62	Extent of highland cultivated as reported by Minneriya respondents	123
63	Extent of original lowland acquired as reported by Minneriya respondents	123
64	Extent of lowland cultivated as reported by respondents	123
65	Other forms of lowland tenure reported by Minneriya respondents	124
66	Sources of water as reported by Minneriya respondents	126

LIST OF TABLES (continued)

Table		Page
67	Types of water problems reported by Minneriya respondents.	126
68	Minneriya respondents' perceptions of where water problems most often occur in field channels.....	127
69	Water problems as reported by Minneriya respondents.....	127
70	Minneriya respondents' report of how they know the D-channel rotation schedule has changed.....	128
71	Minneriya respondents' perceptions of who makes changes in the D-channel rotation system.....	129
72	Minneriya respondents' perceptions of who influences the D-channel rotation system.....	129
73	Methods of obtaining highland irrigation.....	130
74	Reports of illicit tapping from Minneriya respondents by hydrological region.....	131
75	Perceptions of Minneriya respondents regarding authority to punish irrigation offenders.....	132
76	Minneriya respondents' report of irrigation structural damage by location.....	133
77	Causes of structural damage as reported by Minneriya respondents.....	133
78	Location of encroached land as perceived by Minneriya respondents.....	135
79	Responsibilities proposed by sample farmers for a formal water users' organization at the field channel level.....	141
80	Condition of irrigation structures as perceived by Minneriya respondents.....	142
81	Reasons for the current condition of physical structures..	143
82	Field sites for the 1986 *yala* WID study on Minneriya.....	148
83	Family position and marital status of Minneriya respondents.....	150

LIST OF TABLES (continued)

Table		Page
84	Age and education of Minneriya respondents.....	151
85	Primary activities of Minneriya respondents.....	151
86	Agricultural activities of Minneriya respondents.....	151
87	Off-farm, agricultural work of Minneriya respondents.....	152
88	Off-farm, non-agricultural activities of Minneriya respondents.....	153
89	Minneriya gardening activities.....	154
90	Permanent tree crops on Minneriya.....	155
91	Information about domestic water.....	156
92	Distribution of well problems by hydrological location....	156
93	Primary sources of agricultural information for Minneriya respondents.....	157
94	Occasional sources of agricultural information for Minneriya respondents.....	158
95	Sources of cash for day-to-day expenses of Minneriya households.....	159
96	Purchase of day-to-day items by Minneriya households.....	159
97	Management of cash resources in Minneriya households.....	160
98	Personal cash sources for Minneriya women..... ..	160
99	Vegetable sources for Minneriya households.....	161
100	Spending preferences of Minneriya respondents.....	161
101	Participation of Minneriya respondents in local societies.	162

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Larry J. Nelson
Coordinator of the
Diagnostic Analysis Project

I. INTRODUCTION

In Sri Lanka, the development of new irrigation systems, and the improvement and rehabilitation of old systems, are prime targets of agricultural planning. Large irrigation systems associated with resettlement projects have been constructed to extend and increase the agricultural productivity of Sri Lanka's Dry Zone. However, the operation of many of the schemes has been less than optimal, and the anticipated results have not always been realized. Consequently, new institutional policies and programs emphasize alternative strategies for improving the productivity and performance of irrigation systems.

One such plan by the Government of Sri Lanka involved creating the Irrigation Management Division (IMD) within the Ministry of Lands and Land Development (MLLD). In addition to other responsibilities, the IMD is expected to establish a system for monitoring and evaluating the performance of irrigation systems. These monitoring and evaluation methods will be based on diagnostic analysis procedures developed by the Water Management Synthesis Project at Colorado State University (Water Management Synthesis Project, 1983).

Diagnostic analysis techniques were introduced to Sri Lanka through three in-country, professional development workshops conducted in 1982, 1983, and 1984. Fundamental to diagnostic analysis is the philosophy that irrigation problems are not confined to one single discipline such as engineering or agronomy, but rather, that they involve a wide range of issues that include social and economic aspects as well. As part of the training workshops, interdisciplinary teams of participants investigated an existing irrigation system, identified constraints, and discussed various approaches to solving irrigation-related problems.

Reports from these workshops were written on the Rajangana Irrigation Scheme in 1982 (Alwis et al., 1983b) and System H of the Mahaweli in 1982 and 1983 (Alwis et al., 1983a; Jayewardene and Kilkelly, 1983). Although these reports were limited in scope due to the nature of the training workshop, they provided useful information and valuable insights into the operation of the irrigation systems studied. As a result, the MLLD recognized the benefits of this investigative approach and desired to employ these concepts as a practical, preliminary approach to identifying constraints in irrigation systems.

An opportunity to use diagnostic analysis as a tool for gathering baseline information arose with the creation of the Irrigation Systems Management Project (ISM). The ISM Project, funded by the United States Agency for International Development, proposes to rehabilitate and improve four irrigation systems in the Polonnaruwa District of Sri Lanka: Parakrama Samudra, Giritale, Minneriya, and Kaudulla.

This baseline data collection effort was called the Diagnostic Analysis Project. Diagnostic analysis was considered the most appropriate investigatory method to use: although physical improvements to the existing irrigation systems were important considerations, various socio-economic efforts were also included in the ISM Project design (Skogerboe et al., 1984).

In effect, the Diagnostic Analysis Project was designed to provide complete understanding of these irrigation systems in order to assist the ISM Project in determining pragmatic, cost-effective means for improving the operation of these systems. The collection of a reliable, extensive volume of data would provide valuable information concerning system operation. In addition, this information could later be compared to information gathered after the irrigation systems are rehabilitated and improved.

The overall objectives of the Diagnostic Analysis Project were:

1. To strengthen IMD's institutional capacity and the abilities of its associated personnel to use diagnostic analysis techniques to study existing irrigation schemes.

2. To assist in establishing a set of evaluation procedures and methodologies for continual monitoring of irrigation system operations.

3. To provide detailed background information on the selected irrigation systems for future use in rehabilitation and improvement projects.

The following report details the diagnostic analysis conducted during 1986 yala on Minneriya Scheme. The report is divided by discipline into sections on main system engineering, on-farm engineering, agronomy, economics, sociology, and women in development. An interdisciplinary discussion of the results can be found in WMS Report 61, **Diagnostic Analysis of Four Irrigation Schemes in Polonnaruwa District, Sri Lanka: Interdisciplinary Report.**

II. MINNERIYA SCHEME

The Minneriya Scheme is one of the oldest irrigation systems in Polonnaruwa District, built by King Mahasen in the 3rd century A.D. The anicut at Elahera, across the Amban Ganga (a tributary of the Mahaweli), which feeds Minneriya is called the Elahera Minneriya Yoda Ela and is considered one of the greatest engineering feats of the ancient civilizations in Sri Lanka. This feeder channel reaches 26 miles in length as it enters Minneriya Tank, and currently functions as well as it did when originally constructed.

Although never completely abandoned after the fall of the ancient civilization, the scheme was in poor condition until restored in 1950 to a storage capacity of 110,000 ac-ft. A more detailed description of the Minneriya tank and canal system is provided in the main system engineering section, with additional information concerning irrigation practices in the on-farm engineering section.

After the expansion and rehabilitation of the ancient tank was completed, approximately 2,200 allottees from the Wet Zone resettled there. The present restoration was started in the late 1930s and was accomplished in four stages. In stages 1-3, allottees were given 5 ac of irrigated lowland for paddy cultivation and 3 ac of highlands for a homestead. In stage 4, 3-ac lots were given for irrigated cultivation and 2 ac for a homestead. Although Minneriya Scheme was originally designed to serve approximately 13,500 ac, it is now estimated to serve 18,000 ac.

The Minneriya Scheme is located in the North Central Province of Sri Lanka (Figure 1) and is characterized as gently undulating Dry Zone with elevations ranging from 45-456 ft above sea level. The average annual rainfall is 58 inches, which falls predominantly during maha (wet season; October to March).

The majority of cultivated area in the Polonnaruwa District is now under a number of major irrigation schemes. Prior to this arrangement, purana (old, traditional) villages cultivated paddy and other crops using local "cascade" tank systems for water storage and irrigation. There is no rainfed paddy cultivation in yala (dry season; April to September), but a limited extent of rainfed paddy cultivation may occur during maha. Paddy is the primary crop cultivated, but small areas of subsidiary crops such as chili, tobacco, maize, soybean, cowpea, groundnut, sesame, onions, and other vegetables are grown in yala where water for field irrigation is limited.

The Polonnaruwa District has been referred to as the "rice bowl" of Sri Lanka as it has some of the highest yields of paddy throughout the island. Average yala paddy yields from 1969 to 1985 were reported to range from 69 to 102 bu/ac in maha and from 46 to 86 bu/ac in yala (Polonnaruwa Kachcheri records). The use of short-season, high

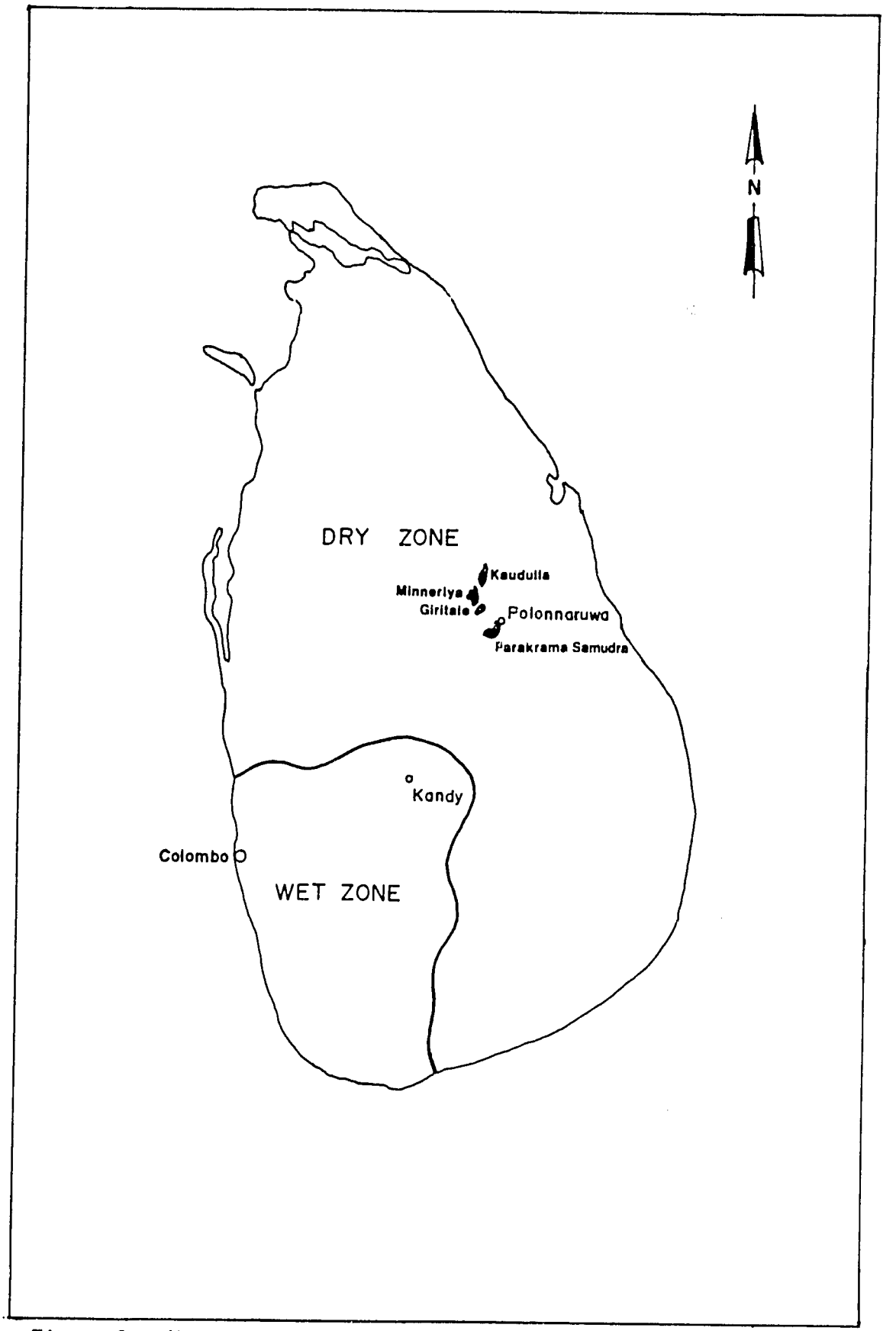

Figure 1. Map of Sri Lanka showing location of Minneriya Tank.

yielding varieties is fairly widespread. A more detailed presentation of agricultural practices in Minneriya is contained in the agronomy section.

The highland allotments generally are not well utilized due to inadequate water. Even so, most families maintain perennial trees such as coconut, banana, or jackfruit. During maha, small gardens containing a diverse mixture of vegetables are planted, but yields remain low.

In the four decades since the major tanks were restored, inmigration created by the resettlement programs and natural increases have swelled population figures for the area considerably. The 1971 population total for the Polonnaruwa District was recorded at 163,700. In 1981 the total reported was 262,800. Figures from the Department of Census and Statistics, Central Bank of Ceylon, showed a total 1984 population figure for the Polonnaruwa District of over 284,000 people. This represents approximately 1.8 percent of the total national population with a density rate of 83 persons/km^2.

The most recent growth rate figure, reported for 1983-84, was 2.2 percent, well above the national average of 1.2 percent. This population growth factor, in combination with unemployment and underemployment, has led to a concentration of low income groups in the rural agricultural sector. The difficulty of absorbing a growing labor force when few alternatives to agriculture are available is considered a serious problem in the district.

Data from the 1981 census reported a district population composed of Sinhalese (90.9 percent), Tamil (2.2 percent), Indian Tamil (0.1 percent), Moor (6.5 percent), Burgher (less than 0.1 percent), Malay (0.1 percent), and other (0.2 percent). A more detailed description of the socio-economic background of Minneriya can be found in the economics, and sociology sections.

Figure 2 shows a map of the area studied in Minneriya Scheme in 1986 yala.

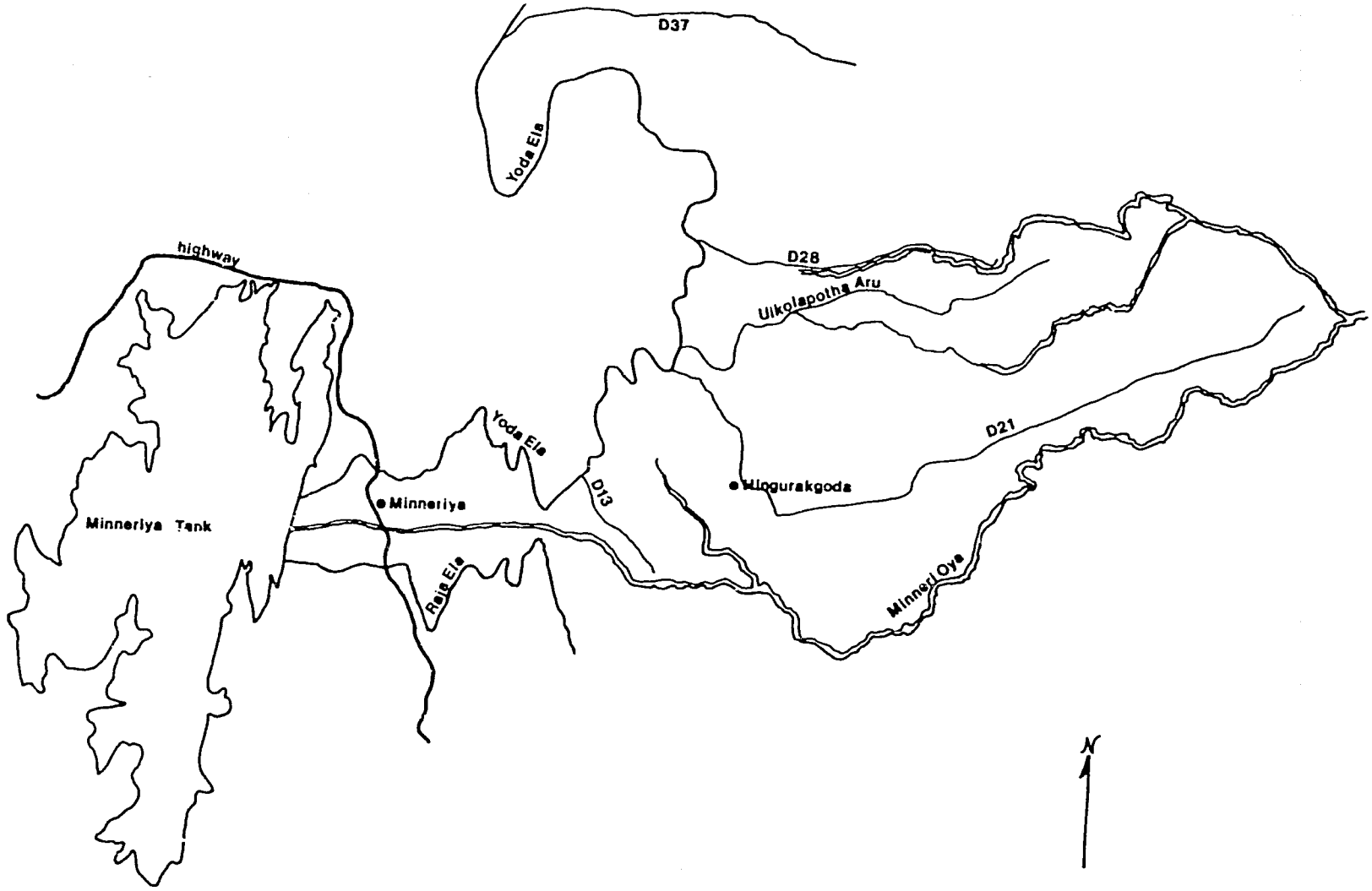

Figure 2. Minneriya Scheme, Polonnaruwa District, Sri Lanka.

III. DISCIPLINE REPORTS

A. MAIN SYSTEM ENGINEERING

1. INTRODUCTION

The objective of the main system engineering discipline was to study water delivery from the Minneriya Tank to the on-farm system. Both the physical delivery of water and the management process used to achieve the delivery of water must be evaluated in order to establish the main system's performance.

With regard to main system engineering, the performance of the main system should be evaluated according to its ability to meet the objective of providing enough water control to ensure that farmers receive water at the times and in the amounts needed. The performance of the main system can be evaluated based on four parameters: adequacy, dependability, equity, and elevation.

Adequacy is the ratio of the amount of water supplied to the amount of water required. Ratios greater than 1 indicate oversupply, and ratios less than 1 indicate undersupply. Determining the water requirement may be difficult and may require gathering a large amount of data. For this report, adequacy was determined by comparing water supply to rice evapotranspiration in Minneriya. (For some systems the amount of water required can be substituted with the amount the system was designed to supply. This adequacy ratio is appropriate for systems designed to provide supplemental or deficit irrigation.)

Dependability can be determined by evaluating the variability of adequacy over time. For this study, the coefficient of variation in the supply over time was used to describe system performance.

Equity, like dependability, can be determined by studying the variability of adequacy. However, with equity we are concerned with the variation of adequacy over the system (spatial variability). To characterize equity, the coefficient of variation in supply over the system was used.

Elevation as a performance parameter does not "fit" the other three parameters, but is nevertheless important. Elevation in this report refers to the system's ability to deliver water at a water surface elevation (head) that is adequate enough to command the fields or farms that are to be irrigated. Unfortunately, data to evaluate this parameter were not available when this report was written.

Quantifying main system performance through diagnostic analysis can provide system managers with data for making appropriate improvements. Describing the main system performance demonstrates the constraints on, and positive aspects of, the system. While the

constraints within Minneriya Scheme may be similar to other systems, quantifying performance allows one to rank the problems in order of their severity. The priority problems and strengths of a system make that system unique.

The Minneriya Scheme currently commands approximately 18,000 ac (estimate compiled from an earlier study of aerial photos). Almost all land is devoted to growing paddy.

Besides its own catchment area, the Minneriya Tank receives water supplies from the Mahaweli River. Releases to irrigated lands are through two sluices on the tank. One, the Raja Ela, supplies water to about 1000 ac. The other sluice supplies water to the Minneriya Yoda Ela (17,000 ac), which was the canal studied during the diagnostic analysis.

The Minneriya Tank also supplies water to the Kaudulla Tank and the Kantalai Tank. These diversions were made via two gated spillways.

The original scheme was designed for a canal capacity of 1 cfs for 40 ac of commandable area. Over time, the command area of the scheme has almost doubled to the current 18,000 ac. Therefore, the original capacity is not adequate to meet the new irrigated area. The increase in acreage has come from farmers extending their irrigated lands into right-of-ways and into land not considered commandable originally.

The increase in area has required imposing a rotation schedule along the main channel. The main channel has continuous flow, and the flow into distributary channels (D-channels) is rotated. The rotation schedule is weekly with D-channels receiving water 3.5 days each week. Two channels -- D21 and D28 -- have an increased allocation of 1.5 days due to their long lengths. Therefore, D21 and D28 should receive water for 5 days each week.

2. METHODOLOGY

To understand how the system operates and to identify both strengths and constraints, it was decided to collect data on water deliveries to points along the Yoda Ela and along several of the D-channels. Sixty-three measurement (sampling) points were selected. Of these 63 points, 45 were analyzed. The others were discarded for various reasons.

The flow was measured by using a staff gauge installed in the channel. The staff gauge reading (in feet) was converted to flow rate. The gauge reading was calibrated to a flow rate by measuring the flow rate in the channel with a current meter. The current metering was done during several (usually three) gauge readings. Failure to make current meter determinations of flow rate or an inability to establish a suitable staff gauge/flow rate relationship was one reason some of the measurement points were discarded.

a. Acreage

The acreage commanded by each measurement point is critical to the analysis of the data. The area of command for each point is used to convert flow rate (cubic feet per second, cusecs) to a supply rate (millimeters per day, mm/day). The supply rate allows for a comparison of the measurement points.

The acreage was difficult to accurately determine. Most of the acreage figures used in this analysis came from the revenue record of the Irrigation Department, although some of the area has been surveyed using aerial photographs. When possible, the aerial photographic acreage values were used for analyses.

b. Distance

Distances along the channels from the main sluice were obtained from Irrigation Department records. The distance values were used to evaluate variations in supply with distance along the channels.

c. Staff Gauges

Staff gauges were located along the main channel at all division points to measure the discharge from the main channel into each D-channel. Also, staff gauges were installed in the main channel at various other locations along its length.

Staff gauges were installed along D-channels 8 and 28. To measure diversions from the D-channel to smaller bank channels, a cutthroat flume or a long-throated (broad-crested weir type) flume was used. These two types of flumes have established head-discharge relationships. Therefore, gauge readings can be directly converted to flow rates.

The staff gauge and flume gauge readings were taken daily after the devices were installed. Most readings on the Minneriya Scheme started on 5 June 1986 or 6 June 1986. However, due to delays, not all devices were installed at the same time, which meant that some readings did not start until later. All measurements ended on 31 August 1986.

d. Recording and Analysis of Data

Data were collected by Irrigation Department personnel assigned part-time to the Diagnostic Analysis Project. The data were recorded in field books and then transferred to data sheets for entry into a microcomputer. Most of the data were analyzed on the computer. Calculations performed were simple mathematical and statistical manipulations. For instance, flow rates and acreages were converted to supply rates. The basic equation is:

$$qt = k\ dA$$

$$A/q = \frac{t}{kd}$$

where

q = flow rate
t = time
d = depth of water per unit area
A = area
k = constant for unit conversion

Therefore, d/t is the supply rate in millimeters per day. The term A/q is referred to as water duty and at times is presented as acres per cusec (i.e., 40 ac/cusec).

The statistical calculations used were the average, standard deviation, and coefficient of variation. Also, a regression analysis was performed on some data. However, the coefficient of variation (CV) is the most important measure presented in this report.

To evaluate performance, a standard or reference criterion must be selected to show how much variation can be expected or accepted in an irrigation system. A rule of thumb used by engineers to evaluate, and sometimes design, systems is to allow 10 percent variation from a design value. In a discussion on maintenance of irrigation systems, FAO (1982) states that a 10-20 percent reduction in absolute efficiency with respect to the design is normally acceptable before maintenance is required.

For the purposes of this report, a value for the coefficient of variation of 0.15 or less was considered good. This states that the ratio between the standard deviation of the supply rate and the mean supply rate is 15 percent for the sample. Values greater than 0.15 were judged as indications of areas where improvements were needed.

CV is defined as equal to the standard deviation divided by the average, where both the average and the standard deviation refer to the sample. The coefficient of variation is dimensionless, which allows for comparisons not only within a system, but also among systems. In our case, average was the mean of a supply rate over a time period, or over an area, with the standard deviation being of the mean supply rate.

Regression analysis can indicate a relationship between independent and dependent variables. The relationship is determined by selecting a model and then testing the strength of the relationship or model. For this study, the following was selected as the model:

$$y = bx + c$$

The strength of the model is determined by the correlation coefficient, which is computed from the sample data. The correlation coefficient is usually designated as r^2.

To determine the water requirement for the system and for the command area of each measurement point, the following equation was calculated:

Requirements = ET + losses - inflow

where

losses = (on-farm losses) + (main system losses)

inflow = rainfall + other inflows to the system

To determine on-farm losses, the on-farm system must be evaluated. The on-farm section of this report presents the calculations for relative water supply and water use efficiency.

For the main system losses, information on conveyance losses in the system's channels was needed. Unfortunately, the engineering team did not directly measure conveyance losses. However, some data collected could be used to calculate conveyance losses on the system. Due to time limitations, these calculations were not performed.

When discussing main system losses, some idea of the operational losses to be expected is needed. Operational losses include those due to channel filling, and losses due to opening and closing gates and the subsequent loss of tail water. While these losses could all have been estimated, it was decided to evaluate the supply rate information directly, without guessing on the other factors. Therefore, the results section of the main system engineering report presents an evaluation of supply rates on the system compared to evapotranspiration for rice.

e. Problems, Limitations, and Strengths of the Diagnostic Analysis Study

To study and evaluate the Minneriya Scheme, more physical, management, and operational data should have been collected. For example, the physical condition of the hydraulic structures within the system needed to be evaluated. Unfortunately, this type of evaluation was not conducted. Also needed was some insight into the management decision-making process; for instance, determining what the rationale was for establishing the rotation schedule.

On the positive side, much data was collected, which should provide a good database for system managers to make appropriate improvements. In addition, personnel assigned to the project gained some valuable training and knowledge about the operation of their system. The staff who helped with the diagnostic analysis will be helping to operate and rehabilitate portions of the scheme.

3. RESULTS AND DISCUSSION

The data analysis that follows is devoted to establishing the performance of the Minneriya Scheme by discussing adequacy, dependability, and equity.

a. Adequacy

Rice is the major crop grown on the Minneriya Scheme. Figure 3 and Appendix A present daily rates for rice evapotranspiration (ET) in the Minneriya Scheme.

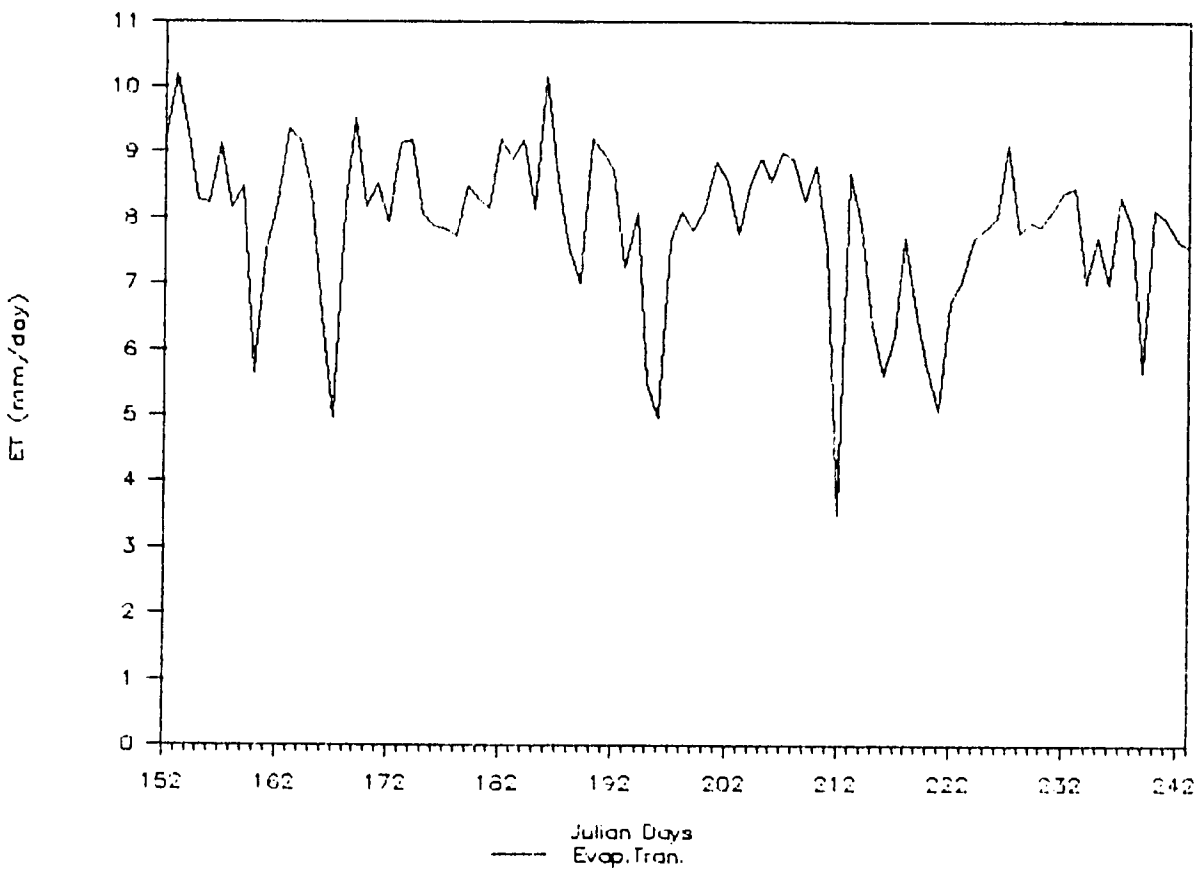

Figure 3. Rice evapotranspiration for Polonnaruwa region, 1986 yala.

Comparing Figures 3 and 4 indicates that the overall supply rate of the system is slightly less than the evapotranspiration rate of rice per day. The sharp dips in the graph represent dates of sluice gate closures due to rainfall. Figure 3 shows the evapotranspiration of rice for a period closely corresponding to the study period on the Minneriya Scheme.

The data analysis depicted in the above figures shows that overall supply to the Minneriya Scheme cannot meet the evapotranspiration

requirement for a rice crop. If system losses are added to evapotranspiration to obtain overall system requirements, then the water supply from the sluice cannot adequately meet crop needs for the scheme's approximate 18,000 ac of rice.

Figure 5 presents the hydrographs for supply rates along the main channel studied on the Minneriya Scheme. As can be seen in the graph, as the distance from the sluice increases, the fluctuations in supply increase. The general trend is for the average supply rate to increase with distance. The higher average is probably partly due to the Irrigation Department's underestimate of irrigated acreage -- the Irrigation Department's records were used to calculate supply. The increase of wide fluctuations with distance from the sluice is a consequence of hydraulic variations due to the upstream rotation schedule implemented along the main canal.

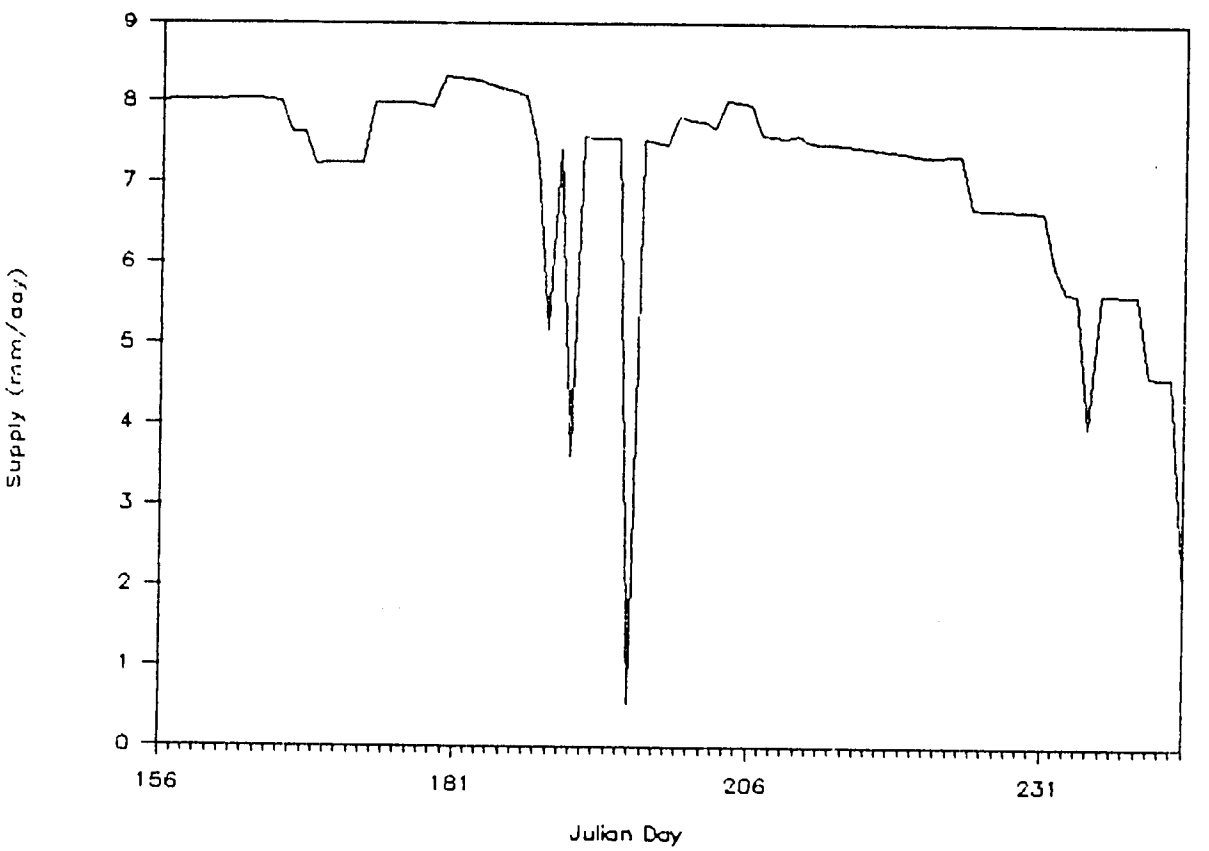

Figure 4. Sluice supply rate at Minneriya, 1986 *yala*.

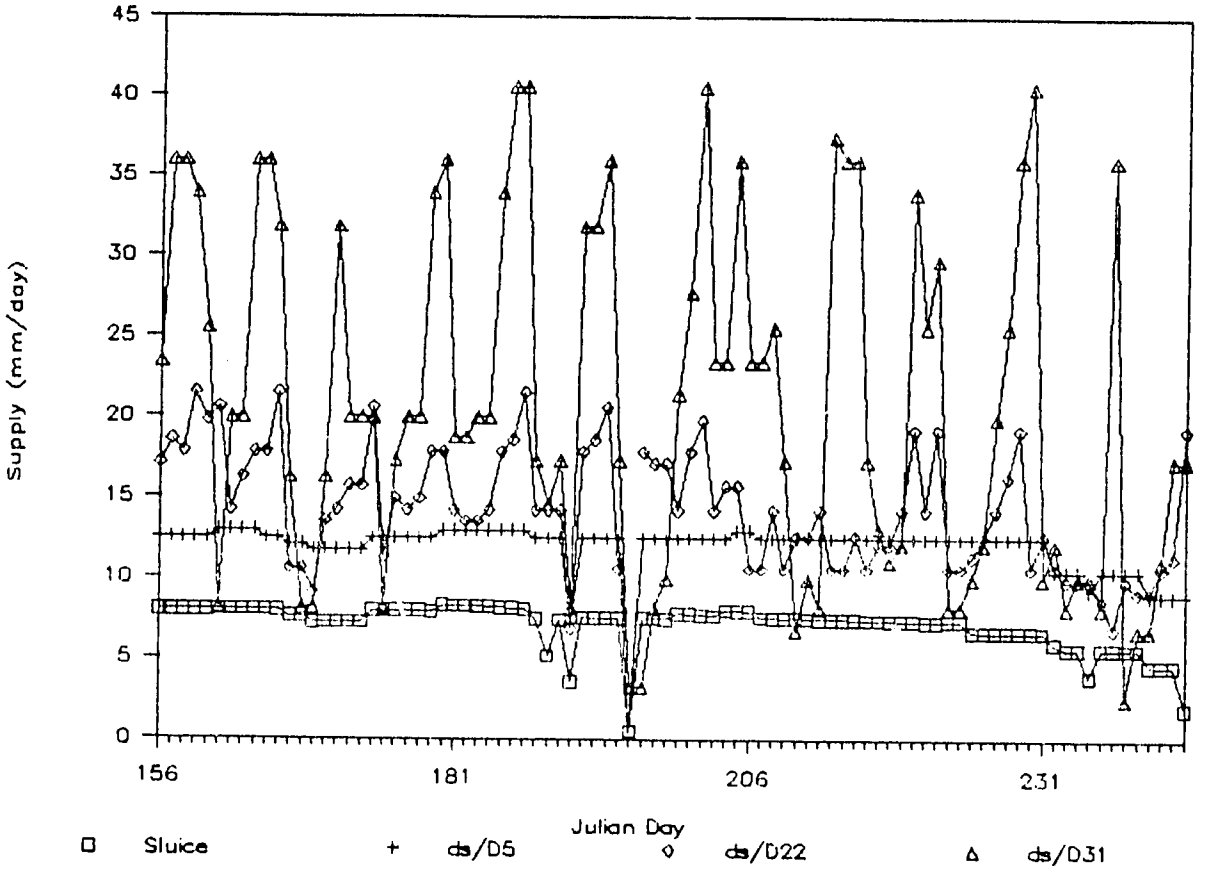

Figure 5. Supply rates for various locations along the main channel under study in Minneriya, 1986 yala.

The water supply to several D-channels and the supply variation is presented in Figures 6 through 12. The general tendency was for fluctuations to increase with distance from the sluice. Once again, supplies relative to requirement appeared to be nearly adequate compared to evapotranspiration rates only.

Appendix B summarizes the results for all the measurement points. By inspecting the average daily and weekly supply rates, it can be seen that most values are greater than the evapotranspiration requirement for the system (approximately 9 mm/day, including a value for percolation and seepage at the field).

If it is assumed that overall system efficiency is 50 percent -- which is typical of good surface delivery systems -- then the requirement becomes approximately 13.5 mm/day. Of the 34 D-channels listed in Appendix B, 13 have supply rates less than the estimated requirement. Figure 13 graphically depicts this finding.

Channels D14, D27, D36 and D37 are notable in that their supply rates are very low. The weekly average supply rates for the above channels are in the range of 3.3 to 5.7 mm/day, well below the evapotranspiration requirement for rice (Appendix B). Note that some

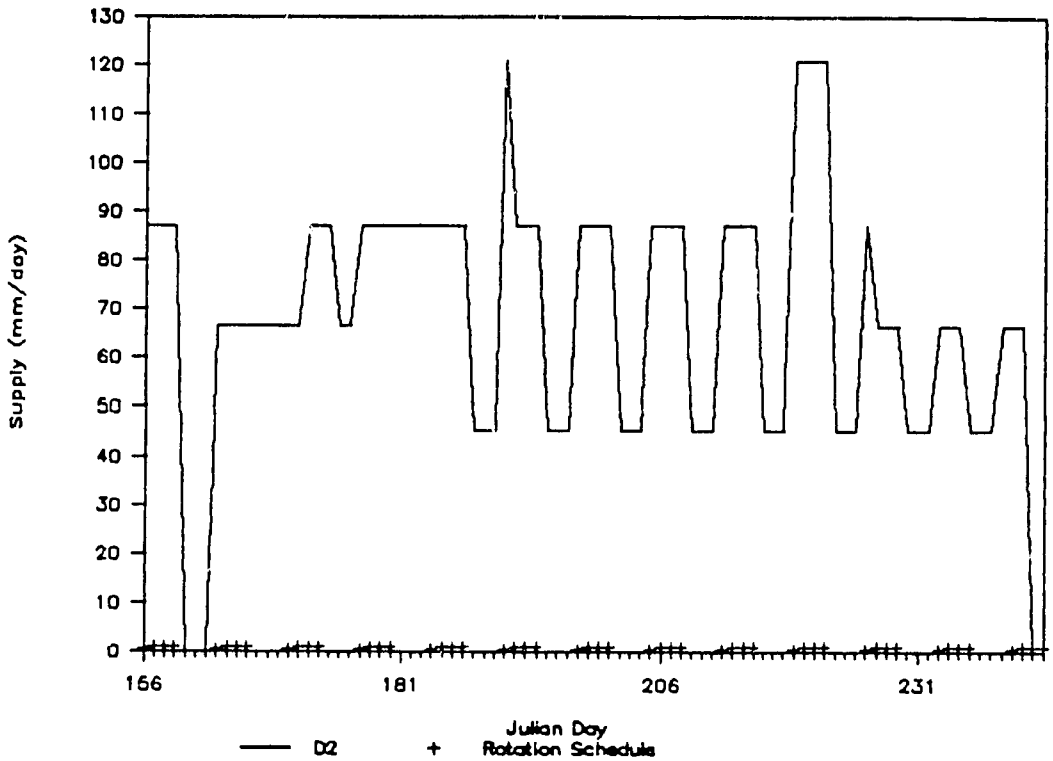

Figure 6. Supply hydrograph for channel D2, Minneriya, 1986 yala.

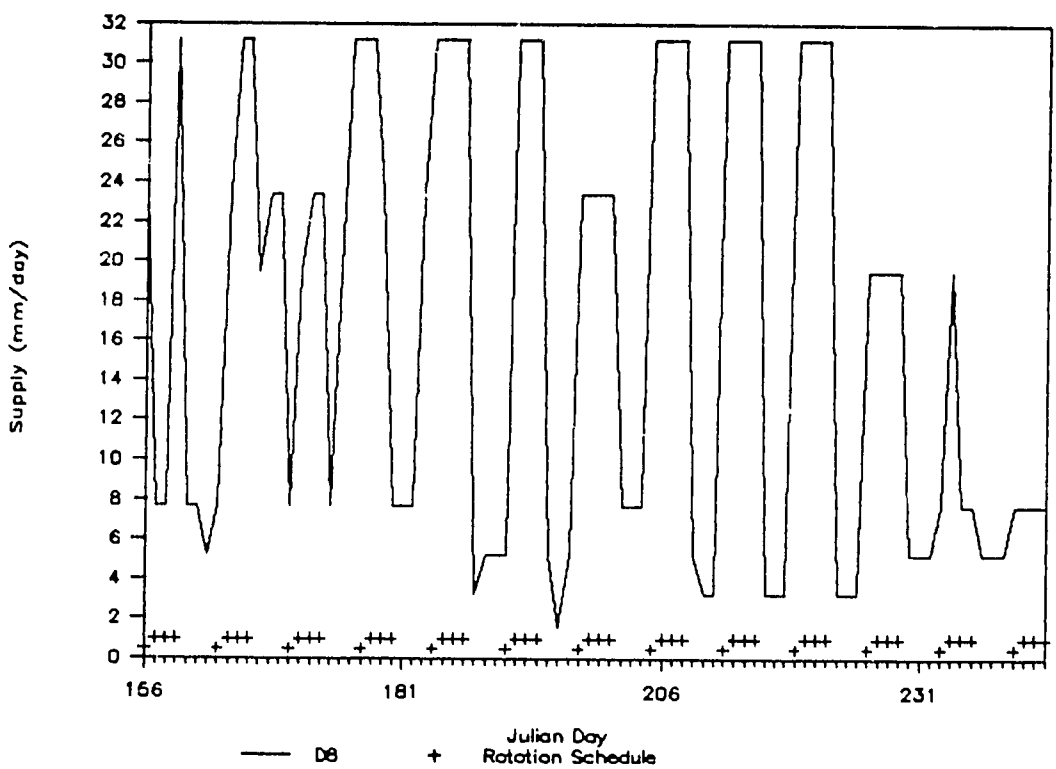

Figure 7. Supply hydrograph for channel D8, Minneriya, 1986 yala.

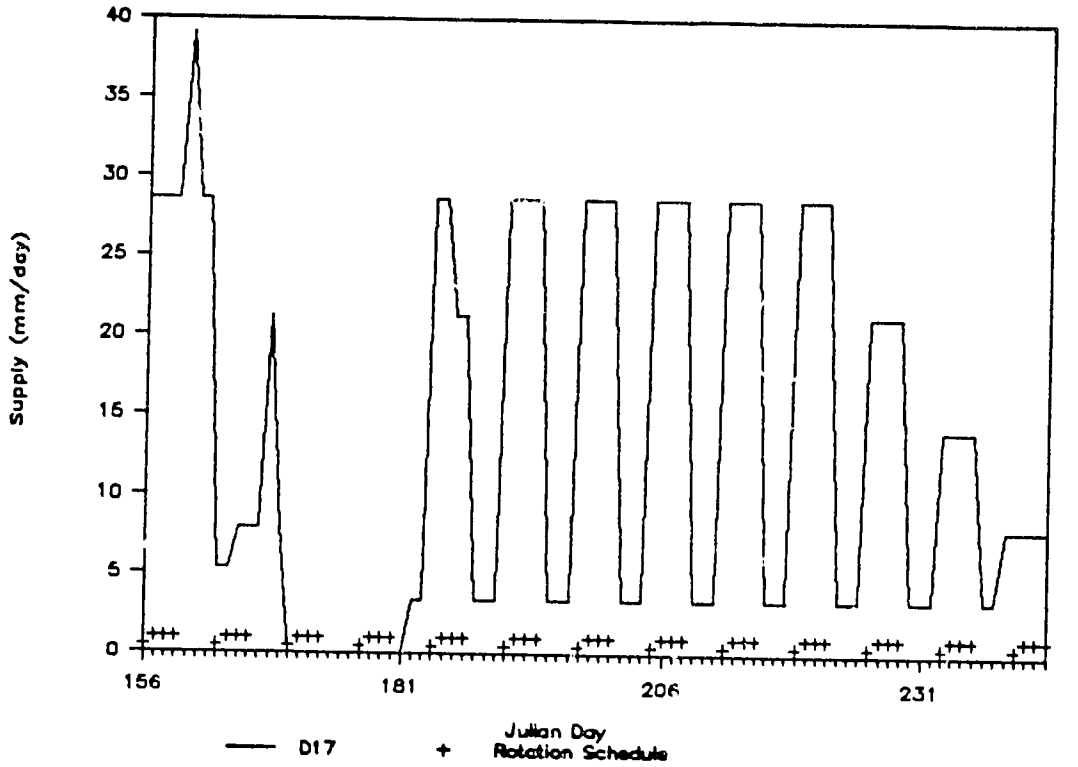

Figure 8. Supply hydrograph for channel D17, Minneriya, 1986 yala.

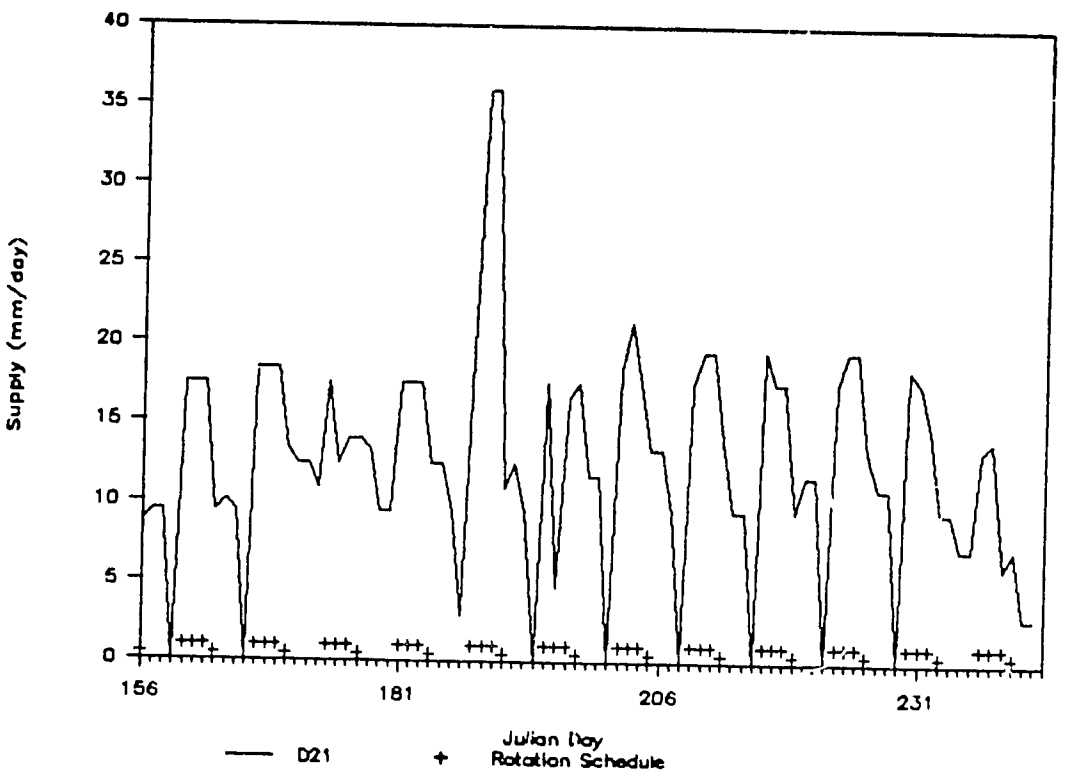

Figure 9. Supply hydrograph for channel D21, Minneriya, 1986 yala.

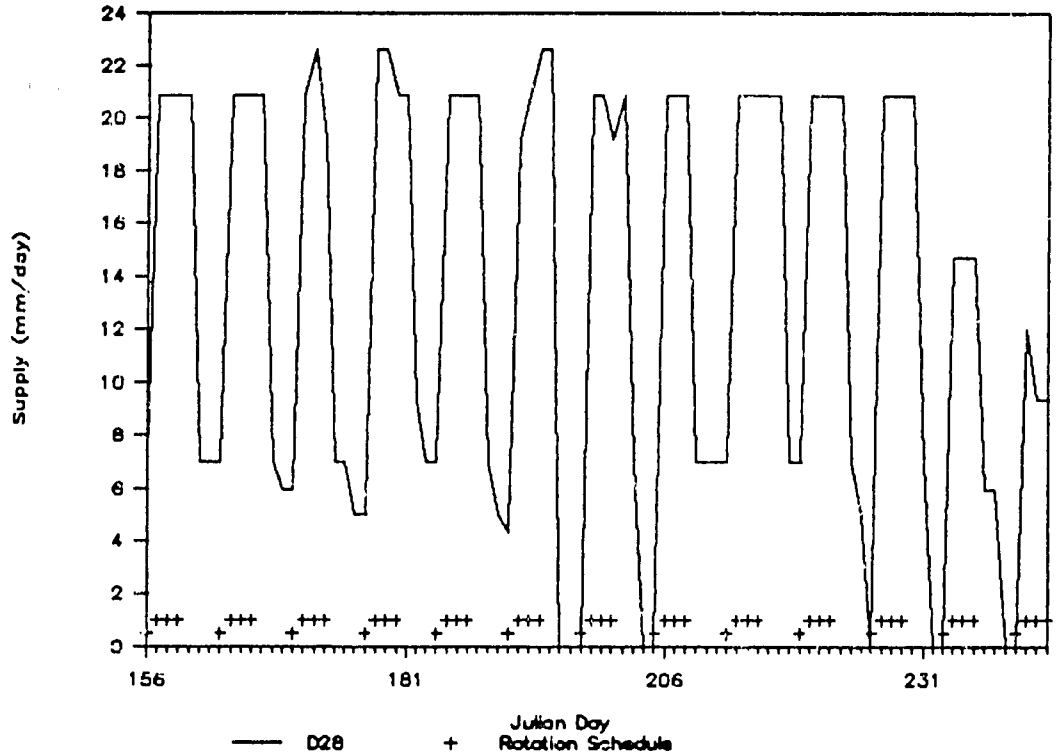

Figure 10. Supply hydrograph for channel D28, Minneriya, 1986 yala.

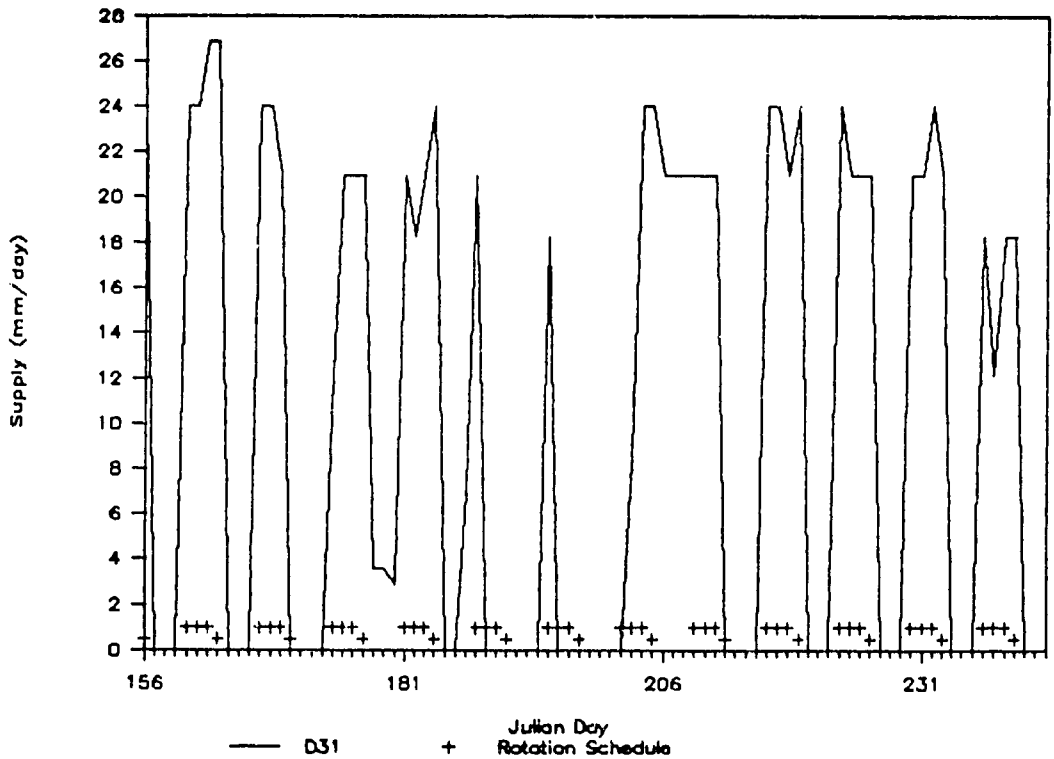

Figure 11. Supply hydrograph for channel D31, Minneriya, 1986 yala.

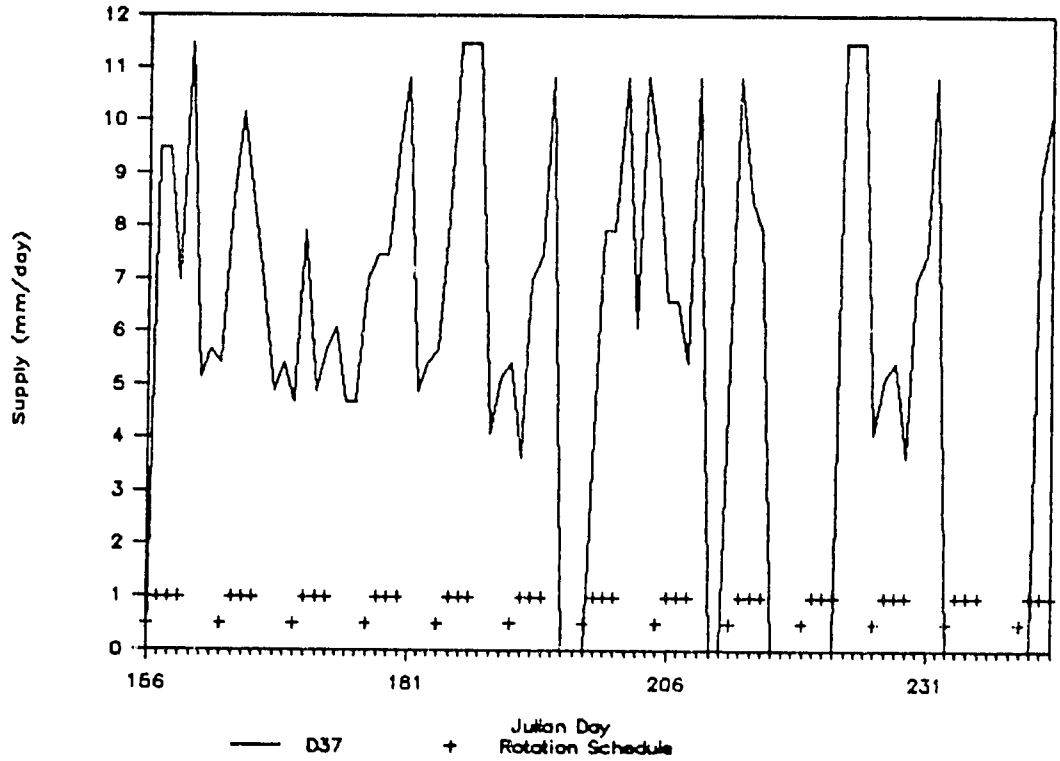

Figure 12. Supply hydrograph for channel D37, Minneriya, 1986 yala.

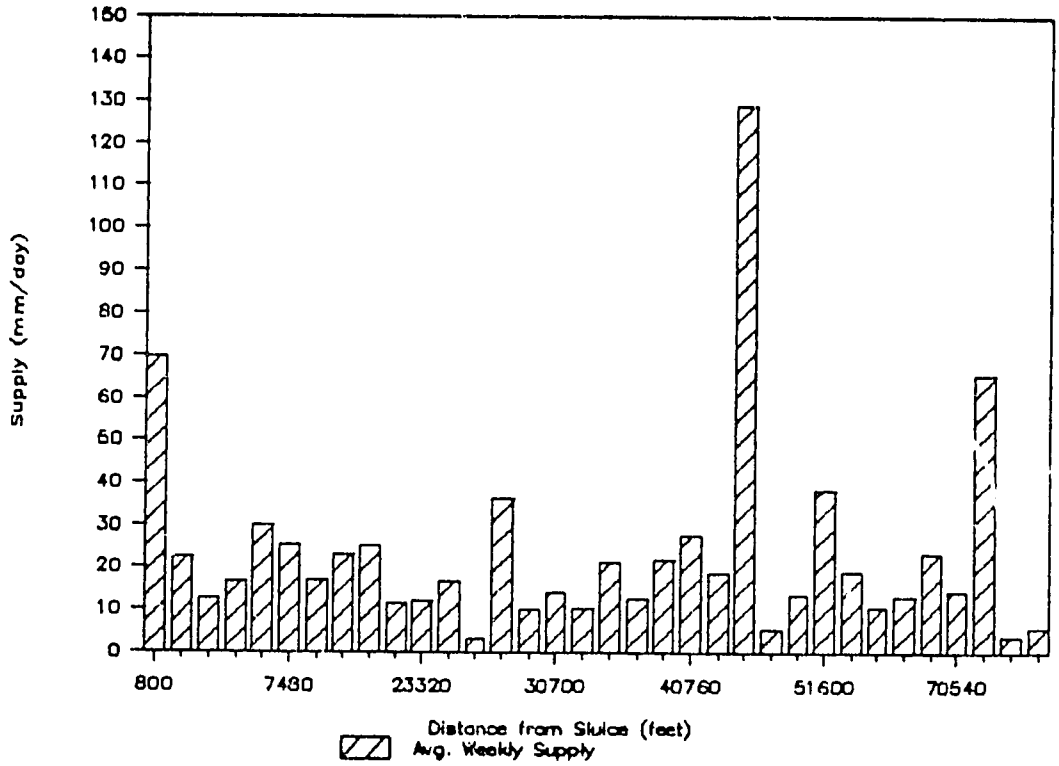

Figure 13. Variation of average weekly supply versus distance, Minneriya, 1986 yala.

farmers were irrigating with water from drains and using return water from other D-channels. This water supply to farmers was not measured.

b. Dependability

The coefficients of variation are presented in Appendix B for the average daily and average weekly supply rates. The coeffi- cients of variation for the weekly average supply rate are more meaningful values since the week corresponds to the rotation period. A review of the table reveals that 28 of the 34 D-channels have coeffi- cients of variation (CV) greater than the standard of 0.15, which indicates than even weekly average supply rates fluctuate widely.

The CVs for the sluice and the three measurement points along the main channel are relatively small, ranging from 0.07 to 0.18 just downstream of D31. It appears that the major factor contributing to the large CVs among the D-channels is the rotation schedule. The hydraulic fluctuation created by opening and closing gates to D-channels causes discharges to vary into the channels. Fluctuations occur because the regulating structures on the main channels are not adjusted or they are non-functional.

Another problem that can be seen from the hydrographs presented in Figures 6 to 12 is that gates to D-channels do not appear to be completely closed during the off period of a rotation. The plus signs along the x-axis indicate days that the particular D-channel was to receive water supplies. In most cases, the rotation was followed to a limited extent. The supply to D-channels decreased on the days when the supply was to be off for each D-channel, but in most D-channels the gate was not totally closed. Whether the incomplete gate closure was due to damaged structures or lack of discipline was not known.

From the dependability point of view, it is important that the rotation was followed because farmers could usually expect the D-channels to be operating during their respective rotation period.

c. Equity

Equity may be the most controversial of the parameters. The only intent here is to quantify the distribution of water supplies over the system. However, an assumption is made that D-channels, and subsequently, farmers, receive proportional allocations of water based on area. This is probably a valid assumption given that the Minneriya Scheme is essentially a one-crop system. The problem as stated above is to accurately and fairly determine commandable area.

A review of Figure 14 shows how the coefficient of variation varies with distance along the main system. Each bar in the graph represents the CV of the weekly average water supply for a D-channel during the diagnostic analysis on the Minneriya Scheme.

While the graph indicates inequity over the system, there is no consistent pattern in the distribution of the CV with distance. The CVs vary from a low of 0.11 to a high of 0.98, with the average system-

wide CV being equal to 0.28. The value 0.28 is greater than the standard (0.15) proposed above.

The major finding here is that there was considerable variation in supply over the system. The major factors contributing to inequity in the supplies were the rotation schedule implemented along the main channel and the failure to close gates on D-channels when the rotation required gate closure.

No pattern of inequity emerged from head to tail, according to Figure 14. Even so, several regression analyses were performed on measured variables to establish whether or not a pattern existed concerning water supplies throughout the system. The regression analyses are presented in Appendix C.

The four regression models that were analyzed are presented in each quadrant of the table. The regressions were done with the independent variable being distance in feet of each measurement point from the main sluice. The dependent variable was different in each model. The four dependent variables chosen were average daily supply rates, average weekly supply rates, standard deviation, and CV of the weekly supply rates.

No relationship (as determined by r^2) was found between the variables analyzed. By extension, there was no pattern to the variability in supply over the system. However, there was still great variability in supply over the system as measured by CV.

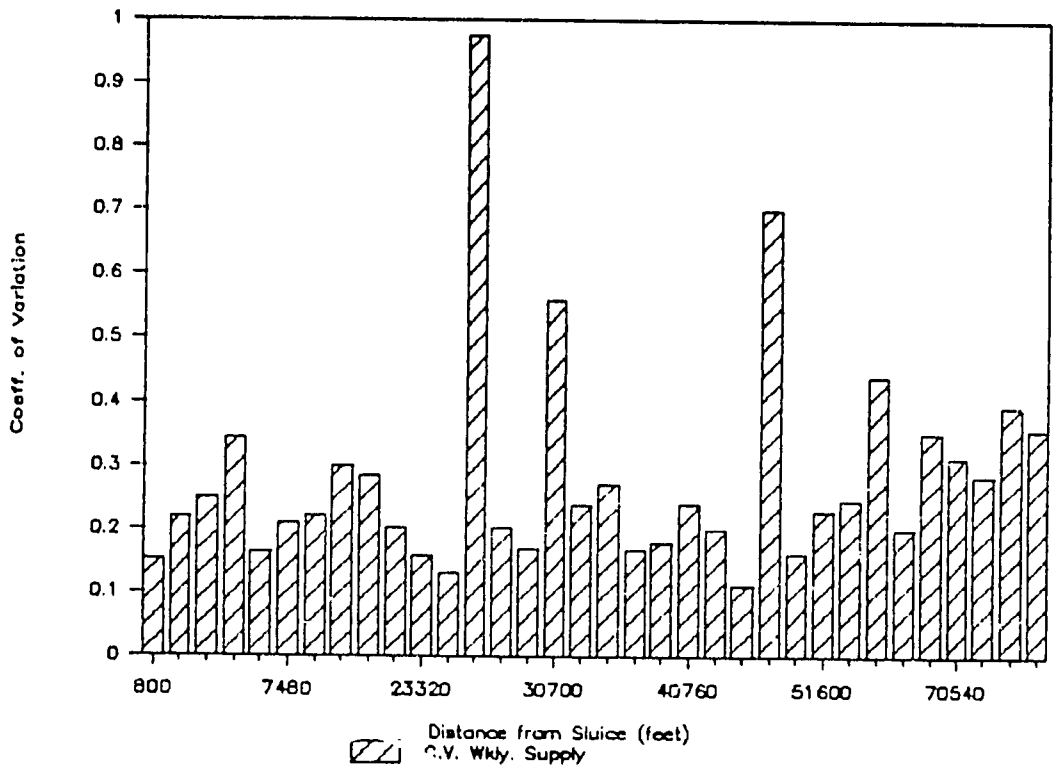

Figure 14. Coefficient of variation for weekly average supply versus distance, Minneriya, 1986 yala.

4. CONCLUSION AND RECOMMENDATIONS

Overall, the system cannot meet the crop water requirement without creating some inequities. The command area is too large for the supply being provided. Farmers have managed to expand their irrigated acreage by using return flows and drainage water. Given that their current best estimate of acreage (18,000 ac) is reasonably accurate, the water supply rate of the scheme is 10.7 mm/day. Comparing the average supply during the time period studied to the 7.92 mm/day average ET for rice for the same period shows that the supply is inadequate if all conveyance and operational losses are added to evapotranspiration.

While the rotation schedule was followed somewhat, it was not totally implemented. The gates of some D-channels were left partially open so that they flowed continously, albeit at sometimes lower flows. The D-channels near the tail of the system experienced large fluctuations in supply; partially due to the rotation, but possibly partly in response to the low average supply during each rotation. It appeared that an oversupply was provided in an attempt to mitigate the low average weekly supply. It is hypothesized that this oversupply may be helping tail farmers along D-channels. The oversupply increases return flows to D-channels and drainage water, which tail farmers use for irrigation. Therefore, the rotation itself was dependable. However, steady supply rates were poor.

Equity in distribution of water supplies over the system was also poor. The average CV for all weekly average supply rates (0.28) was high, which indicates a large variability in supply. However, there seemed to be no pattern to the inequity. That is, some D-channels received considerably more or less water than other D-channels. However, there was no pattern or concentration of "poor" areas and "good" areas (i.e., head and tail differences were not present on the Minneriya main system with respect to water supply).

The rotation schedule seemed to strongly affect adequacy, dependability and equity. The rationale for the rotation needs to be examined and possibly modified. It was the rotation that caused hydraulic transients in the main channel, which affected the discharge into D-channels. Large operational losses occur when D-channels are filled each rotation. The possibility of rotating along D-channels should be studied, especially after farmers have formed associations. Such a rotation may operate more efficiently. Extending the rotational "on" period may also improve performance. The constraining factors are the storage capacity of Minneriya Tank and inflows and outflows to and from other systems.

Some consideration must be given to the influence of the rotation on the average supply rate if there is no accompanying increase in system capacity, reduction of irrigated acreage, or change to crops that have a lower water requirement.

B. ON-FARM ENGINEERING

1. INTRODUCTION

If irrigation water use is to be improved in Sri Lanka, the water delivery system and the on-farm irrigation system must be viewed as an integrated whole. To take full advantage of water supplied, farm irrigation systems need to be properly designed, and farmers must be helped to improve their skills of irrigation scheduling and water application. Good water management on the farm requires that a dependable supply be available to irrigators when they need it and in the amount they need. If the on-farm water delivery system fails to meet this requirement, it imposes constraints that hinder agricultural production.

Existing on-farm irrigation systems can be evaluated by studying their performance in the field. After defining system boundaries, measurements of system parameters are made. When the field data are summarized and analyzed, they provide descriptive information on the system as it exists and operates in the field. However, the adequacy of the system cannot be appraised unless system objectives have been clearly defined. With system objectives in mind, the investigator can initially identify the primary problems that might be preventing the objectives from being met. This diagnostic analysis of the system is a prerequisite to considering alternatives for system renovation.

a. Objectives of On-Farm Water Delivery

The purpose of any scheme of irrigated agriculture is to produce a bountiful harvest for the benefit of man -- the farm family and the wider market it serves. An on-farm water delivery system serves this purpose by supplying the required amount of water at the appropriate rate, at the appropriate time, and at the appropriate place. This implies several objectives for the system.

The first objective is adequacy: the flow must be the needed amount delivered at the right rate and at the right time. The flow rate must be large enough to deliver the water required by the crops during the time available for irrigation. The amount of water needed in an irrigation system varies with location and time as a function of crop type, stage of crop growth, soil properties, climatic conditions, and other factors. If the water supply is inadequate, crops may suffer stress, resulting in unacceptable reduction in crop yields.

A second objective of the on-farm water delivery system is equity. The spatial variance of water deliveries along the canal network should be minimized so that each irrigator receives a fair share.

Efficiency is a third objective of the system. In a region like the Dry Zone of Sri Lanka, where water at times limits production, irrigation should be practiced in a manner that conserves valuable water resources.

Reliability, the fourth objective, is closely related to the first two. Reliability means that water is delivered to farms in a quantity and on a schedule that are pre-set and known by farmers and system operators. It has been argued that this objective is the most important, for without reliability the farmer cannot plan his irrigations intelligently and use the water effectively. Also, an unreliable water supply hinders other critical farming practices (cultivation and application of fertilizers and herbicides, among others) which must be scheduled around or in conjunction with irrigations.

2. METHODOLOGY

The following sections of this report describe the procedures, results and conclusions of a diagnostic analysis of on-farm water delivery in the Minneriya Scheme in Polonnaruwa District of Sri Lanka. The aims of this study were to derive indicators of system performance from field data, use these indicators to evaluate the system in light of its objectives, and identify any major problems in the system along with the factors contributing to those problems. The performance indicators selected for this study were associated with the four objectives of the on-farm water delivery system mentioned above. Table 1 lists these objectives along with the field data required, as discussed below.

The relative water supply (RWS) was used to indicate how well the system meets the objective of providing an adequate water supply. It was defined as the ratio of water supplied to water required:

$$RWS = IR/(ET + S + P - RN)$$

where

IR = irrigation water delivered (L^3),

ET = evapotranspiration of the crop (L^3),

S = lateral seepage flow across the boundaries surrounding the command area to adjacent sites and seepage from field conveyance channels (L^3),

P = subsurface percolation to groundwater (L^3), and

RN = effective rainfall (L^3).

In submergence agriculture, where the soil profile is maintained at or near saturated conditions, seepage and percolation losses are considered unavoidable and, hence, a part of the water requirement. When the value of RWS was less than 1.0 for any given time period, the water delivery during that time period was considered inadequate.

Equity was evaluated by studying the spatial distribution of water supply relative to water requirements within a network. A suitable performance indicator is the spatial coefficient of variation ($CV(\bar{x}$ RWS) in RWS over the domain of a distributary canal network defined as:

$CV(\tilde{x})_{RWS} = STD(\tilde{x})_{RWS}/MEAN(\tilde{x})_{RWS}$

where $STD(\tilde{x})_{RWS}$ = sample standard deviation of the distribution of RWS at delivery points within a distributary canal network.

$MEAN(\tilde{x})_{RWS}$ = sample mean of the distribution of RWS at delivery points within a distributary canal network, and

$\tilde{x}$ indicates that the sample was taken over points in space at a given point in time.

Table 1. Objectives of the on-farm water delivery system, associated performance indicators, and field data required for determination, Minneriya, 1986 yala.

System Objectives	Performance Indicators	Data Required
Adequacy	Relative water supply (RWS) (ratio of water supplied to water required).	Amount of water required; (evapotranspiration + losses - rainfall). Amount of of water supplied.
Equity	Coefficient of variation between delivery points within a network.	Spatial distribution of amount of water required and amount of water supplied.
	Trends in spatial variability (dependence on position of delivery points along network).	
Efficiency	Water use efficiency (WUE) (ratio of water required to water supplied).	Amount of water required; (evapotranspiration + losses - rainfall). Amount of water supplied.
Reliability	Coefficient of variation in RWS over time at delivery points.	Temporal distribution of amount of water required and amount of water supplied.

The coefficient of variation is a dimensionless quantity that is normalized relative to the mean value of the observations. Hence, it was a suitable measure for comparing the spatial variability occurring at different points in time or in different canal systems.

A distributary canal network that meets water requirements with perfect equity would have a value of $CV(\bar{x})_{RWS}$ equal to 0. The higher the value of $CV(\bar{x})_{RWS}$ for any period of time, the higher the spatial variability, and hence the inequity, in water delivery.

Spatial variability in on-farm water delivery often exhibits trends within a distributary canal network. That is, the degree to which the water requirement is met at a given delivery point may depend on the location of that delivery point within the canal network. An indication of such trends may be obtained by comparing the values of RWS over an irrigation season at delivery points located upstream in a system (at the head of the canal or farm channels) with the values at points located downstream (at the tail of the canal or farm channel).

The performance indicator to use to assess the efficiency of the on-farm water delivery is water use efficiency (WUE). This parameter is commonly used to evaluate lowland flooded paddy and is defined as:

$$WUE = (ET + S + P - RN)/IR$$

The term expresses the ratio of system output (in this case, useful water consumed as crop evapotranspiration and unavoidable losses, adjusted by rainfull supply) to system input (irrigation water supplied). Hence, the higher the value of WUE is, the more efficiently the system supplies the water demand. In cases where the water delivered was insufficient to meet the requirement, the WUE was assigned a value of 1.0.

A measure of system reliability is the coefficient of variation ($CV(\bar{t})_{RWS}$) in the relative water supply over time at a given point in the system:

$$CV(\bar{t})_{RWS} = STD(\bar{t})_{RWS}/MEAN(\bar{t})_{RWS}$$

where

$STD(\bar{t})_{RWS}$ = sample standard deviation of RWS over observations made at several points in time,

$MEAN(\bar{t})_{RWS}$ = sample mean of RWS at a given delivery point in the system made at several points in time, and

$\bar{t}$ indicates that the sample was taken over time at a given point in space.

At a given location in the system, if the amount of water supplied relative to the amount required is consistent over time, the value of

$CV(\bar{t})_{RWS}$ will be 0. In this case, the system performance may be considered reliable (although not necessarily adequate) since the farmer knows what to expect in terms of relative water supply. Accordingly, the higher the value of $CV(\bar{t})_{RWS}$, the more temporally variable, and hence unreliable, the relative water supply.

To calculate each of the performance indicators defined above, data were collected on the timing and amount of water required and the water supplied at a sample set of delivery points at the farm level within Minneriya Scheme. The rationale and methods employed are briefly discussed in this section.

a. Site Selection

To evaluate farm water delivery, data were collected at the head of selected field channels and at the turnouts to selected farm allotments. Data were collected at delivery points within four distributary canals off the Yoda Ela main canal of Minneriya Scheme: D13, D21, D28, and D37. Canal D13, located 7.6 km from the head sluice, was selected to represent the head of the main system. Canals D21 and D28, located in the middle of the system, were 11.5 km and 15.0 km from the head sluice, respectively. Canal D37 was located near the end of the main canal, 23.4 km from the head sluice. The sample set comprised 47 delivery points (17 farm channels and 30 allotments). A map showing the general location of study sites is given in Figure 15. Appendix D lists and describes the measurement sites.

The number and location of delivery points sampled were determined by several factors: farmer cooperation, ease of access, ease of equipment installation, and availability of manpower and equipment. Also, the decision was made to sample locations at the head, middle, and tail of the distributary canals to detect suspected trends in spatial variability of water supply.

b. Field Measurements

Command Area Surveys. Field surveys were conducted using theodolite surveying instruments to determine the cropped area commanded by each delivery point. Areas of paddy and other field crops were determined in the surveys.

Water Requirements. Water requirements were evaluated by determining crop evapotranspiration, seepage and percolation losses, and rainfall for each of the study sites. Since subsidiary crops were only about 7 percent of the cultivated area in the study region, water requirements were computed assuming all crops to be paddy.

Potential evapotranspiration (ET_o) in Minneriya Scheme was calculated using the method of Jensen and Haise (Jensen, 1980). In this method, ET_o is computed by the following empirically derived equation:

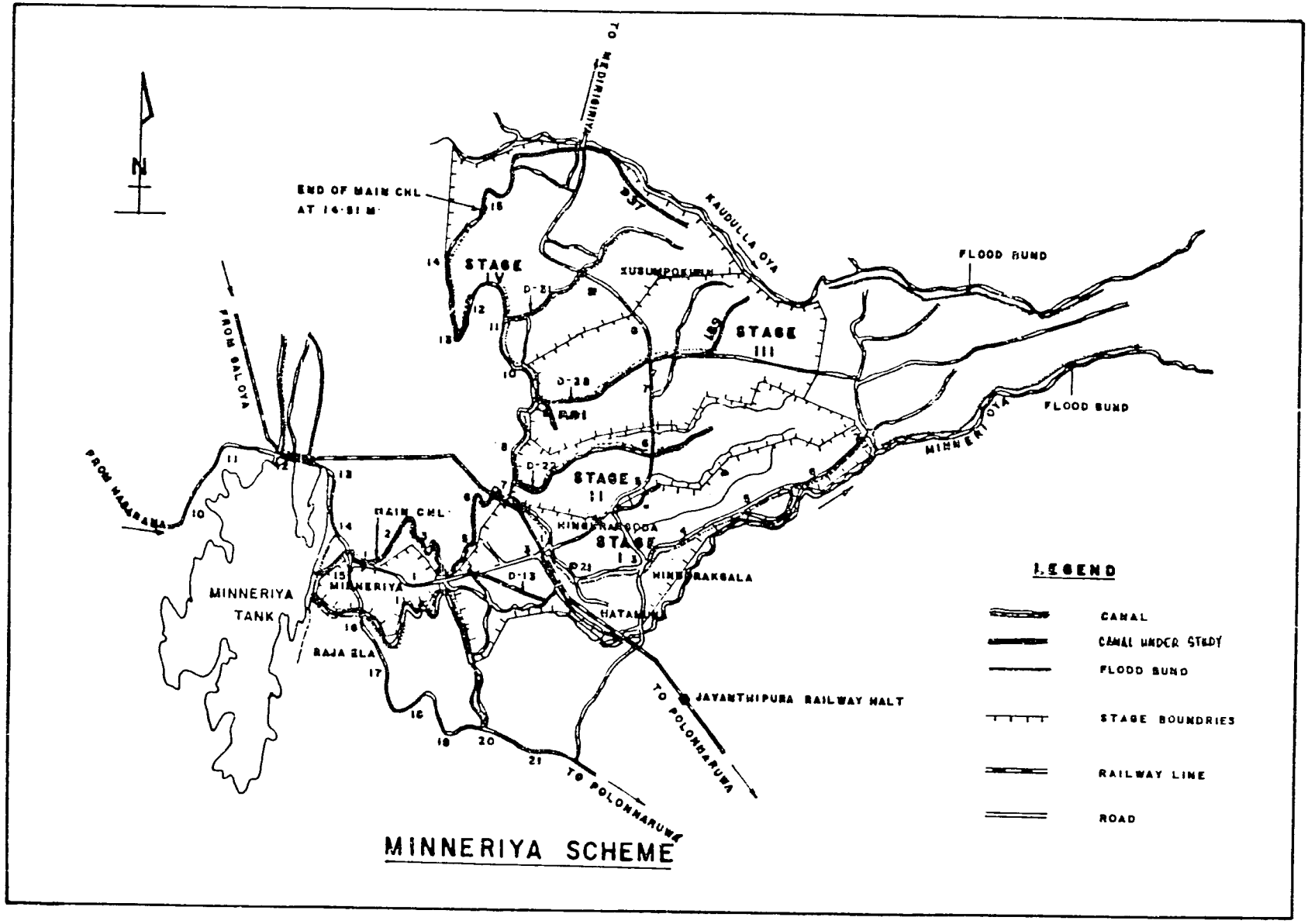

Figure 15. The Minneriya Scheme showing location of on-farm engineering diagnostic analysis study sites for 1986 vala.

$$ET_o = Ct(T-Tx)Rs$$

where

Ct = 1/(Cl + 7.3CH)
CH = 50/(e2 - el)
Tx = -2.5 - 0.14(e2 - el) - (E/550)
E = elevation of site (m)
e2 = saturation vapor pressure of water at the mean monthly maximum air temperature of the warmest month in the year (long-term climatic data) (mb)
el = saturation vapor pressure of water at the mean monthly minimum temperature of the warmest month in the year (mb)
T = mean daily temperature (Celsius)
Rs = total daily solar radiation (Langleys).

Long-term climatic data needed for determining el and e2 were obtained from the weather station in Aralaganwila, located about 43 km southeast of Minneriya Tank. Daily temperature and solar radiation were measured at the Diyasenapura weather station (maintained by the Irrigation Department) using a Datapod™ (model DP219) potential evapotranspiration monitor. The device was fitted with a Licor™ (model L1200S) pyranometer for measuring solar radiation and an Omindata™ (model TP 10V) temperature probe. Readings were recorded by the Datapod™ once every 10 minutes.

Actual crop evapotranspiration was computed from:

$$ET = K_c ET_o$$

Where K_c is the crop coefficient dependent on the type of crop and its growth stage. For rice in the region, K_c was taken as 1.15 during the initial growth stage (approximately May 15 to July 15), 1.10 during mid-season (approximately July 15 to August 15), and 1.00 during the mature stage (approximately August 15 to September 15) (Doorenbos and Pruitt, 1977).

Seepage and percolation losses from paddy fields were estimated by conducting water balance studies in the field. The depth of standing water was recorded at specified time intervals in several selected liyaddas (small bunded subdivisions of farm allotments) around the scheme. Cracks and crab holes in the liyadda bunds were sealed off and the depth of water was measured by a sloping gauge -- a simple instrument made of a measuring tape fixed onto a wooden frame set at a slope of approximately 1 vertical to 5 horizontal. Readings were taken hourly for about 8 hours. The rate of seepage and percolation was calculated as the difference between the observed rate of water depletion in the liyadda and the rate of evapotranspiration calculated for that day.

Seepage from field channels was estimated from data obtained from the nearby Kaudulla Scheme, where channel ponding tests were conducted

at selected sites. Water was impounded between two temporary earthen dams constructed at both ends of a selected reach of channel. The change in water depth was measured using a sloping gauge and recorded hourly along with the width of the water surface. The seepage rate was calculated as in the liyadda studies.

Rainfall was measured by a rain gauge operated by the Irrigation Department at Minneriya Tank bund.

Water Deliveries. Flows at each of the delivery points were measured using either cutthroat (4-inch, 8-inch, or 12-inch) flumes or long-throated (100 mm or 150 mm) flumes. Previous studies in nearby regions indicated that readings twice daily would be adequate for estimating the mean daily (24 hrs) flow rates. Thus, measurements of flow depth in the flumes were recorded at approximately 8:00 a.m. and 5:00 p.m. each day.

The first issue of water for the 1986 yala occurred on April 20. From April 20 to May 25 water was supplied continuously to facilitate land preparation. On May 26 the rotation schedule commenced. Flow measurements were started sometime between May 6 and May 20 at most of the sites and ended on about August 31.

Rating equations used to calculate free and submerged flow through the cutthroat flumes are given in Skogerboe et al. (1972). Rating equations for long-throated flumes, which were calibrated only for free flow conditions, are given in Bos et al. (1984).

Physical Conditions of the Field Channels. At selected sites, surveys were conducted to determine channel cross sections and bed slopes. These data were collected to evaluate the conveyance characteristics of the channels and their effect on water supply.

An attempt was made to study the roughness of the canal banks towards the end of the season. In the calculations, bed slope of the canal was used in place of hydraulic gradient because in the design, uniform flow was assumed and bed slope was used in the Manning's equation. Due to time limitations, only 5 field channels were studied. Four of them gave acceptable results.

Land Leveling by Farmers. To make optimum use of water, land should be leveled as much as possible. When the surface is uneven, additional water is required to cover the high spots of the liyadda. The evenness of liyadda surface achieved by the farmer is an indication of his efficiency.

Data from 24 liyaddas distributed throughout the study area of Minneriya Scheme were used for the analysis. Each liyadda was divided by grids into approximately rectangular sections, and spot levels were taken at the center of each grid section.

Location of Pipe Outlets. The pipe outlets of Minneriya were designed and constructed long ago. It was observed that some farmers do not use these pipe outlets. A pipe outlet that is not correctly

located hampers the water supply to the farm. Hence, to study the condition of pipe outlets, the elevations of canal beds and farms were taken with respect to pipe outlets. These measurements were made in 39 locations.

3. RESULTS AND DISCUSSION

Field data were compiled and analyzed to determine the various performance indicators of interest. In the following sections the results are presented and discussed.

a. Relative Water Supply

Measured values of mean daily temperature and solar radiation are given in Appendix A. The elevation of the site was 70 m. Values of e1 and e2 computed from long-term climatic data collected at Aralaganwila were 23.92 mb and 35.23 mb, respectively. A plot of paddy evapotranspiration at Minneriya during 1986 yala is given in Figure 16. Calculated values of ET ranged from a low of 4.95 mm/day to a high of 10.20 mm/day.

Rainfall observed at Minneriya is summarized in Appendix E. A total of 77.5 mm was supplied by four rainfall events that occurred from June 1 to August 31.

Results of liyadda water balance studies conducted at nine sites to determine seepage and percolation are summarized in Table 2. Spatial variability of seepage and percolation was expected to be significant within the study region (coefficient of variation among the liyadda measurement sites was found to be 1.0). However, data were insufficient to describe this variability on larger allotments and field channels where delivery analysis was conducted. Thus, seepage and percolation for the allotment and field channel command areas were assumed uniform over the region as the mean of the liyadda observations: 2.4 mm/day. This value was conservative compared to the value of 5.1 mm/day adopted by the Irrigation Department of Sri Lanka for design and operational purposes (Irrigation Department, 1981).

Seepage from field channels at the Kaudulla site, where soil conditions were similar to those in Minneriya, was found to be about 0.031 ($\pm$ 0.016) $m^3/m/day$. This was equivalent to less than 0.5 mm/day (over the command area) for most sites. Hence, field channel seepage was neglected in determining command area water requirements.

Flume data were analyzed to determine flow hydrographs at each of the measurement points. Observed flow rates ranged between 0 cfs and 3.70 cfs (105 L/s) at the head of farm channels, and between 0 cfs and 1.90 cfs (59 L/s) at turnouts to allotments. Example hydrographs for two field channels and two allotments within the scheme are shown in Figures 17 through 20. These graphs illustrate the variation in flow rates that occurred over time at the given delivery point. When the flow rates were zero indicates off periods in the rotation schedule.

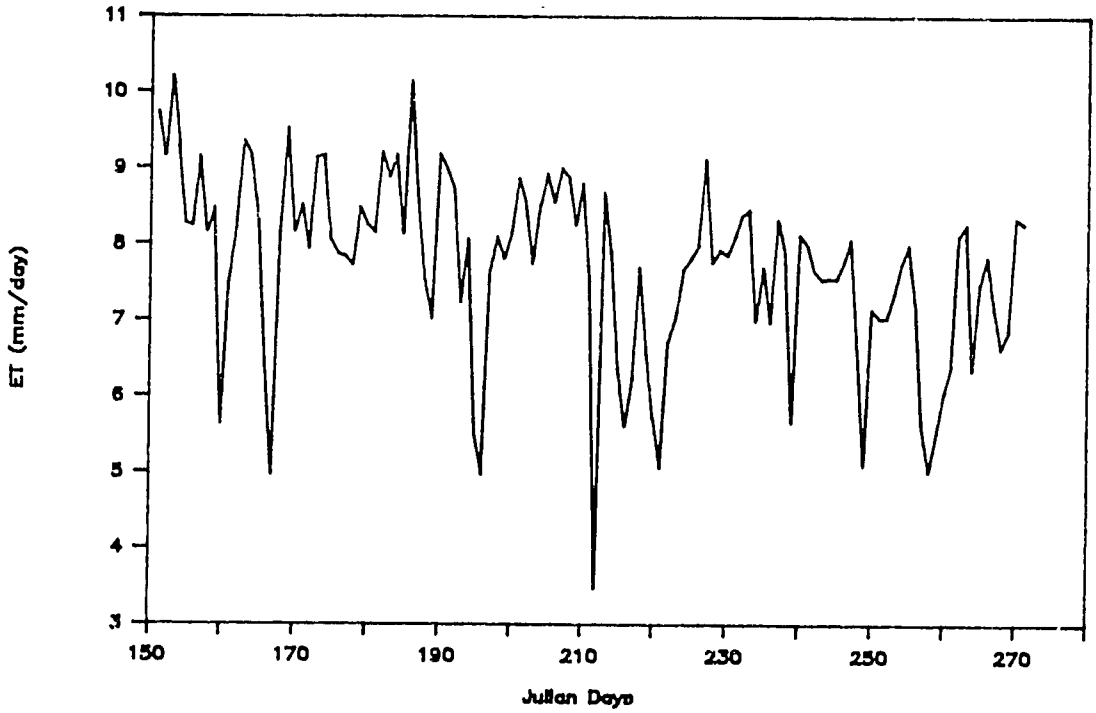

Figure 16. Evapotranspiration rate of paddy in Minneriya Scheme, 1986 yala.

Table 2. Liyadda water balance tests for seepage and percolation, Minneriya Scheme, 1986 yala.

Site	Date	Depletion (mm/day)	ET (mm/day)	S+P* (mm/day)
Allotment 398, D13	Jul 27	7.7	8.9	0**
Allotment 398, D13	Jul 27	9.7	8.9	0.8
Allotment 398, D13	Aug 15	9.5	9.1	0.4
Allotment 394, D13	Aug 15	11.7	9.1	2.6
Allotment 394, D13	Aug 15	14.7	9.1	5.6
Allotment 4, D21	Jul 27	7.8	8.9	0**
Allotment 145/1, farm channel LB2, D21	Aug 9	6.8	5.1	1.7
Allotment 44/7, farm channel RB2, D21	Aug 23	14.2	7.7	6.5
Allotment 60/7, farm channel RB2, D21	Aug 23	11.3	7.7	3.6

*Seepage and percolation.
**When the measured depletion rate was less than the calculated ET, the value of (S+P) was assumed to be zero.

For purposes of comparison, the design supply rates for the field channels in Figures 17 and 18 were plotted as straight lines. The design supply rate for Minneriya Scheme was 1 cfs/40 ac of command area. This flow rate was used to design the channel capacities assuming that the total cultivated area was in lowland paddy. The fact that the hydrographs in Figures 17 and 18 at times rose significantly above the design supply rate indicates the degree to which the system was operating above design capacity. This over-capacity operation was necessary since the system, which was designed for continuous flow, is now operated on a rotation schedule.

Flow rates at each of the measured delivery points were converted to command area water supply by dividing by the area of cropped land served downstream of the measurement point. The cropped areas measured for each of the delivery points are given in Appendix D. The seasonal mean water supply in millimeters/day is given in Table 3 for each of the measurement points within canal networks D13, D21, D28 and D37.

Water supply and water requirement data were simultaneously collected only during June 1 to August 31, 1986. Relative water supply was computed for weekly periods within this time frame by dividing weekly average values of water supply by weekly average values of water required. Plots of the results are given in Figures 21 through 27 for points along canals D13, D21, D28, and D37. A relative water supply of 1.0, corresponding to the required supply, was plotted as a straight line on the graphs. At any point in time when the value of RWS fell below this line, the supply was inadequate. Relative water supply varied considerably both from point to point within the system and over time at any given point. A further analysis of this variability is presented below.

The seasonal mean of RWS for each of the measurement points was computed as the mean of all of the weekly values of RWS. The results, summarized in Table 3 and in Figures 28 through 31, showed that the supply was inadequate (RWS < 1.0) at about 30 percent of the locations measured. Water supply was severely inadequate (RWS < 0.8) at about 15 percent of the measurement points. When crops suffer this degree of water shortage, yield reductions usually occur. However, the magnitude of the reduction depends on other agricultural practices and the stage of crop growth.

b. Spatial Variability of Delivery

Coefficient of Variation in RWS. Values of $CV(\tilde{x})_{RWS}$ were computed for weekly time periods and plotted in Figures 32 through 35 for each of the distributary channels. The lines plotted in these figures give the values of $CV(\tilde{x})_{RWS}$ over time for a particular distributary channel. Values ranged from 0.26 to 1.06 for canal D13, from 0.41 to 0.63 for canal D21, from 0.37 to 1.27 for canal D28, and from 0.18 to 0.50 for canal D37.

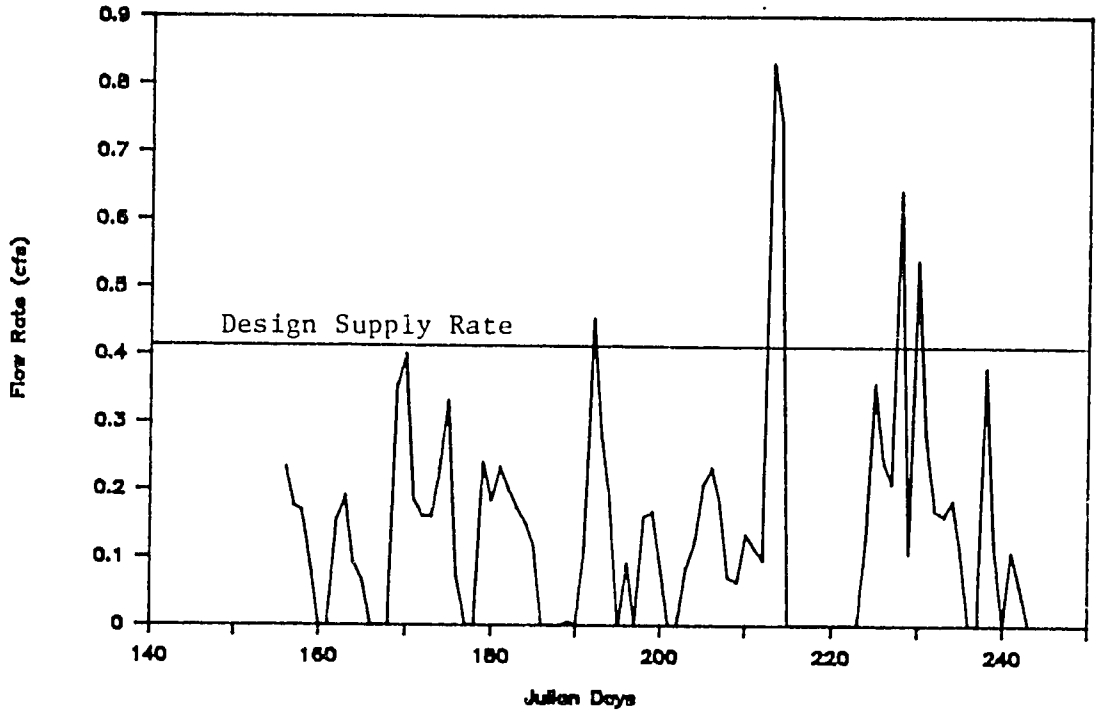

Figure 17. Hydrograph of flow rate delivered to head of field channel LP014, canal D21, Minneriya, during 1986 yala.

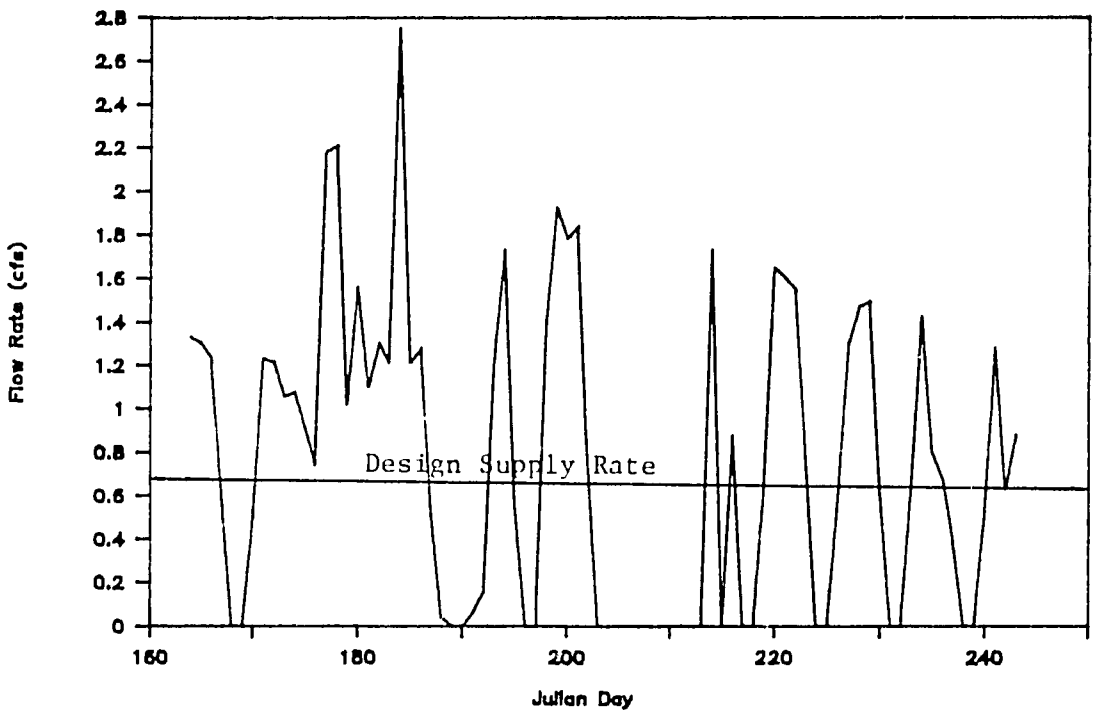

Figure 18. Hydrograph of flow rate delivered to head of field channel RB4, canal D13, Minneriya, during 1986 yala.

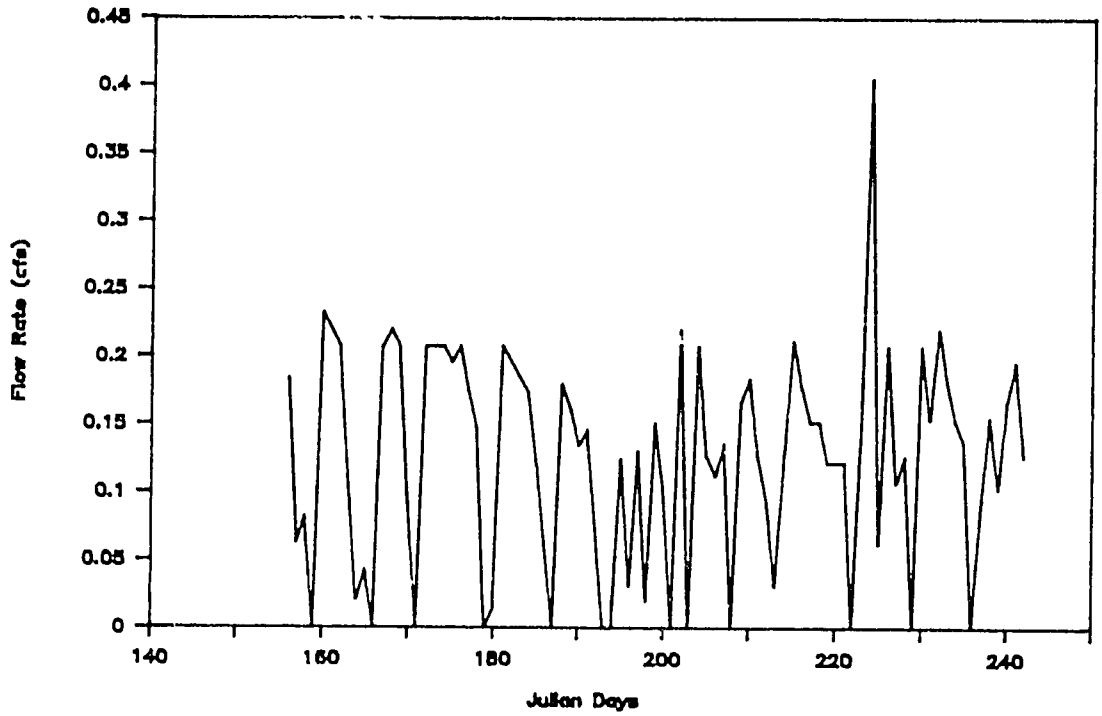

Figure 19. Hydrograph of flow rate delivered to allotment 44/7 on field channel RB2, canal D21, Minneriya, during 1986 yala.

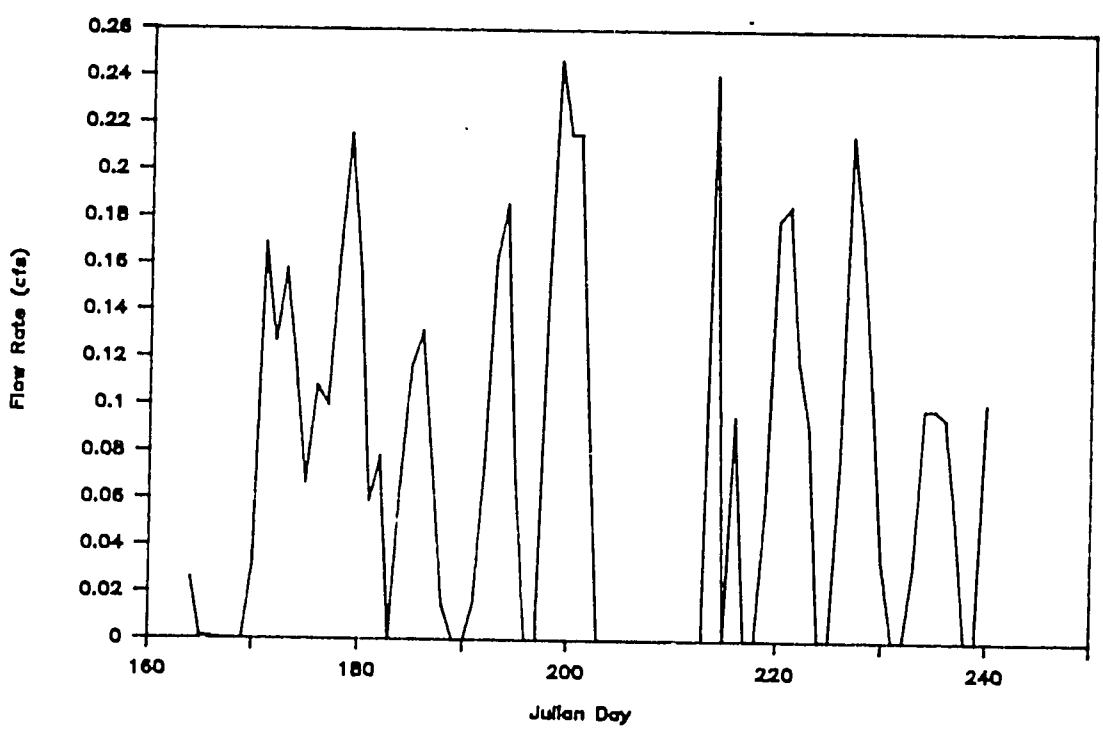

Figure 20. Hydrograph of flow rate delivered to allotment A on field channel RB4, canal D13, Minneriya, during 1986 yala.

Table 3. Statistics of seasonal water supply for Minneriya Scheme, 1986 *yala*.

Measurement Site	Mean Supply (mm/day)	RWS Mean	RWS CV(%)	Mean WUE
1	-	-	-	-
2	15.60	1.70	0.49	0.66
3	7.97	0.83	0.59	0.91
4	7.05	0.76	0.49	0.94
5	5.26	0.59	0.71	0.97
6	9.33	1.04	0.52	0.87
7	25.45	3.02	0.73	0.48
8	-	-	-	-
9	-	-	-	-
10	-	-	-	-
11	5.14	0.57	0.31	1.00
12	13.37	1.51	0.41	0.73
13	8.27	0.91	0.33	0.95
14	16.60	1.87	0.41	0.59
15	15.26	1.70	0.47	0.67
16	20.37	2.28	0.41	0.51
17	22.03	2.47	0.36	0.44
18	28.78	3.19	0.36	0.34
19	5.11	0.59	0.73	0.96
20	20.04	2.36	0.70	0.56
21	13.44	1.45	0.44	0.74
22	15.62	1.72	0.27	0.62
23	14.92	1.67	0.45	0.66
24	7.90	0.89	0.39	0.93
25	6.98	0.72	0.45	0.97
26	18.78	2.05	0.28	0.52
27	11.37	1.26	0.45	0.81
28	7.99	0.88	0.31	0.94
29	12.08	1.28	0.26	0.79
30	10.94	1.20	0.36	0.84
31	10.40	1.13	0.34	0.85
32	7.46	0.83	0.29	0.96
33	9.21	1.00	0.32	0.91
34	4.32	0.47	0.40	1.00
35	9.71	1.03	0.36	0.88
36	4.31	0.47	1.10	0.96
37	16.23	1.78	1.21	0.77
38	10.66	1.15	0.41	0.83
39	23.08	2.62	1.70	0.74
40	7.10	0.81	1.38	0.94
41	7.59	0.79	0.45	0.95
42	11.66	1.27	0.37	0.77
43	18.[illegible]	2.02	0.64	0.61
44	10.05	1.10	0.39	0.84
45	12.06	1.31	0.38	0.76
46	16.45	1.74	0.36	0.62
47	11.69	1.24	0.57	0.79

A variability of ± 10 percent from the spatial indicated that RWS was considered acceptable in this analysis. Results showed in all cases that the spatial variability in RWS significantly exceeded this allowance (i.e., $CV(\bar{x})_{RWS} > 0.10$) along each of the distributary canals throughout 1986 yala. These high values for $CV(\bar{x})_{RWS}$ meant that all points in the system were not receiving the same relative supply of water within an acceptable margin of variability. Hence, the water supply was not equitable throughout the system.

Trends in Variability. A study of Figures 28 through 31 did not clearly indicate the existence of any spatial pattern or trend in the relative water supply within any distributary canal network. For instance, a field channel located near the end of canal D21 had a RWS of about 2.4, while a field channel at the head of D21 had a RWS of only 0.6. On the other hand, another field channel near the end of D21 also had a RWS of only 0.6. In canal D28, about 45 percent of the measured points along the tail of the system received an adequate water supply. However, among points located at the head of D28, there were again about 45 percent which received too little water.

Water Use Efficiency. Values of seasonal mean water use efficiency computed for each of the observation points are given in Table 3. Though values ranged from 0.34 to 1.0, they were generally quite high (> 0.70 for about 70 percent of the sites). However, at many of the sites this high efficiency was gained at the expense of inadequate supply to meet the water requirements.

In addition to the above, the degree of levelness of farms was also studied. For each liyadda, the range of levels (difference between maximum and minimum levels) and the area of the level differences were calculated. The mean excess heights varied from 0.04 ft to 0.29 ft. The minimum mean excess depth of 0.04 ft occurred in two liyaddas in Minneriya Scheme (Table 4).

Seasonal Variability of Water Supply. Values of $CV(\bar{t})_{RWS}$ computed over weekly values of RWS are summarized in Table 3. Values were considered excessive when they were outside an acceptable range of variability of ± 10 percent from the mean (i.e., $CV(\bar{t})_{RWS} > 0.10$). Values were relatively high (> 0.10) for each of the points of observation, indicating significant temporal variability in RWS in Minneriya Scheme. This variability constituted poor system reliability since farmers could not expect a consistent level of water supply.

c. Channel Conveyance Characteristics

Data on canal cross sections and bed slopes indicate that channel conveyance characteristics differed significantly from the design profiles given by the Irrigation Department (1981). In many cases, bed widths were larger and canal slopes were steeper than originally designed. The most frequently found adverse physical features of the field channels are identified and tabulated in Table 5 in order to identify their effect on adequacy and equity.

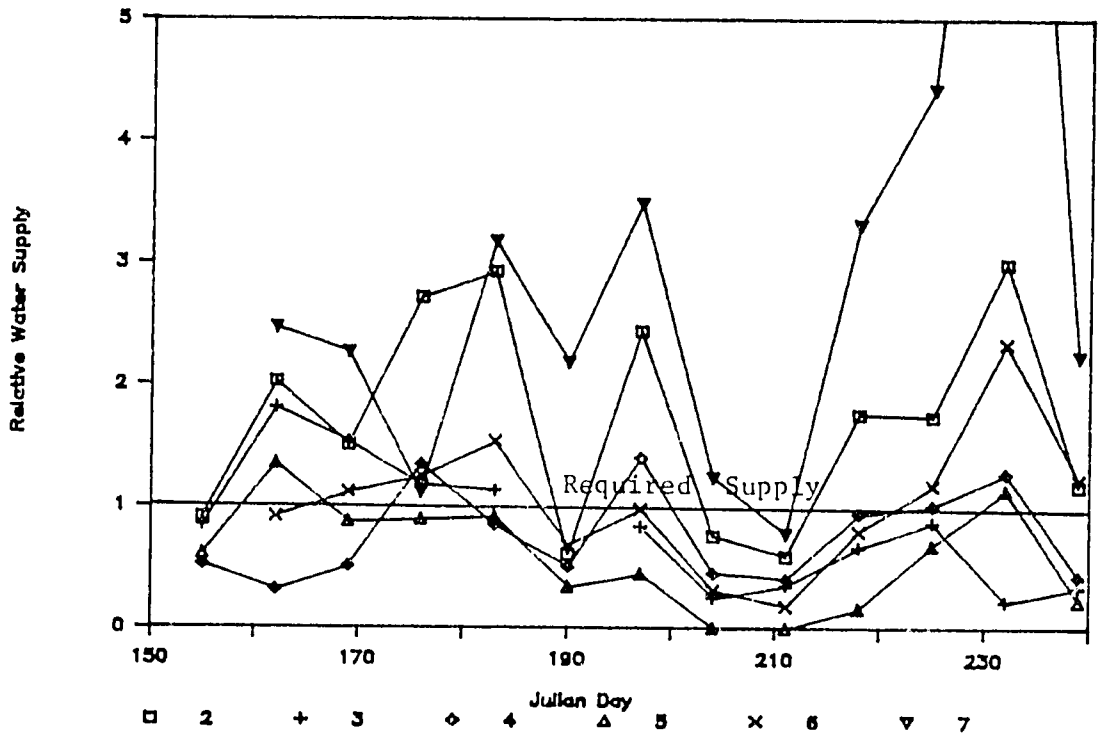

Figure 21. Relative water supply at sites 1 through 7 of canal D13, Minneriya, during 1986 yala.

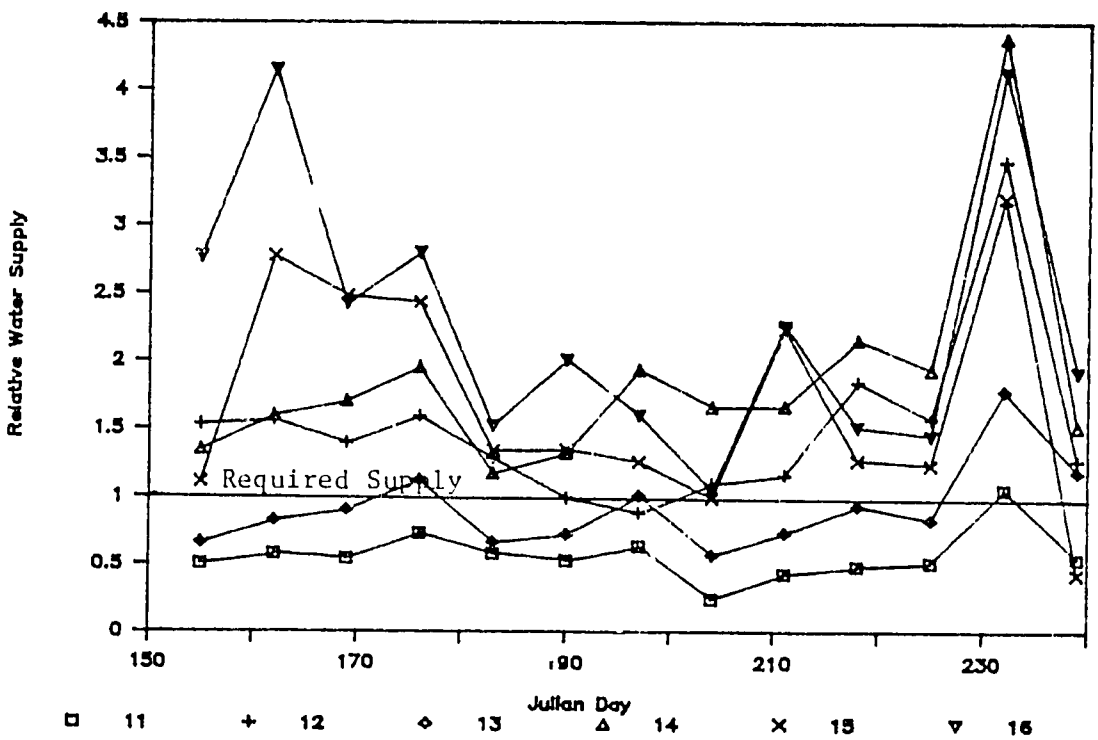

Figure 22. Relative water supply at sites 1 through 16 (reach 1) of canal D21, Minneriya, during 1986 yala.

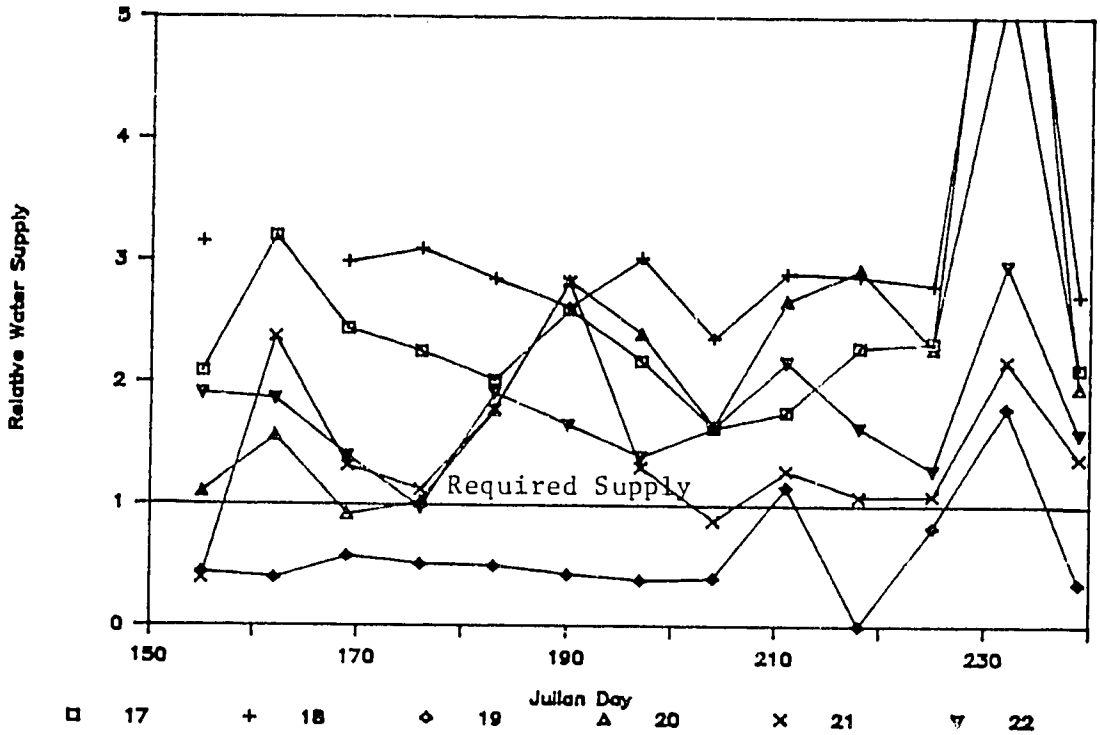

Figure 23. Relative water supply at sites 17 through 23 (reach 2) of canal D21, Minneriya, during 1986 yala.

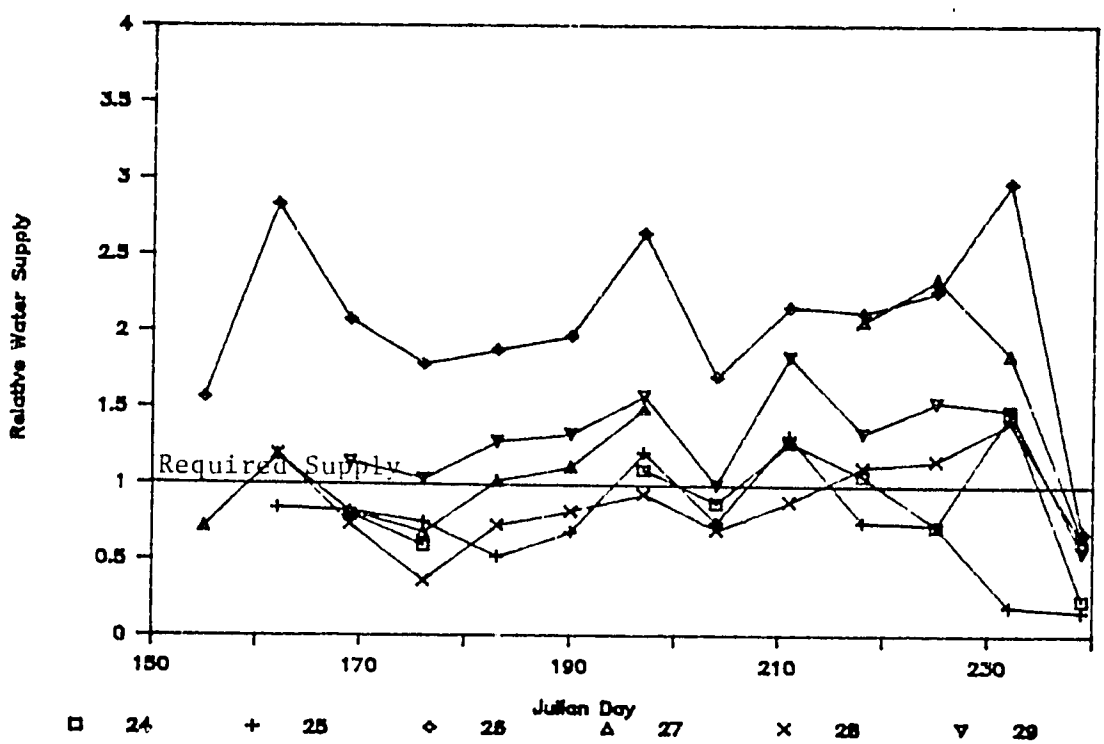

Figure 24. Relative water supply at sites 24 through 29 (reach 1) of canal D28, Minneriya, during 1986 yala.

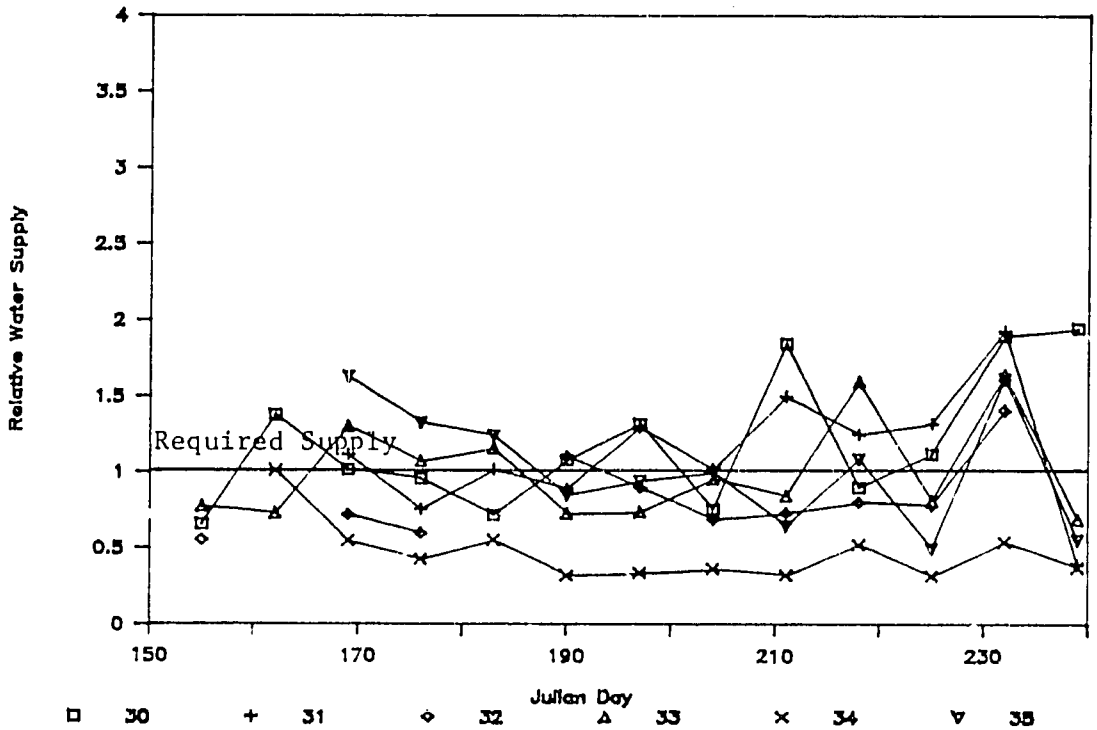

Figure 25. Relative water supply at sites 30 through 35 (reach 2) of canal D28, Minneriya, during 1986 yala.

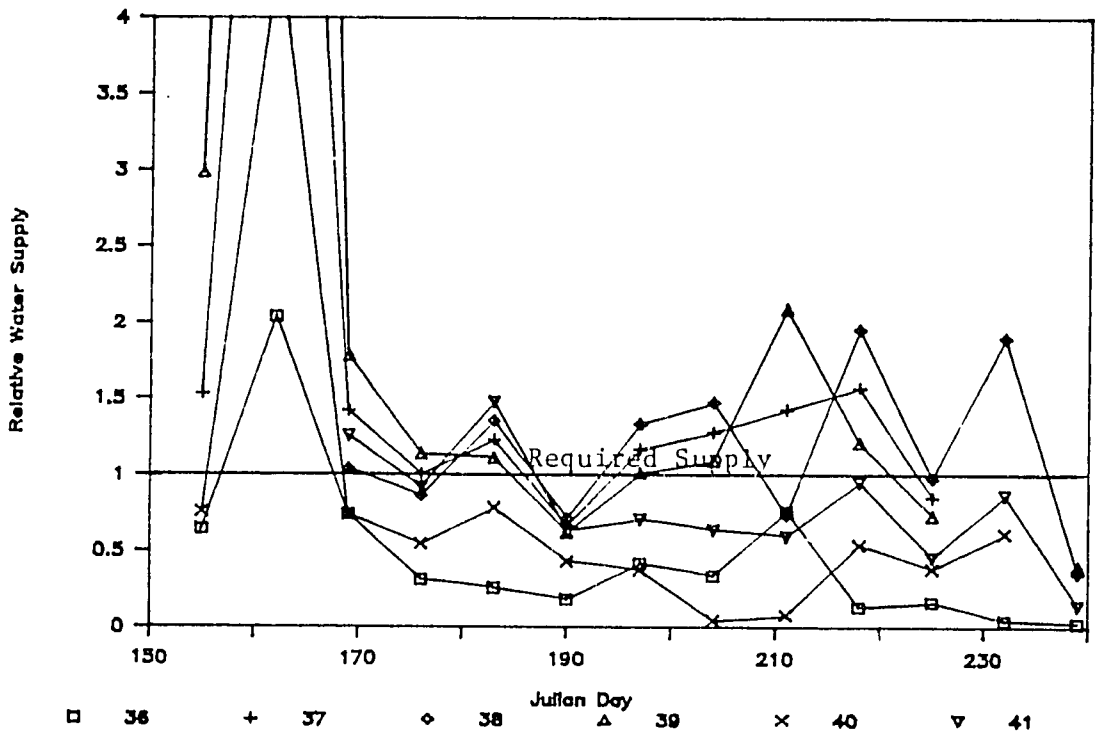

Figure 26. Relative water supply at sites 36 through 41 (reach 3) of canal D28, Minneriya, 1986 yala.

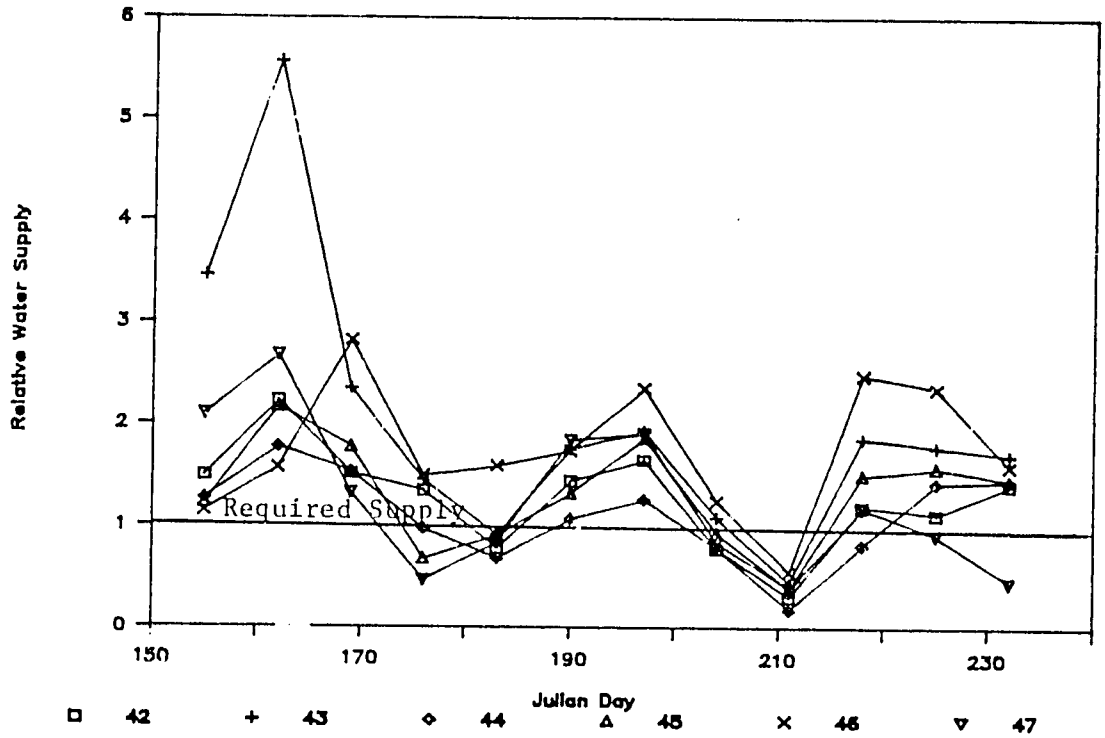

Figure 27. Relative water supply at sites 42 through 47 of canal D37, Minneriya, 1986 yala.

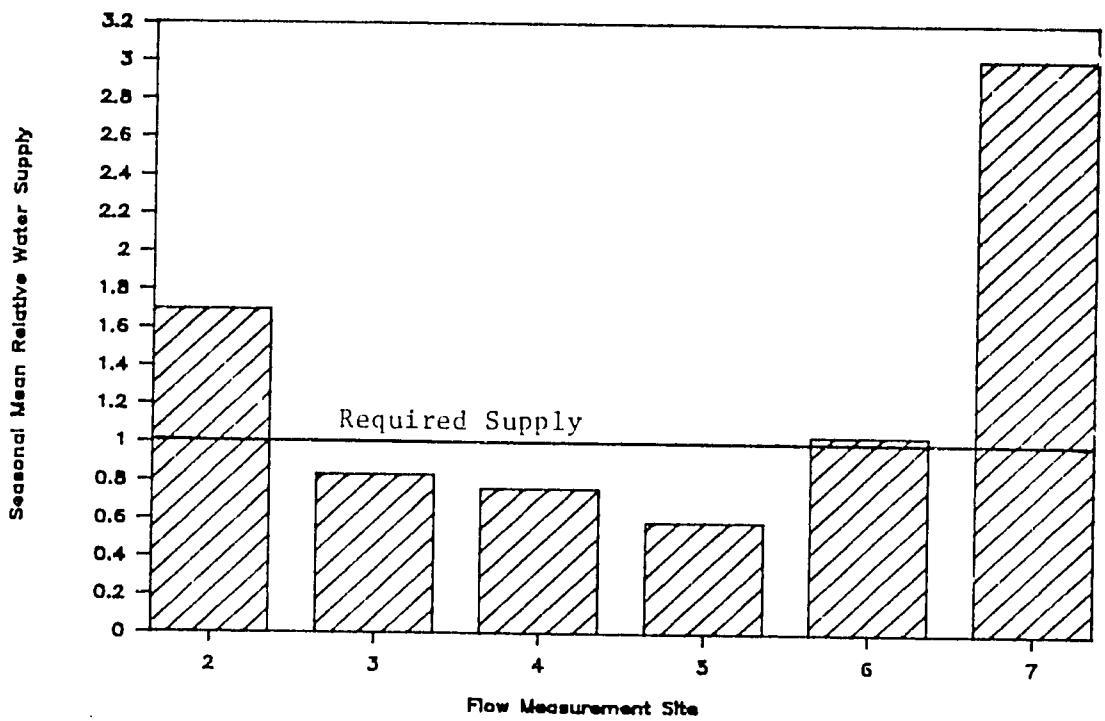

Figure 28. Seasonal mean relative water supply at sites on canal D13, Minneriya, 1986 yala.

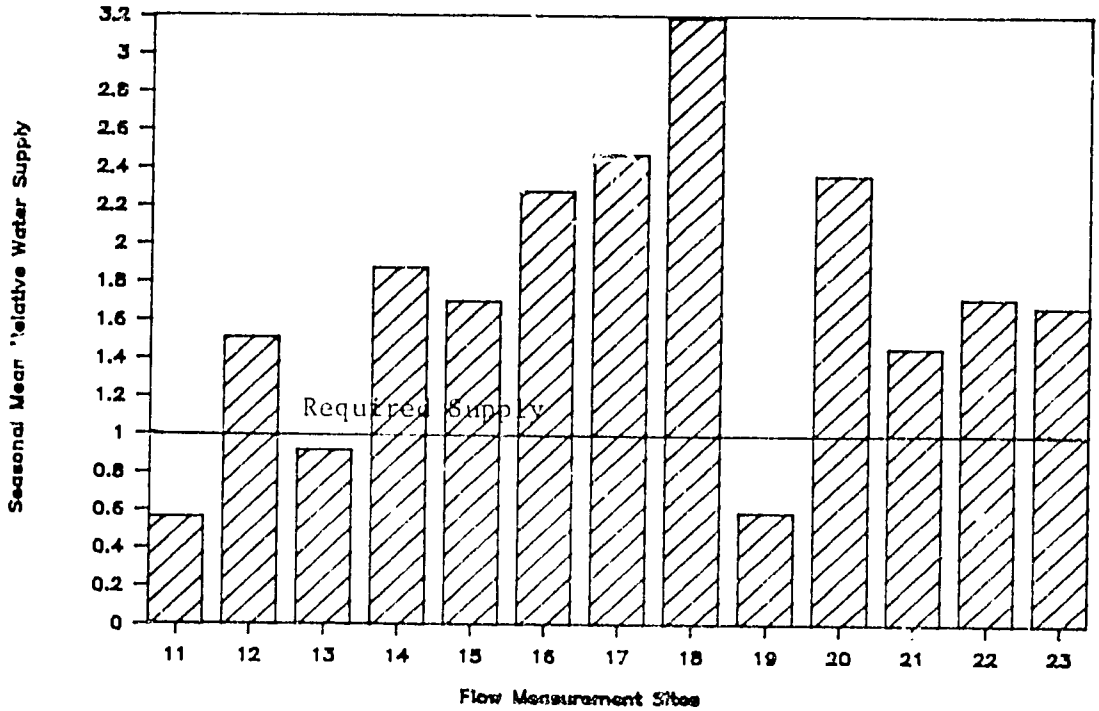

Figure 29. Seasonal mean relative water supply at sites on canal D21, Minneriya, 1986 yala.

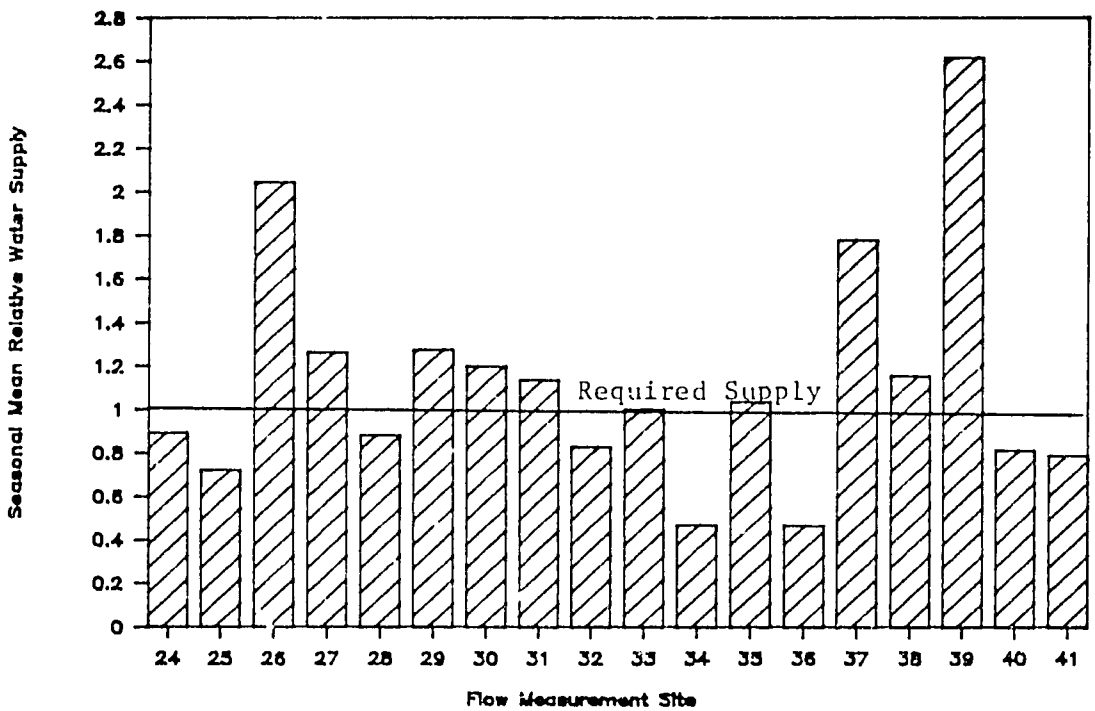

Figure 30. Seasonal mean relative water supply at sites on canal D28, Minneriya, during 1986 yala.

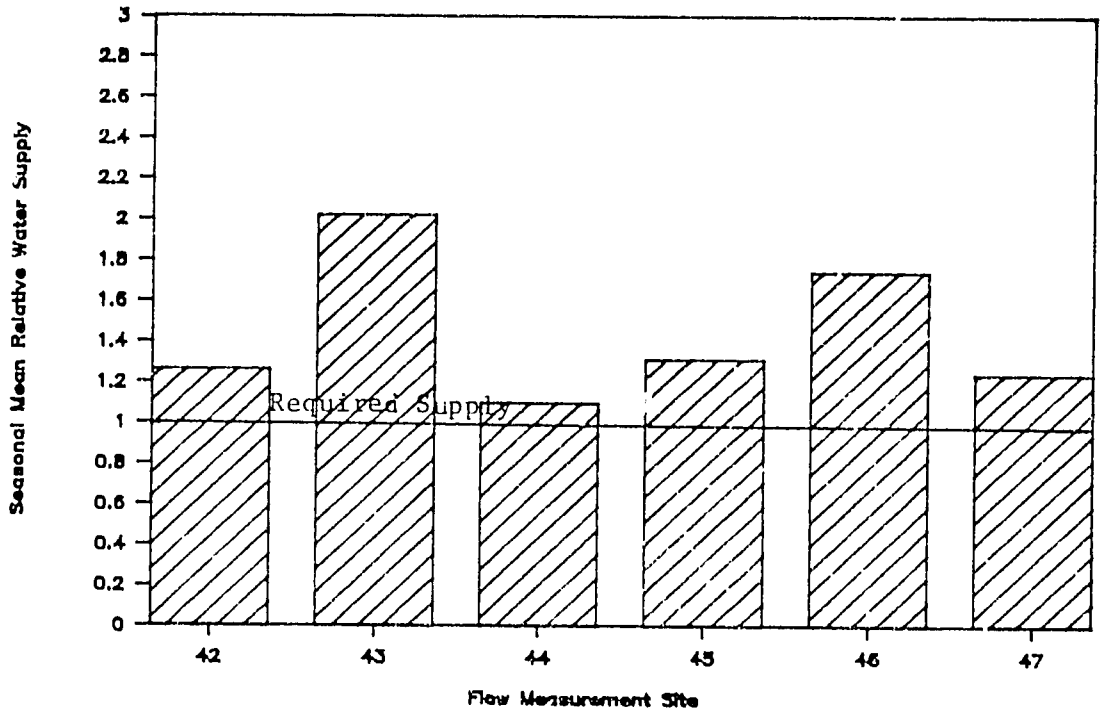

Figure 31. Seasonal mean relative water supply at sites on canal D37, Minneriya, during 1986 yala.

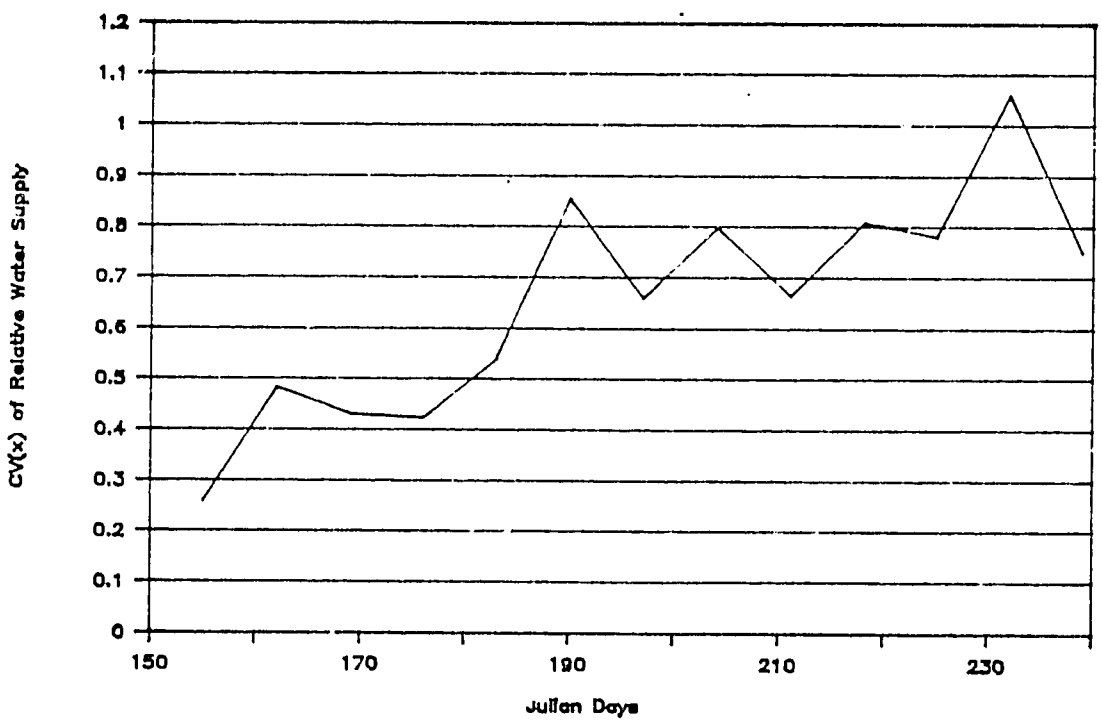

Figure 32. Spatial coefficient of variation in relative water supply among sites on canal D13, Minneriya, 1986 yala.

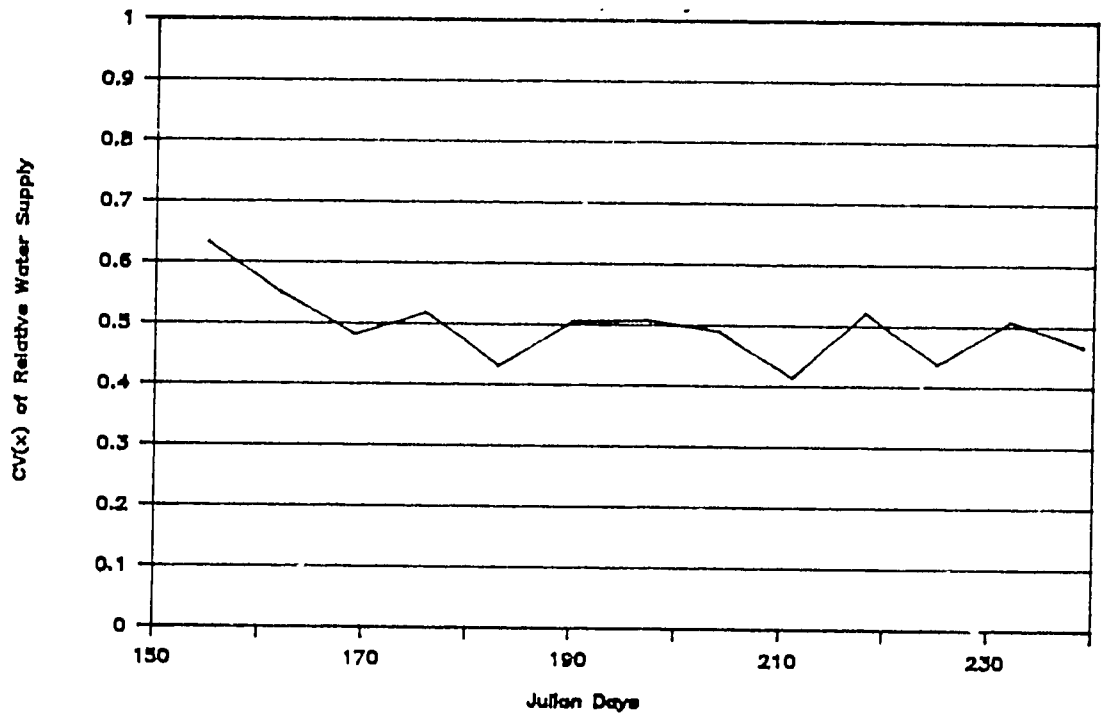

Figure 33. Spatial coefficient of variation in relative water supply among sites on canal D21, Minneriya, during 1986 yala.

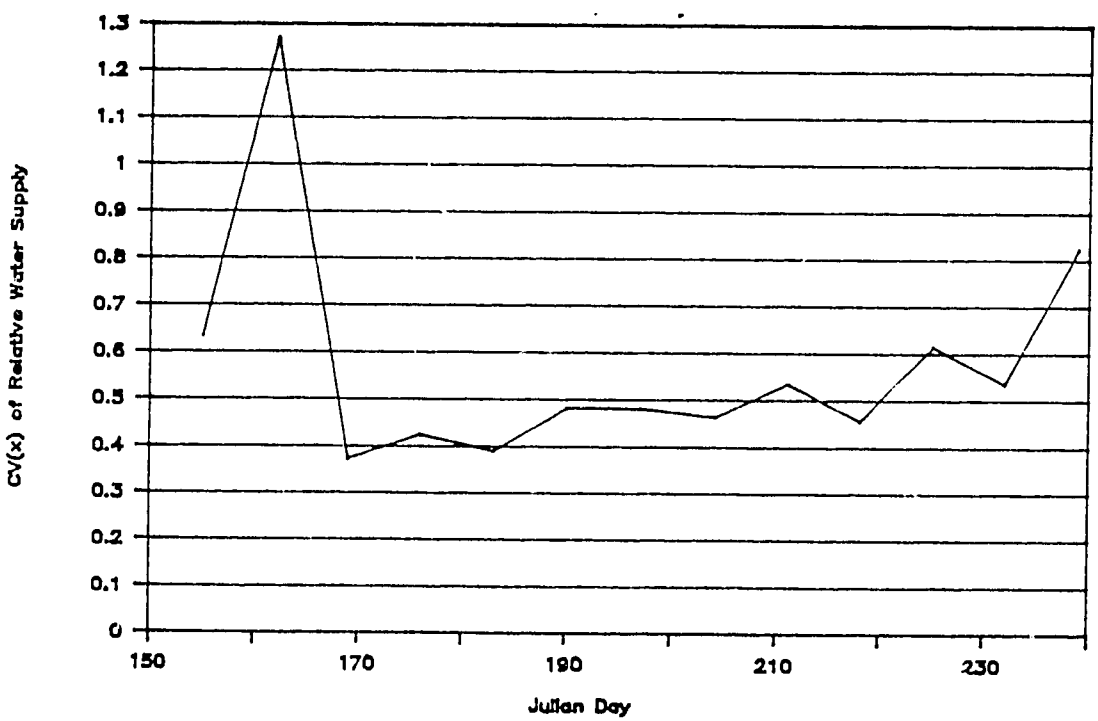

Figure 34. Spatial coefficient of variation in relative water supply among sites on canal D28, Minneriya, during 1986 yala.

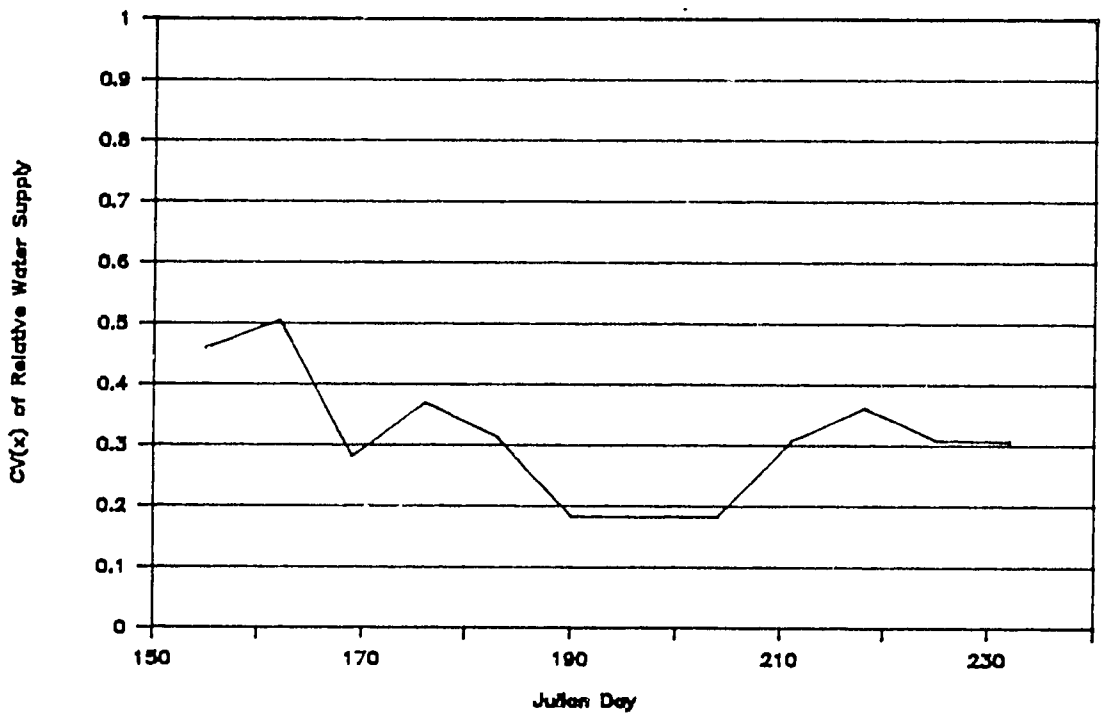

Figure 35. Spatial coefficient of variation in relative water supply among sites on canal D37, Minneriya, during 1986 yala.

Table 4. Mean excess heights (ft) and frequency of occurence in Minneriya study liyaddas, 1986 yala.

Range of Liyadda sizes (ft^2)	0.00-0.05	0.05-0.10	0.10-0.15	0.15-0.20	0.20-0.25	0.25-0.30
< 3000	0	6	0	0	0	0
3000-6000	1	3	3	0	0	1
6000-9000	1	1	1	1	1	1
9000-12000	0	2	0	0	0	0
12000-over	0	2	0	0	0	0

Studies were conducted on five field channels for canal roughness. Four field channels gave reliable results. The estimated values of Manning's 'n' are given in Table 6. However, further studies on canal roughness and other flow control characteristics are recommended, as they would be useful in future consideration of system rehabilitation.

Table 5. Relationship between water supply and physical features of the canals on Minneriya, 1986 *yala*.

Field Channel	Canal Bed Slope	Adverse Features Present	Seasonal RWS**			
			Intake	Head	Middle	Tail
RB4	0.0038	a,c,e	1.7	0.83	0.76	0.59
LB8	0.0033	a,c,e	1.04	3.02		
RB10	0.0027	a,e				
D21						
RB2	0.0034	a,c,e	0.57	1.51	1.87	0.41
LP04	0.0044	a,e,f				
LP014	0.0015	a,e	0.59			
LP016	0.001	a,e	2.36			
LP022	0.0017	a,e				
D28/RB1						
FC1	0.00005	b,c				
FC3	0.0008		2.05			
FC5	0.005	a	1.26	0.88	1.28	
RB1 (tail)	0.04	a,c	1.2	1.13		0.83
D28/LB9						
FC1	0.0028	a,c,g	1.0		0.47	1.03
FC2	0.0014	a,e	0.47			
FC3	0.005	a	1.78	1.15		2.62
FC4	0.0027	a,c	0.81		0.79	
D37						
FC1	0.0013	a,f	1.27	2.02		
FC2	0.0022	a,e	1.10			
FC3	0.0006	a	1.31			
FC4	0.0013	a	1.24			

*a = Average canal bed slope larger than specified.
b = Average canal bed slope smaller than specified.
c = Average canal bed slope larger in the tail region.
d = Average canal bed slope larger in the head region.
e = Canal bed and canal bunds uneven.
f = Canal bed rises above intake sill level.
g = Sub-field channel.
**RWS = Relative water supply.

Table 6. Summary of roughness coefficients (Manning's n) for Minneriya study sites, 1986 yala.

Field Canal	Bed Slope	Manning's n	Discharge (cfs)
RB2/D21	0.0034	0.0583	0.311
LP04/D21	0.0044	0.0557	0.365
	0.0028	0.0474	0.249
RB4/D13	0.0028	0.057	0.632

Note that the channels selected in this study for water supply measurement had relatively steep slopes since such conditions facilitated setting the flumes under free-flow conditions.

The pipe outlet elevations seem to vary considerably with respect to both the farm and the canal bed. The results are given in Table 7 and the implications are discussed in the on-farm engineering results.

4. CONCLUSIONS: SYSTEM PERFORMANCE, PROBLEMS, AND CONTRIBUTING FACTORS

a. Adequacy

This study revealed that many points in Minneriya Scheme received inadequate water supply from the delivery system. There seem to be several interrelated factors that contributed to this problem.

The canal network in Minneriya apparently was designed to deliver water continuously (Irrigation Department, 1981). However, in 1986 yala the system operated on a rotation schedule in which most distributary canals received water 3.5 days/week. Since the duration of water supply was cut in half, the flow rates must be twice those required for a continuous flow system. This requires correspondingly larger carrying capacities in the canals and field channels than were originally designed.

In some parts of the system, increased flow did not pose a serious problem since adequate freeboard existed in the original design and since, in many instances, channel cross sections and bed slopes have increased over time. However, where channel cross sections have deteriorated due to sloughing banks, silting and deposition, uncontrolled growth of weeds and aquatic plants, and obstructions caused by delapidated structures, the problem of low capacity was compounded and adequate flows could not be delivered.

Longitudinal sections of some field channels show that the channel bed rises to an elevation above the offtake sill immediately after the offtake due to silt deposition. The silt deposition is a likely result of reduced flow velocity due to expansion immediately after the offtake. The change in elevation reduces the offtake discharge because the effective head in the distributary channel is reduced.

Table 7. Elevations of field channel bed and farm with respect to farm pipe outlet sill, Minneriya, 1986 *yala*.

Field Channel	Allotment No.	FC Bed Elev. (ft) Above	FC Bed Elev. (ft) Below	Farm Elev. (ft) Above	Farm Elev. (ft) Below
D13/LB1	NA		0.33		0.95
			0.03		0.03
			0.03		0.95
			0.39		0.62
			0.0		0.82
		0.13			0.00
D21/RB2	44/7	0.07		0.12	
	61/7		0.26		0.48
D21/LB2	146		0.50		1.81
D21/LP04	88	0.10			0.48
D21/LP014	1005		0.22		0.23
	1003		0.29		0.00
	1004		0.16	0.14	
D2/LP016	1070	0.01			0.27
	1069		0.15		0.25
	1068		0.44		0.28
D21/LP022	1139	0.02		0.10	
	1135		0.29	0.25	
D28/RB1/FC1	26		0.19		0.33
	27	0.18			0.46
	28		0.0		0.98
	29	0.39			1.34
	30	0.13		0.09	
D28/RB1/FC3	02		0.0		0.82
	02		0.0		0.82
FC5	17	0.13			0.26
	18	0.07			1.34
D28/RB1/Tail	08		0.16		1.45
	09		0.16		0.49
D28/LB9/FC1	NA		0.23		0.10
FC3	NA		0.25		0.02
FC4	NA	0.003			0.02
D37/FC1	NA		0.13		0.05
FC2	NA	0.36			0.03
FC3	NA	0.43			0.07
FC4	NA	0.72			0.05

Some of the field channels selected for the study were sub-field channels; most of which branched off at a right angle to the parent field channel. Hence, the supply to the sub-field channel depended on the availability of a regulating structure in the parent field channel. Most sub-field channels had comparatively lower relative water supply. The lack of regulating structures probably contributed to this.

Similarly, the condition of the regulating structures in the distributary channels affected the flow into the field channels. A comparison of LP014 and LP016, which take off from the same distributary channel and have more or less identical conditions at the intake, demonstrates this effect. Although LP016 is downstream of LP014, the former has a greater RWS. This is because a well-functioning drop structure which regulates the flow is present downstream of LP016.

The Manning's n values calculated are considerably higher than the values assumed in the design. However, further study on the subject is suggested. It was observed that some of the channel beds and bunds were uneven. This reduces the channel capacities and results in wastage of water.

There are other possible causes of inadequacy. Unauthorized land cultivation has increased over the last several years resulting in a total command area that was about 33 percent greater than that for which the system was designed to serve. Canal banks leaked heavily in some places due to heavy vehicular traffic. Also, there was no explicit operational agenda by which farmers and irrigation officials were organized to manage the allocation of flows.

Although water supplies were inadequate at several points in the system, farmers often acquired the water they needed from drains, from runoff from adjacent allotments outside the command area, or from illegal extraction of water from the distributary canals.

The estimate for seepage and percolation from paddy lands constitutes what is, perhaps, the largest source of error in determining field water requirements. Since the spatial variability of this phenomenon is significant and may make up a large part of the total water requirement at any given site, more research needs to be conducted in its determination.

b. Equity

There was a fairly high degree of spatial variability in the water supply, with some points receiving excess water and others suffering from severe shortages. This inequity did not appear to follow the often observed pattern where field channels near the head of the system receive more water than those near the tail.

The bed slopes of field channels varied in magnitude by a considerable amount. The variation was not only between field channels, but within the field channel itself. Some of the field channels showed very high gradients, probably due to poor maintenance of channel struc-

tures. Some had very mild slopes, which were evident in channels with no structures for a considerable length.

Within the field channel itself, variation of the bed slope was observed. In some cases, the slope at the tail region was higher than that at the head. This might contribute to the farmer at the head getting a higher supply.

The pipe outlets seemed to be located at varying elevations with respect to the canal bed and farm surface. Sometimes the farm seemed to be at a higher elevation than both the pipe outlet and the canal bed. These farms experienced water shortages, and many farmers resorted to illicit tapping at a more convenient location on the canal. Illicit tapping affects the water control and, subsequently, the equity of water distribution.

There are several other factors which influence equity of water distribution: inadequate water measuring structures, unauthorized placement of temporary dams and obstructions in canals to control water levels, inadequate cooperation among farmers for scheduling irrigations along field channels, and illegal extraction of water from the system.

c. Efficiency

Overall, the water use efficiency of the scheme was fairly high. This was due in a large part to inadequate water supply. However, at several points in the system the water use efficiency was quite low, indicating waste. Much of this water was reused from drains by less fortunate farmers, but not without exacting a cost of time and labor.

The results of the study on farmer's land leveling show that there was no significant relationship between the mean excess heights and liyadda sizes. The most and the least degrees of evenness were achieved within the same range of liyadda sizes. However, mean excess heights as low as 0.04 ft have been achieved, and a significant number of farmers have achieved less than 0.1 ft of mean excess height. The distribution of excess heights through liyaddas show that there is no appreciable gradient across liyaddas. Farmers land leveling could be improved further, which would result in water savings and improved water use efficiency.

d. Reliability

The high values of $CV(\bar{t})_{RWS}$ observed in the system revealed significant temporal variability and thereby, poor reliability, of water supply. Such a condition was probably due in part to the unscheduled accommodations of extra water supply made by the Irrigation Department to some parts of the system and to a lack of scheduling along field channels. Also, as with inequity, the structural and operational facilities required for precise flow control were not in place.

C. AGRONOMY

1. INTRODUCTION

The agronomy component was responsible for providing a description of the irrigated cropping system, including assessing the major variable affecting crop production on Minneriya Scheme. This assessment involved a description of the soils, crops, and management practices of the cultivators.

2. METHODOLOGY

The 1984 Diagnostic Analysis of Farm Irrigation Systems Workshop and a six-day reconnaissance survey in January 1985 provided the background information used to plan the detailed agronomic studies. Observations made during these two activities indicated that the cropping system was essentially a paddy monoculture of sufficient complexity to warrant daily or near daily examination. Several variables thought to affect paddy production within the field channel were identified as particularly important: size of the cultivation unit; variety of paddy; method of plant establishment; availability of water; amount, time, and type of fertilizer applied; and degree of weed and pest infestation.

a. Site Selection

Four distributary channels were selected as common study sites for the diagnostic analysis (Table 8). The four distributary canals were selected to represent expected hydrological differences. For sampling purposes, the distributary channels were further divided into head, middle, and tail regions, from which one or more field channels were selected for detailed investigation. Because of their length, two of the distributary channels, D21 and D28, were subdivided into head and tail regions. Three to four field channels were selected to represent each of these regions. The field channels also represented expected hydrological differences along the distributary channel.

b. Field Personnel

Six Agricultural Diploma holders were employed as data collectors, with each assigned to one of the six study sites. Each diploma holder was responsible for collecting agronomic data daily in three or four selected field channels in the distributary channel study site. The Agriculture Diploma holders resided near the study site and were provided with bicycles for traveling between field channels.

An agricultural graduate from the University of Peradiniya was employed to assist the Agriculture Diploma holders in collecting and analyzing data. The agricultural graduate was provided with a motorcycle for traveling to and from the field study sites.

Table 8. Agronomy field site characteristics for Minneriya (1986 *yala*).

	D1			D21 Head			D21 Tail		
Distance to sluice (mi)	4.7			7.1			14.5		
Field channels	RB4	RB10	LB8	LB2	RB2	LP04	LP014	LP016	LP022
Allotments	7	4	5	2	7	2	4	6	6
Total area	31.0	21.0	25.0	4.5	27.5	14.0	19.5	29.0	28.0
Cultivators	7	5	9	2	7	3	4	7	6

	D28 Head				D28 Tail			D37			Total
Distance to sluice (mi)	9.3				15			14.5			
Field channels	RB1-FC1	RB1-FC2	RB1	FC1	FC2	FC3	RB2	LB5	LB7	LB9	
Allotments	5	6	2	4	3	5	3	3	4	4	82
Total area	27.0	31.0	11.5	20.0	15.0	24.5	9.0	9.0	12.5	12.0	371.0
Cultivators	15	14	9	5	4	7	3	5	4	5	121

c. Data Collection

Agronomic investigations of Minneriya were initiated with the first water issue (April 23) and culminated with crop cuttings in September-October of 1986. Each data collector was responsible for obtaining data from all of the separately cultivated fields along the selected field channels in the study sites. (On-farm engineering measurements were conducted on most of the same field channels.)

During the first two weeks of the agronomic study, the data collectors met with individual cultivators to explain the purpose of the investigations and to initiate data collection. During this period the diploma holders prepared a list of all of the cultivators in the study area. Included in this list was the address of the cultivator, his allotment number, the allotment size, the name and relationship of the legal title holder, and the names of other individuals cultivating

on the same allotment during the 1986 yala. The sociology and economics components of the diagnostic analysis used this list to select cultivators for interviews.

The diploma holders also prepared field channel sketches showing drainage channels, access roads, allotments, and cropping patterns. In addition, informal discussions were held with individual cultivators to obtain information on the date of the start of land preparation, number of plowings and harrowings used, type of power used, completion date of land preparation, dates of planting, method of planting, crop variety, area sown, and any plant protection measures used.

Throughout the remainder of the irrigation season, data collectors were responsible for observing specific practices of the individual cultivators. Field observations were made daily or on alternate days in each of the selected field channels. Observations were often supplemented with informal conversations with the farmer when more detailed information, such as the amount of fertilizer or insecticide applied, was not observed. The observational data collected included date of fertilizer application, amount and type of fertilizer applied, date of insecticide application, amount and type of insecticide applied, the reason for applying the insecticide, the degree of control obtained, date of weeding, method of weeding, amount and type of weedicide applied, degree of control obtained, disease infestations, and dates of panicle initiation, flowering, and harvest.

In addition, an attempt was made to determine the relative availability of water. On alternate days (sometimes 3-4 days) the data collectors walked an established route along the bunds of the paddy fields. The route was, as near as possible, a straight line following the slope of the land. The route began in the head region of the field channel and ended at or near the drainage channel in the tail region of the field channel. The relative availability of water was recorded for each liyadda using the following scale:

0 = Below field capacity, soil surface dry, many large cracks.

1 = Field capacity or above, soil surface moist to wet with none to few cracks.

2 = 1-5 cm of standing water.

3 = > 5 cm of standing water.

Data on relative availability of water were recorded for approximately two months beginning during the vegetative period of rice growth and concluding when weed growth on the bunds impaired movement in the fields.

Other data collected in each field channel included:

* Soil pH using a colorimetric pH test kit.

* Soil fertility measured indirectly using colorimetric N-P-K plant tissue test kits. Tissue tests were conducted at or soon after panicle initiation.

* Populations of plants, productive and nonproductive tillers, and weeds were determined using a 50-cm diameter plastic ring. The ring was randomly placed in the field and the number of plants, productive and nonproductive tillers, and weeds were counted. Five replications were done.

Yala paddy yields were estimated from crop cutting surveys conducted at the end of the season. A 1-m^2 sample, replicated five times, was selected as the sampling unit. Crop cuttings were collected from sampled fields in each study site. Additional crop cuttings were conducted on fields where the cultivator planted more than one variety. Each crop cutting was conducted as follows.

One-meter square, wooden frames were randomly tossed into the field. All plants falling inside the frame were carefully harvested and placed in a burlap bag. Five crop cutting samples were collected from each field. The harvested samples were carefully removed to an appropriate place for threshing. Samples were separately threshed by foot on an 8-ft, square tarpaulin. Each sample was winnowed by hand using a kulla. The cleaned paddy was placed in separate plastic sample bags, labeled, and brought to Polonnaruwa for weighing using a triple-beam laboratory balance. Seed moisture of the paddy was determined using a seed moisture meter. After weighing, the paddy samples were returned to the cultivator.

At the end of yala, the Soil Survey Division of the Irrigation Department was contracted to conduct a detailed soil survey of the selected study sites. Upon completion of the survey, soil survey maps of each field channel were prepared.

d. Data Analysis

The initial reduction and tabulation of field data was accomplished in the field by the field assistant. Tabulated data were analyzed using either Lotus 1-2-3™ or Microstat™ software programs on a Compaq™ microcomputer. Statistical analyses included mean, frequency, and standard deviation.

3. RESULTS AND DISCUSSION

a. Unit of Cultivation

It is commonly assumed that a single farm family is associated with a 3- or 5-ac allotment at Minneriya Scheme. However, a number of factors have influenced the actual unit of cultivation. These include original acreage allotted, encroachment, and land fragmentation.

The original allottees in Minneriya were provided with approximately 5 ac of lowland and 3 ac of highland in Stages I-III (D13, D21, D28), and with approximately 3 ac of lowland and 2 ac of highland in Stage IV (D37). The lowland acreage was designated for irrigated paddy production and the highland for use as a homestead. Blocking out plans prepared during the settlement periods indicated that the original lowland allotments actually varied in size from 2-7 ac in Stage I-III and from 2-5 ac in Stage IV. Similar differences in allotted acreages for the highland homestead were noted. While topographical features might make it difficult to provide allotments of uniform sizes, there was no apparent reason for the wide variation in size of the original allotments.

Engineering surveys of the field channel study sites (Appendix F) tended to confirm the allotment boundaries shown in the original blocking out plans. Noticeable exceptions to this were allotments that bordered field channels, drainage channels, and field channel access road easements. Almost all of these allotments had increased in size as a result of encroachment onto reserved areas. On D13, D21, and D28, nearly 31 percent of the allotments were greater than 5.5 ac in area. The increased area associated with these allotments primarily resulted from encroachment onto reserved areas. Similarly, nearly 70 percent of the allotments on D37 were greater than 3.5 ac and 40 percent were greater than 4.5 ac. The larger area associated with these allotments was due to the original allotment being larger than designed and to encroachment.

In most of the allotments not increased in area by encroachment, the original allottee is certainly economically disadvantaged. Of 75 surveyed allotments on D13, D21, and D28, approximately 13 percent were less than 3.5 ac in area. However, none of 13 surveyed allotments in D37 were less than 3.0 ac.

The unit of land available to the individual cultivator has been decreased by the subdivision of allotments (Table 9). During 1986 yala, subdivision of allotments resulted in 18 percent of the Minneriya cultivators farming 1 ac or less, with another 22 percent cultivating between 1 and 2 ac. In the D13, D21 head, D21 tail, D28 head, and D28 tail study sites, where allotment size was approximately 5 ac, 104 individuals cultivated 71 allotments. Approximately 17 percent of these individuals cultivated 1 ac or less, and nearly 57 percent cultivated between 1 and 3 ac. Within these five study sites, subdivision of allotments was highest in the D28 head. In this study site, all but one of 13 allotments were subdivided. As a result of subdivision, 13 of 38 cultivators farmed 1 ac or less and another 18 cultivated between 1 and 2 ac. In the D37 study area, where the original allotment size was approximately 3 ac, only 2 of 12 allotments were subdivided. However, the two subdivided allotments were cultivated by five individuals, of whom four cultivated 1 ac or less.

Table 9. Degree of fragmentation in Minneriya allotments during 1986 yala (n=121).

Unit of Cultivation	Number of Cultivators						Cum %
	D13 (n=21)	D21Head (n=12)	D21Tail (n=17)	D28Head (n=38)	D28Tail (n=16)	D37 (n=17)	
≤1	4	0	0	13	1	4	18.2
>1 - 2	3	3	0	18	2	0	21.5
>2 - 3	3	3	3	2	4	12	22.3
>3 - 4	2	4	2	4	1	0	10.7
>4 - 5	9	2	9	1	8	1	24.8
>6	0	0	3	0	0	0	2.5

The overall effect of encroachment, original allotment size, and subdivision of allotments in the study area suggests that while a few individuals benefitted by encroaching onto reserved areas, inequalities in the size of the original allotments and increased population pressure on the land have reduced many of the cultivators on Minneriya to subsistence farming. It was also apparent from data presented in the sociology section of this report that the problem of subdividing allotments will increase as second- and third-generation families begin to inherit these lands.

b. Soils

The Soil Survey Division of the Irrigation Department was contracted to conduct a detailed soil survey of the field channel study sites to obtain basic soils information for Minneriya. In addition to mapping soils, the survey team was requested to characterize a typical soil profile for each soil type. The soil survey was initiated during the irrigation closure period between the 1986 yala and 1986-87 maha and was completed in early December of 1986.

Two major soil groups -- reddish-brown earth (RBE) and low, humic gley (LHG) soils -- were identified by the soil survey team (Appendix F). RBE soils were identified as Rhodustalfs in the Seventh Approximation system of soil classification. RBE soils, which are predominant in the Dry Zone, were largely formed in place on the knolls and upper to middle slopes of the rolling topography. These soils, which are light in texture, are generally regarded as good agricultural soils if rainfall is supplemented by irrigation. However, they are structurally weak and thus are susceptible to water erosion. In addition, RBE soils located in the middle to lower slopes of the rolling topography are often affected by high water tables during heavy rains.

The LHG soils are primarily alluvial and were found in the lower slopes and valleys. LHG soils are equivalent to Haplustalfs in the Seventh Approximation system of soil classification and Gleyic Luvisols in the FAO system of soil classification. These heavy-textured soils have poor drainage characteristics and thus are susceptible to water-

logging. Because of this, LHG soils are only suitable for paddy cultivation. A more detailed background description of each soil group, tables of the physical and chemical properties, and general soil profile descriptions for both soil groups are presented in Appendix F.

A summary of the soil types and their approximate area, expressed as a percentage of the total area of the field channels, is shown in Table 10. Of the two soil groups identified, RBE soils were the most extensive, occupying nearly 47 percent of the total study area. Within study sites, RBE soils comprised 22-100 percent of any particular study site.

Table 10. Approximate area of each soil type expressed as a percentage of the surveyed area (Minneriya, 1986 *yala*).

Soil Type	Percent				Overall Percent
	D13	D21	D28	D37	
Reddish-brown earth, well-drained	0	0	14	0	3
Reddish-brown earth, moderately shallow, imperfectly drained	7	4	0	0	4
Reddish-brown earth, imperfectly drained	45	18	42	100	40
Low humic gley, poorly drained	48	78	44	0	53

The RBE soils were subdivided into three drainage classes: well-drained, moderately well-drained, and imperfectly drained (Appendix F). Only well-drained and imperfectly drained soils were observed in the field channel study sites (Table 10). Of the two drainage classes, imperfectly drained RBE soils accounted for an average of 40 percent of the total field channel area. Within study sites, imperfectly drained RBE soils comprised from 22-100 percent of any particular study site.

Well-drained soils were observed only in the D28 study area. According to the soil survey team leader, much of the area now identified as imperfectly drained RBE soil was, prior to irrigation, well-drained RBE soil. That these soils have become imperfectly drained has important water management implications for their use in the cultivation of other field crops.

The LHG soil group occupied approximately 53 percent of the study area (Table 10). Within study sites, LHG soils occupied from 0-78 percent of any particular study site. LHG soils were subdivided into drainage classes -- poorly drained and very poorly drained. However, within the field channel survey, only poorly drained LHG soils were observed. Because these soils were poorly drained, they were only suitable for irrigated paddy production.

The pH of the RBE and LHG soils was determined during the cropping season. Measured pH values for the RBE soils ranged from 6.2-7.4, while pH values of the LHG soils ranged from 6.8-7.6. These pH values were within the expected range for each soil group. In addition, visual observations of crop performance were used to assess problem soils (specifically, iron toxicity and salinity). These observations indicated no serious soil problems in the field channel sites. However, similar observations made during the reconnaissance survey of Minneriya suggested that a few low lying areas exist that have salinity problems.

c. Cropping Pattern

During the 1986 yala, approximately 5 percent of the study area was fallow. This land was fallow primarily because it could not be commanded by the irrigation system.

Data on soils presented in the previous section indicated a potential for cultivating crops other than paddy on approximately 35-40 percent of the irrigated command area of Minneriya during yala. However, during the 1986 yala, only 9 percent of the study area was cultivated with crops other than paddy. Chili was the principal crop. Within study areas, the most extensive cultivation of chili occurred on D28. Nearly 15 percent of the D28 command area was planted with chili. Interestingly, in D37, which had 100 percent RBE soils, only 2 percent of the area was planted in chili.

While most cultivators understood that potential profits from other field crops, such as chili, were much higher than paddy, they were unwilling to risk the higher investment costs associated with these crops. Their preference for paddy over other crops was explained by:

* lower investment costs.
* availability of good quality seed.
* knowledge of, and less intensive, cultivation practices.
* shorter cropping period.
* fewer problems with theft.
* fewer storage problems.
* less severe price fluctuations.
* a more organized marketing system.

d. Cultivation Season

In mid-September, the 1986 yala kanna meeting for Minneriya was held in Medirigiriya. The kanna meeting was chaired by the government agent and supported by the district department heads responsible for agriculture and settlement. While the major purpose of the kanna meeting was to finalize the 1985 yala irrigation schedule, it also served as a platform for the cultivators to air grievances and for the departments to disseminate information on relevant topics. However, the meeting was attended by less than 300 persons, most of whom were vel vidanes, rather than average cultivators.

The final 1986 yala irrigation schedule was based on the cultivation of short-season (3 to 3-1/2 month) varieties of paddy, which the farmers were requested to grow. Some of the more important dates established for the 1986 yala schedule were:

April 13	First water issue
May 13	Completion of land preparation
May 24	First rotational water issue
August 26	Closure of canals

This schedule provided irrigation water for 125 days, of which 30 days were for land preparation and 95 days were for crop growth. Although the schedule appeared reasonable, continuous water issues were extended into the second week of June, and the entire irrigation season was extended to the second week of September. An attempt is made to document some of the reasons for the extensions in subsequent sections of this report.

e. Land Preparation

Land preparation is one of the most important management components in paddy cultivation. Poor and untimely land preparation may result in unlevel fields, poor stand establishment, and early weed infestation. All of these problems affect the performance of the crop and often increase production costs. More importantly, extended land preparation may delay the completion of the cropping season.

Data concerning the start and completion of land preparation, power sources used, the number of plowings, and the number of harrowings were obtained through field observations and informal interviews with the cultivators. In addition, observations on the quality of land preparation were made. The quality of land preparation was evaluated by the degree of weed control obtained, availability of water, and by the degree of tilth and leveling obtained.

The date that cultivators started land preparation was compared with the date of the first scheduled water issue to determine the time required to initiate land preparation. The time required for land preparation was defined as the period between the start and completion of land preparation. The overall time required for land preparation was defined as the period between the date of the first scheduled water issue and completion of land preparation.

According to the Agriculture Department, 14-21 days is generally sufficient to complete land preparation. Land preparation periods greater than 21 days should only be necessary where irrigation water is limited, or in poorly maintained fields with large accumulations of organic residues.

Proper land preparation for paddy requires that the field be soaked for 2-5 days before the first plowing and maintained at or near saturation throughout the plowing period. During this period the bunds around the paddy are cleaned and repaired. Normally, two plowings are needed to turn the soil, weeds, and organic residue under. Approximately 7 days between plowings is needed to decompose the incorporated organic residue. Between plowings the bunds around the field are repaired and plastered.

Once the organic residue decomposes, the field is flooded with 2-5 cm of water, harrowed, and roughly leveled. Prior to planting, the field is again flooded with 2-5 cm of water, harrowed, and leveled. The field is then drained to 1-2 cm of standing water for planting.

Based on these recommendations, the Minneriya 1986 yala irrigation schedule developed by the Irrigation Department provided 30 days of continuous water issue for land preparation. Even though this schedule appeared reasonable, land preparation was not completed on schedule. As a result, the Irrigation Department extended continuous water issues for two weeks. This extension increased the amount of water issued for land preparation by nearly 50 percent and contributed to the delay in completing the cropping season. Because this problem was common in both yala and maha, it was considered important to determine the factors which contributed to delays and subsequent extensions of the irrigation season.

Overall, the time required to initiate land preparation once scheduled water issues began ranged from the day of the first water issue to 32 days after the official first water issue, and averaged 11 days. Only 50 percent of the cultivators had initiated land preparation within the first 10 days after the first official water issue (Table 11). Another 15 days were required before nearly 96 percent of the Minneriya cultivators initiated land preparation activities. Within study sites, major delays in initiating land preparation primarily occurred in study sites located at the head and tail of the system.

Table 11. The time between the first scheduled water issue and the initiation of land preparation as reported by Minneriya cultivators, 1986 yala (n=121).

Number of Days	D13 (n=21)	D21Head (n=12)	D21Tail (n=17)	D28Head (n=38)	D28Tail (n=16)	D37 (n=17)	Cum %
0	0	2	4	0	2	0	6.6
5	4	4	2	1	3	0	18.2
10	0	3	6	18	8	3	49.6
15	3	3	2	15	1	6	74.4
20	4	0	2	3	1	5	86.8
25	6	0	1	1	1	2	95.9
30	3	0	0	0	0	1	99.2
35	1	0	0	0	0	0	100.0

Although observat.ons on land preparation were made, data collectors did not obtain information on reasons for delaying the start of land preparation. However, two possible reasons for delays in starting land preparation were suggested. First, inadequate water delivery during land preparation may have caused many cultivators to delay the start of land preparation. Second, problems in obtaining credit, power sources for land preparation, and labor for planting may have caused some cultivators to delay land preparation.

Once land preparation was initiated, the time between the start and completion of land preparation ranged from 10 days to 45 days, and averaged 23 days. Over 65 percent of the cultivators completed land preparation activities within 20-25 days (Table 12). The majority of cultivators (94 percent), regardless of their hydrological location, completed land preparation within 35 days. Thus, it was apparent that once land preparation was initiated, it was possible for cultivators to complete land preparation within 30-35 days.

Table 12. The time between the first plowing and the completion of land preparation as reported by Minneriya cultivators, 1986 *yala* (n=121).

Number of Days	D13 (n=21)	D21Head (n=12)	D21Tail (n=17)	D28Head (n=38)	D28Tail (n=16)	D37 (n=17)	Cum %
10	0	0	0	1	0	1	1.7
15	3	0	5	14	1	4	24.0
20	6	3	5	9	3	2	47.1
25	6	3	2	7	2	2	65.3
30	5	4	2	4	5	3	84.3
35	1	1	1	2	4	3	94.2
40	0	1	2	1	0	2	99.2
45	0	0	0	0	1	0	100.0

Overall, the time between the first scheduled water issue and the completion of land preparation ranged from 16-57 days, and averaged 34 days. Only 38 percent of the cultivators completed land preparation within the scheduled period (Table 13). An additional 20 days was required before more than 97 percent of the cultivators completed land preparation.

Table 14 shows the different power sources that Minneriya cultivators used for land preparation. Overall, over 60 percent of the cultivators used two-wheel tractors for land preparation. The majority of these cultivators used two-wheel tractors for all land preparation. Only a few cultivators used a combination of two-wheel tractors and four-wheel tractors or animal power for land preparation. A large percentage of the cultivators in the D21 head, D28 head, D28 tail, and D37 study sites used a combination of animal and hand labor for land preparation.

Table 13. The time between the first scheduled water issue and the completion of land preparation as reported by Minneriya cultivators, 1986 *yala* (n=121).

Number of Days	D13 (n=21)	D21Head (n=12)	D21Tail (n=17)	D28Head (n=38)	D28Tail (n=16)	D37 (n=17)	Cum %
20	0	2	1	4	1	0	6.6
25	0	0	6	9	0	2	20.7
30	4	3	3	6	3	2	38.0
35	1	2	3	5	3	1	50.4
40	4	3	4	9	6	4	75.2
45	4	1	0	4	3	3	87.6
50	7	1	0	1	0	3	97.5
55	0	0	0	0	0	2	99.2
60	1	0	0	0	0	0	100.0

Table 14. Power sources used by Minneriya cultivators during land preparation (1986 *yala*).

Power Sources	D13 (n=21)	D21Head (n=12)	D21Tail (n=17)	D28Head (n=38)	D28Tail (n=16)	D37 (n=17)	Total %
2-wheel tractor	100	58	76	18	69	0	48.8
4-wheel & 2-wheel	0	0	18	0	0	18	5.0
2-wheel & animal	0	0	6	18	0	0	6.6
Animal & hand labor	0	42	0	64	31	82	39.7

Table 15 shows the land preparation operations used by Minneriya cultivators. The majority of cultivators ploughed one or more times and harrowed and leveled one or more times to prepare their fields.

Data collectors also evaluated the quality of land preparation in paddy fields throughout the study area. Included in their assessment of land preparation were availability of water for land preparation, degree of tilth and leveling obtained, and degree of weed control obtained. Although most of the cultivators ploughed and harrowed their fields more than once, land preparation was rated as average or poor in nearly 71 percent of the fields in the study area (Table 16). Only 29 percent of the fields received a good rating. These fields were primarily located in the D28 study area.

Table 15. Land preparation operations used by Minneriya cultivators during the 1986 *yala*.

Operation	D13 (n=21)	D21Head (n=12)	D21Tail (n=17)	D28Head (n=38)	D28Tail (n=16)	D37 (n=17)
Rototilling & leveling	0	0	41	0	0	0
Ploughed once & leveled one or more times	0	67	53	8	56	6
Ploughed twice & leveled one or more times	0	0	0	0	0	88
Ploughed two or more times & harrowed and leveled one or more times	108	33	6	92	44	6

Table 16. Visual assessment of the quality of land preparation in paddy fields of Minneriya Scheme (1986 *yala*).

Quality	D13 (n=21)	D21Head (n=12)	D21Tail (n=17)	D28Head (n=38)	D28Tail (n=16)	D37 (n=17)	Total %
Good	0	0	0	71	44	6	29
Average	52	25	0	29	56	82	40
Poor	48	75	100	0	0	12	31

f. Planting

As previously mentioned, the 1986 *yala* *kanna* meeting established an irrigation season for Minneriya of 125 days -- the first 30 days of which were designated for land preparation. To meet this schedule, farmers were requested t. grow short-season, improved varieties of paddy. No recommendations on the method of planting were given.

Generally, it was assumed that the majority of cultivators on Minneriya would broadcast yala paddy. Since short-season paddy varieties only require irrigation water for 80-95 days and mature within 90-105 days, it appeared that the irrigation schedule established during the kanna meeting was reasonable.

Data collected on planting in each study site included paddy varieties, method of planting, and dates that planting was started and completed. Most of this information was collected through informal interviews with the cultivators. Whenever possible, information obtained through informal interviews was confirmed by field observations.

Paddy Varieties. According to the cultivators, 11 different paddy varieties were grown in the study sites. Of these, 6 were short-season varieties and 5 were long-season varieties. Two paddy varieties -- BG-90-4 and BG-330 -- were not on the Agricultural Department's list of recommended varieties (Table 17).

Table 17. The percentage of each study site planted with different paddy varieties as reported by Minneriya cultivators (1986 yala).

Paddy Varieties	D13 72	D21Head 41	D21Tail 76	D28Head (n=38)	D28Tail (n=16)	D37 (n=17)	Total %
Short-Season							
BG-34-8	93.1	32.2	43.4	35.0	12.2	23.0	47.2
BG-276-5	5.6	0	0	7.4	2.6	1.5	3.4
BG-94-1	0	0	0	0	0	3.0	0.8
BG-34-6	0	0	0	2.2	0	0	0.4
BG-90-4	0	0	11.2	7.4	52.1	3.0	13.1
BG-330	0	0	0	0	5.2	0	1.1
Long-Season							
BG-379-2	1.4	54.9	32.2	14.9	27.8	0	20.8
BG-380	0	0	0	20.1	0	1.4	4.2
BG-11-11	0	0	13.2	13.0	0	4.5	6.5
BG-90-2	0	0	0	0	0	5.3	1.5
BG-450	0	9.9	0	0	0	0	1.1

Interestingly, approximately 10-15 percent of the cultivators were either unable to name or incorrectly named the variety of paddy they had planted. The farmers' lack of knowledge was significant and was unexpected by the Agriculture Department.

Data collectors were also unsuccessful in identifying some varieties of paddy. Variety misidentification occurred for approximately 10 percent of the sample. Even so, the data collected were still of value for evaluating the farmers' preference for certain paddy varieties.

Overall, BG-34-8 -- a short-season, improved variety -- was most common. Approximately 47 percent of the entire Minneriya study area was planted with this variety. The other five short-season paddy varieties occupied an additional 19 percent of the study area. Of these, only significant acreages of BG-90-4 were reported on only some of the study sites (Table 17).

Long-season paddy varieties were reported by cultivators to grow on approximately 34 percent of the study area (despite recommendations given at the kanna meeting). Three of the long-season paddy varieties -- BG-379-2, BG-11-11, and BG-380 -- were reported on significant areas of some of the study sites.

Records of planting and harvesting dates kept by the data collectors suggested that long-season paddy varieties were grown on as much as 53 percent of the study area. The high proportion of long-season paddy varieties contributed significantly to the need to extend the 1986 yala irrigation season past the schedule originally established.

Planting Methods. Two planting methods -- broadcast sowing and transplanting -- were used by Minneriya cultivators during the 1986 yala. Both methods were recommended by the Agriculture Department. In general, most Minneriya cultivators preferred transplanting over broadcasting as they perceived that transplanted fields usually produced higher yields. Although agricultural research has indicated that similar yields can be obtained from either planting method, it was recognized that transplanting offered several advantages over broadcasting when other management practices were less than optimum.

When transplanting under the conditions existing at Minneriya, it is easier to control the plant environment in a small nursery during the critical periods of germination and initial seedling growth than is possible for seedlings in a broadcast field. A cultivator is more assured of obtaining a uniform stand when paddy is transplanted, and transplanted seedlings are able to compete with weeds more effectively than broadcast seedlings can. Finally, transplanting effectively reduces the period of field irrigation and potential exposure to unfavorable field conditions by 25-30 days. While these advantages certainly improve the potential for obtaining higher paddy yields with transplanted paddy, transplanting involves a major investment in labor, time, and capital.

Because of this investment, broadcasting was often used by Minneriya cultivators who wanted to decrease the financial risks associated with producing a paddy crop and by those who lacked capital or had trouble scheduling planting crews. In general, most cultivators considered yala to be more risky than maha because of the uncertainty of irrigation deliveries. Therefore, they were less willing to invest in transplanting during yala.

Approximately 62 percent of the paddy acreage in the study area was broadcast (Table 18). Within study areas, broadcast paddy ranged from 46-80 percent of the paddy acreage. The high proportion of broadcast paddy indicated that most cultivators were unsure of the yala

water deliveries. The fact that less than half of the area of D37 was broadcast suggested that cultivators in this study site obtained water from the drainage system.

Table 18. The percentage of each study site broadcast or transplanted with either long-season or short-season varieties (Minneriya, 1986 *yala*).

Planting Method and Varietal Type	D13	D21Head	D21Tail	D28Head	D28Tail	D37	Total %
	relative percent						
Broadcast, short-season	52.8	22.2	48.0	48.0	47.0	45.5	45.6
Broadcast, long-season	0.0	40.7	31.6	20.4	8.7	0.0	16.7
Transplanted, short-season	45.8	12.3	6.6	6.7	16.5	31.1	19.7
Transplanted, long-season	1.4	24.7	13.8	24.9	27.8	23.4	18.0

In three of the six study sites, a significant proportion of the acreage was broadcast with long-season paddy varieties. Because broadcasting and long-season varieties resulted in a longer period of plant growth, these cultivators required an extension of the irrigation schedule by approximately 3 weeks. The use of long-season varieties in combination with broadcasting appeared to be somewhat risky given the possibility that irrigation deliveries could have stopped before the crop matured. However, cultivators indicated that they broadcast long-season paddy varieties because long-season paddy varieties had greater yield potential and were less sensitive to the timing of management activities, such as weeding or agro-chemical application.

Transplanted paddy only accounted for nearly 38 percent of the total paddy acreage in the study sites (Table 18). Significant acreages of transplanted paddy were observed in all of the study sites. The fact that significant acreages were transplanted in these study sites indicated that the cultivators were reasonably confident of *yala* water deliveries. Only in the D21 tail study area was the transplanted acreage substantially less than the overall average for Minneriya.

Overall, cultivators initiated planting activities as early as 13 days before the scheduled completion of land preparation and as late as 35 days after the scheduled completion of land preparation. Early planting was primarily observed in the D21 tail and D28 head study areas. Interestingly, cultivators who delayed planting were primarily

located in the head and tail of the system. For 121 cultivators, the average time required for broadcasting and transplanting was 4 days.

According to the yala irrigation schedule for Minneriya, all planting should have been completed within 35 days after the first scheduled water issue. However, by the 35th day after the first scheduled water issue, only 47 percent of the paddy had been planted in the study area (Table 19). An additional 20 days passed before planting was completed on nearly 98 percent of the study area. Although there were a few instances where extended planting periods contributed to extensions in the irrigation issues, delays in land preparation were the major factor that caused cultivators to extend planting beyond the period established in the irrigation schedule.

Table 19. The number of days between the first scheduled water issue and completion of planting as reported by Minneriya cultivators (1986 yala).

Number of Days	D13 (n=21)	D21Head (n=12)	D21Tail (n=17)	D28Head (n=38)	D28Tail (n=16)	D37 (n=17)	Cum %
20	0	2	2	0	1	1	5.0
25	1	1	5	10	0	0	19.0
30	2	2	3	7	2	2	33.9
35	3	2	3	4	3	1	47.1
40	3	1	2	6	3	1	60.3
45	3	2	2	7	3	3	76.9
50	7	0	0	4	1	2	88.4
55	1	2	0	0	3	5	97.5
60	0	0	0	0	0	2	99.2
65	1	0	0	0	0	0	100.0

g. Fertilizer Application

Soil fertility and management are critical aspects of paddy production. Paddy yields of 150 bu/ac or more are only possible when soil fertility is properly managed throughout the growing season. To assist the farmer, the Agriculture Department provided detailed fertilizer recommendations for paddy cultivation in the low country Dry Zone. These recommendations specified the timing, type, and amount of fertilizer required for transplanted and broadcast short-season and long-season paddy varieties (Table 20). Data collected on the type, amount, and timing of fertilizer applications was used to determine how closely the cultivators in the study areas followed the Agriculture Department's recommendations.

Basal Fertilizer Application. The Agriculture Department recommended that a basal fertilizer dressing of V-mixture (5-15-15) be applied and incorporated into the soil immediately prior to planting paddy (Table 20). The basal fertilizer application was recommended in order to improve initial seedling growth and plant tillering.

Table 20. Fertilizer recommendations for paddy cultivation, Minneriya 1986 *yala*.

Fertilizer Application	Planting Method*	Age Class (Months)	Fertilizer Type	Amount** (lbs/ac)	Time Applied***
Basal	B	3	V-mixture	150	Final Harrowing
		3.5	"	150	"
		4-4.5	"	150	"
	T	3	V-mixture	150	Final Harrowing
		3.5	"	150	"
		4-4.5	"	150	"
Top dressing 1	B	3	Urea	55	2 WAS
		3.5	"	55	"
		4-4.5	"	55	"
	T	3	Urea	82	2 WAT
		3.5	"	82	"
		4-4.5	"	55	"
Top dressing 2	B	3	Urea	27	5 WAS
		3.5	"	27	"
		4-4.5	"	55	6 WAS
	T	3	TDM	82	5 WAT
		3.5	"	82	6 WAT
		4-4.5	Urea	55	4 WAT
Top dressing 3	B	3	TDM	110	7 WAS
		3.5	"	110	8 WAS
		4-4.5	"	110	10 WAS
	T	3	---	---	---
		3.5	---	---	---
		4-4.5	TDM	110	8 WAT

*B - Broadcast, T - Transplanted
**V-mixture - Paddy fertilizer mixture (N-P-K = 5-15-15)
TDM - Paddy top dressing mixture (N-P-K = 30-0-20)
Urea - Ammonium nitrate (N-P-K = 46-0-0)
***WAS - Weeks after sowing
WAT - Weeks after transplanting

Only 51 percent of the cultivators in the study area applied a basal fertilizer (Table 21). All of the cultivators who applied a basal fertilizer applied V-mixture. Approximately 8 percent of the cultivators applied V-mixture at or above the recommended rate (150 lbs/ac), and nearly 34 percent applied V-mixture below the recommended rate.

Within study sites, only 24 percent and 13 percent of the cultivators in D13 and D28 head study sites applied a basal dressing of V-mixture. Many of these cultivators indicated that they preferred not to apply basal fertilizer because it encouraged excessive weed growth.

Many cultivators also indicated that fertilizers purchased in the 1984 yala were adulterated.

Table 21. The relative application rates of V-mixture applied by cultivators in the study area (Minneriya, 1986 yala).

Rate of Application	D13 (n=21)	D21Head (n=12)	D21Tail (n=17)	D28Head (n=38)	D28Tail (n=16)	D37 (n=17)	Total %
	relative percent						
Above recommended	0	8	17	8	6	12	8.2
At recommended	0	8	35	0	13	12	9.1
Below recommended	24	67	24	5	68	64	33.7
Did not apply	76	17	24	87	13	12	49.0

The majority (77 percent) of basal fertilizer applications in the study area were applied within 1-5 days before planting. It is probable that most of these fertilizer applications were incorporated into the soil. By incorporating the fertilizer into the soil, cultivators minimized the amount of nitrogen lost by volatilization. However, basal fertilizer applications in approximately 23 percent of the fields were applied after planting. Because fertilizers probably were not incorporated into the soil, the effectiveness of nitrogen in these fertilizers may have been reduced.

Top Dressing 1. The Agriculture Department recommended that a first top dressing of urea be applied and incorporated into paddy fields two weeks after planting (Table 20). The purpose of the initial top dressing was to improve early plant tillering and growth of the paddy. Incorporating this fertilizer into the soil minimizes nitrogen losses to the atmosphere.

Ninety-eight percent of the cultivators in the study sites applied the first top dressing. Of those who applied the first top dressing, nearly 98 percent applied urea. Fifty-nine percent of the cultivators applied urea at 2-3 times the recommended rate (Table 22). However, the overall efficiency of urea application may have been reduced since none of the cultivators incorporated the urea into the soil. Interestingly, 29 percent of the cultivators in D13 and 76 percent of the cultivators in D28 head also applied V-mixture along with the urea. The majority of these cultivators did not apply a basal fertilizer (Table 21).

Table 22. The relative application rates of top dressing 1 applied by cultivators in the study area (Minneriya, 1986 *yala*).

Rate of Application	D13 (n=21)	D21Head (n=12)	D21Tail (n=17)	D28Head (n=38)	D28Tail (n=16)	D37 (n=17)	Total %
	relative percent						
Above recommended	67	58	71	55	69	35	59
At recommended	19	17	18	11	13	53	20
Below recommended	14	17	12	34	6	12	19
Did not apply	0	8	0	0	13	0	2

Only about 45 percent of the cultivators applied the first top dressing during the second week after planting, as recommended. Overall response to urea applications may be reduced when urea applications are made later than the fourth week after planting.

Top Dressing 2. The Agriculture Department recommended a second top dressing of urea on short-season, broadcast varieties (5-6 weeks after planting) and long-season, broadcast (5 weeks after planting) and transplanted varieties (4 weeks after planting) (Table 20). The application was recommended to improve plant tiller development and increase grain formation. For short-season, transplanted varieties, the Agriculture Department recommended the application of TDM mixture (5 weeks after planting) as a final top dressing to increase grain weight and encourage normal seed development.

The second top dressing was applied on 68 percent of the fields in the study area (Table 23). Approximately 24 percent of the fertilizer applications were urea. Generally, urea was applied to broadcast short-season and broadcast or transplanted, long-season paddy varieties. Nearly all of the urea applications were 2-3 times the recommended rates.

Table 23. Top dressing 2 applied by cultivators in the Minneriya study sites (1986 *yala*).

Fertilizer Type	Number of Cultivators						
	D37 (n=21)	D21Head (n=12)	D21Tail (n=17)	D28Head (n=38)	D28Tail (n=16)	D37 (n=17)	Total %
Urea	1	4	8	16	6	8	35
TDM	20	5	9	21	10	6	59
No fertilizer	0	3	0	1	0	3	6

Approximately 59 percent of the cultivators applied TDM as a second top dressing. Only 23 percent of the cultivators who applied TDM as a second top dressing applied it as the final fertilizer application on transplanted, short-season paddy varieties. The majority of these applications were made at the recommended rate. All other TDM applications were on broadcast, short-season and broadcast or transplanted, long-season paddy varieties.

Similarly, urea was applied on 35 percent of the fields, with approximately 93 percent of the applications made on broadcast, short-season, and broadcast or transplanted, long-season, paddy varieties. All other urea applications were on transplanted, short season paddy. Generally, urea applications were 1.5-2 times the recommended rates.

The time of application varied considerably within and between study sites, ranging from 5 to 10 weeks after planting. The efficiency of fertilizer use was certainly affected by late applications. Approximately 13 percent of the cultivators in the D28 head study site also applied V-mixture with the urea.

Top Dressing 3. The Agriculture Department recommended the application of a third top dressing of TDM mixture for long-season paddy varieties and broadcast, short-season varieties (Table 20). This top dressing was recommended to improve yields and grain development.

Only 38 percent of the cultivators in the study area applied a third top dressing on broadcast, short-season and broadcast or transplanted, long-season paddy (Table 24). Of those who applied a third top dressing, all except two applied TDM. Eighty percent of the TDM applications were at or above the recommended rate. However, the effectiveness of these applications was reduced since none of the cultivators incorporated the fertilizer into the soil. More importantly, most of the applications were made too late in the season to benefit the paddy.

Table 24. Top dressing 3 applied by cultivators in the Minneriya study sites (1986 *yala*).

Fertilizer Type	Number of Cultivators						Total %
	D13 (n=13)	D21Head (n=11)	D21Tail (n=16)	D28Head (n=34)	D28Tail (n=13)	D37 (n=13)	
Urea	0	1	0	1	0	0	2
2TDM	1	3	7	15	6	4	36
No fertilizer	12	7	9	18	7	9	62

When all four fertilizer applications were evaluated, less than 10 percent of the cultivators followed the Agriculture Department's fertilizer recommendations. Generally, many cultivators did not apply a basal fertilizer and most cultivators applied V-mixture at rates that were lower than the recommended rates. In contrast, urea applications

were much higher than the recommended rates. More importantly, a significant percentage of the cultivators did not apply a third top dressing. Instead, they applied TDM on the second top dressing. This suggested that the number of top dressings recommended by the Agriculture Department may not be necessary. Fewer top dressing applications with higher rates of fertilizer would reduce problems cultivators encounter trying to apply fertilizer at the correct time.

Field tissue tests for N-P-K in selected fields throughout the study area tended to support observations made on fertilizer applications. These tests, with a few exceptions, indicated that tissue levels of nitrogen and phosphorus were adequate to excessive, and tissue levels of potassium were low in many of the sites. Low potassium levels may have reduced the overall effect of nitrogen fertilizers and may have contributed to less than optimum paddy yields.

h. Relative Availability of Water

Research by De Datta (1981) indicated that plant growth and yields of paddy were affected by soil moisture conditions. This research reported yield reductions of 8 to 21 percent when soil moisture levels decreased to near field capacity during critical growth stages. In addition, more serious yield reductions were reported as the duration of soil moisture stress increased. De Datta (1981) reported that moisture conditions were most critical for the following plant growth stages of paddy: mid- to late tillering, panicle initiation, and grain head formation.

During 1986 yala, field observations were made in selected liyaddas to evaluate soil moisture conditions in paddy fields throughout the study area. Soil moisture conditions were observed the day before and the day after each water issue in a series of liyaddas located on either side of a line parallel to the field channel and perpendicular to the drainage channel. A scale was used to classify the soil in the liyaddas as follows:

0 - dry, cracked soils

1 - wet soils

2 - 1-5 cm of standing water

3 - > 5 cm of standing water

Within study sites, observations of soil moisture conditions began during the vegetative period between the second week of May and the second week of June and continued through the grain filling period in late August.

Observations of soil moisture conditions indicated that periods of soil moisture stress occurred in all of the study areas (Table 25). However, most of the data collectors failed to distinguish between dry, cracked soils and wet soils during their observations. Thus, while it was apparent that soil moisture stress developed in all study sites, it

was not possible to evaluate the degree of soil moisture stress in D13, D28 head, D28 tail, and D37. Observations did indicate that soils were dry prior to an irrigation issue. This suggested that periods of soil moisture stress for 2-3 days were common in many fields throughout the study area.

Table 25. Observations of soil moisture conditions as a relative percent of total observations in selected *liyaddas* in Minneriya study sites (1986 *yala*).

Observation	D13 (n=56)	D21Head (n=1854)	D21Tail (n=1441)	D28Head (n=1612)	D28Tail (n=504)	D37 (n=2272)
Dry, cracked soil	60.8	15.2	7.4	10	25	10.3
Wet soil	0	12.2	22.6	0	0	0
2.5-5 cm standing water	15.4	36	35.6	80.7	61.9	54
> 5 cm standing water	23.8	36.6	34.5	9.2	13.1	35.7

NOTE: D13. Observations on 4 allotments for 20 days over a 64-day period beginning June 15.
D21 Head. Observations on 8 allotments for 28 days over a 92-day period beginning June 1.
D21 Tail. Observations on 3 allotments for 31 days over a 105-day period beginning May 13.
D28 Head. Observations on 6 allotments for 26 days over a 87-day period beginning May 25.
D28 Tail. Observations on 4 allotments for 18 days over a 72-day period beginning June 15.
D37. Observations on 14 allotments for 22 days over a 77-day period beginning June 13.

i. Weed Control

Environmental conditions in paddy fields favor the growth of many aquatic and semi-aquatic weeds that directly compete with rice plants for nutrients, sunlight, and space. Many of these weeds also serve as alternate hosts for disease and insects that attack paddy. Thus, when weeds are not controlled, substantial reductions in paddy yields usually occur. In addition, the quality of the harvested grain is often reduced by the presence of weed seed.

Weed control should begin with land preparation. Thorough land preparation can reduce initial weed infestations in newly planted fields; thus decreasing the amount of time and effort required to control weeds after planting paddy. Earlier in this report, the quality of land preparation in all of the study areas was rated as poor to average. Most fields would have developed serious weed problems after planting.

The method of planting the cultivator uses also affects weed populations. It is recognized that transplanted paddy, because of its age and size at planting, is better able to compete with initial weed infestations than broadcast paddy. In general, weed infestations in transplanted fields (38 percent of the Minneriya study area was transplanted) were lower than in broadcast fields.

While a cultivator may reduce weed problems with proper land preparation and by transplanting, it may still be necessary to control weed infestations after planting. Research has shown that maximum paddy yields were obtained from fields in which weeds were properly controlled within the first 20-30 days after planting (University of the Philippines, 1970). Accordingly, the Sri Lanka Agriculture Department recommends that weeds be controlled by hand or through herbicide applications within the first 30 days after transplanting or broadcasting paddy. Depending on the severity of weed infestation, 1 to 2 weed control operations were recommended.

Weed control was practiced in 71 percent of the paddy fields in the Minneriya study area (Table 26). All of the cultivators in D13 and D21 tail attempted to control weeds in paddy fields with either herbicide applications or by hand-weeding. In the other study sites, a significant percentage of cultivators did not control weeds during the 1986 yala, and the majority who did attempt weed control applied herbicides. Ethnic disturbances on the borders of Kaudulla Scheme probably increased the difficulty Minneriya cultivators had in obtaining laborers to hand-weed fields during 1986 yala.

Table 26. The percent of fields in the Minneriya study area in which herbicides, hand weeding, or no weeding were practiced (1986 yala).

Weeding Method	D13 (n=21)	D21Head (n=12)	D21Tail (n=17)	D28Head (n=38)	D28Tail (n=16)	D37 (n=17)	Total % (n=121)
Herbicides	72	50	82	52	57	53	60
Hand weeding	28	8	18	3	6	6	11
No weeding	0	42	0	45	37	41	29

Two herbicides -- MCPA and 3,4 DPA -- were used by Minneriya cultivators. While both herbicides control only sedge and broadleaf weeds, they are very effective when properly used. However, only 20 percent of the cultivators who applied herbicides obtained satisfactory weed control (Table 27). Within study sites, the percent of fields where weeds were adequately controlled by herbicides ranged from 11 to 75 percent. Lack of knowledge was the primary reason cultivators failed to control weed infestations with herbicides.

Table 27. The percent of fields in the Minneriya study area in which herbicides or hand weeding were effective (1986 yala).

Weeding Method	D13	D21Head	D21Tail	D28Head	D28Tail	D37	Total
Herbicides	13	17	21	75	22	11	33
Hand weeding	17	100	33	100	0	100	31

Overall, weed infestation was considered a major factor affecting paddy yields in nearly all of the study sites. Infestations greater than 100 weeds/m^2 were observed in all study sites, with average infestations of above 100 weeds/m^2 observed in the D21 head and D37 tail study areas.

j. Pest Control

The tropical climate of Sri Lanka favors the proliferation of insect pests. This problem is further accentuated on irrigation systems such as Minneriya, where a crop (rice) is grown year-round. Failure to control insect pests usually results in substantial reductions in the quality and yield of paddy. For example, 24 separate experiments conducted over six cropping seasons at the International Rice Research Institute indicated that average paddy yields were reduced from 5.3 t/ha to 2.0 t/ha in plots with no insect control (De Datta, 1981). Although other management practices, such as weed control, are effective in helping to reduce insect infestations, controlling rice insects largely depends on the application of insecticides.

Generally, Minneriya farmers reported armyworm, stemborer, and planthopper as the most important insect pests in paddy. Damage from armyworm and stemborer usually occurred during both maha and yala, whereas damage from planthopper occurred only during maha.

Insect infestations were observed in nearly all of the fields in the study area (Table 28). The insect pests were primarily stemborers, thrips, whorl maggots, leaf folders, armyworm, and paddy bugs. Minneriya cultivators applied insecticides in approximately 50 percent of the fields infested by insects. Only in D13, D21 head and D37 were there a significant number of fields in which insecticides were not applied.

Few cultivators applied insecticides more than once during yala (Table 29). Data collectors indicated that many of the cultivators also relied on old, superstitious practices such as placing palm fronds in the paddy fields to prevent or stop insect infestations. In addition, ethnic disturbances on the borders of the Kaudulla Scheme may have affected Minneriya cultivators' decisions about spraying insecticides.

Table 28. The number of fields in each study area where insect infestations were observed and insecticides were applied (Minneriya, 1986 yala).

Paddy Fields	D13 (n=21)	D21Head (n=12)	D21Tail (n=17)	D28Head (n=38)	D28Tail (n=16)	D37 (n=17)	Total %
Insect infestations	21	12	15	38	16	17	98
Insecticides applied	10	9	15	4	13	10	50

Table 29. The number of fields in each study area where one, two, or three or more insecticide applications were made (Minneriya, 1986 yala).

Number of Applications	D13 (n=10)	D21Head (n=9)	D21Tail (n=15)	D28Head (n=4)	D28Tail (n=13)	D37 (n=10)	Total %
One	10	7	11	3	7	9	77
Two	0	2	2	1	5	1	18
Three or more	0	0	2	0	1	0	5

A wide variety of insecticides were used by Minneriya cultivators. They included Azodrin (monocroptophus, Nuvacron), Osbac (Baycarb, Bassa), Bayrusil (Ekalux, Quinalphos), Diazinon (Basudin), Phenthoate (Elsan), Parathion (Alleron, Niran), Actellic, Dimethoate (Perfecthion), BHC, Carbofuran (Furadan Curaterr), Baytex (Fenthion, Lebaycid), Monitor (Methamidaphos, Tamaron), Malathion, and several others which were not identified. Although the use of Malathion was supposed to be restricted to the Government's anti-malarial program, Minneriya cultivators preferred Malathion over other insecticides and were able to obtain it.

Observations of insecticide applications on Minneriya indicated that the majority of cultivators were unaware of the potential health hazards associated with these chemicals. Insecticides were often mixed near drinking wells in the field using drinking water containers to mix the chemicals. In addition, cultivators sometimes mixed more than one insecticide together, unaware of the potential hazards associated with mixing incompatible chemicals. Sprayer applications were made without protective clothing, and usually when it was windy. The indifferent manner in which insecticides were handled was made more serious by the fact that several of the insecticides used by Minneriya cultivators were classified as highly hazardous chemicals. A highly hazardous classification indicates that the chemical is extremely toxic (LD50 of 1-50 mg/kg) and should be handled with extreme care to avoid potential

contamination through contact with the skin or from inhalation or ingestion of the chemical.

k. Harvesting

Harvest Period. Earlier it was mentioned that in the kanna meeting for the 1986 yala, a 125-day irrigation season was established. This schedule was based on the cultivation of broadcast and transplanted, short-season paddy varieties. The scheduled harvest season allowed approximately 20 days, beginning the second week of August, for all harvesting to be completed (between 125 and 145 days after the first water issue). The schedule allowed a minimum of nearly one month between the completion of the yala harvest and the first water issue of maha (tentatively scheduled for October 10). This one-month period was considered essential to properly maintain the canal system and to provide Minneriya cultivators with an opportunity to market their paddy and make the necessary financial arrangements for the maha paddy crop.

Recall that the scheduled irrigation deliveries were extended by approximately two weeks. This extension was primarily due to delays in initiating land preparation and from broadcasting long-season paddy varieties.

The date when cultivators began harvesting was not obtained in the Minneriya study area. However, the date of harvest completion was collected on 121 fields in the study area (Table 30). The first field harvested was located in D21 tail, and was harvested on August 23, 122 days after the first water issue. This field was broadcast with a short-season paddy variety (BG-34-8) that required 99 days to mature from broadcasting to harvest. The last field harvested was located in D13. It was harvested October 1, 161 days after the first water issue. This field was broadcast with a long-season variety approximately 10 days after the scheduled planting date.

Table 30. The number of days required from the first scheduled water issue to the completion of harvest as reported by Minneriya cultivators, 1986 yala (n=121).

Number of Days	D13 (n=21)	D21Head (n=12)	D21Tail (n=17)	D28Head (n=38)	D28Tail (n=16)	D37 (n=17)	Cum %
125	0	0	1	0	0	1	1.7
130	2	2	1	2	0	3	9.9
135	2	3	0	6	2	2	22.3
140	4	2	3	7	0	3	38.0
145	3	0	6	9	5	7	61.2
150	5	2	0	2	9	1	76.9
155	2	1	6	7	2	0	91.7
160	2	2	0	5	0	0	99.2
165	1	0	0	0	0	0	100.0

Overall, approximately 61 percent of the surveyed fields in the study area were harvested within the scheduled period (Table 30). Another two weeks were required before approximately 99 percent of the fields were harvested. In D13, the extended cropping season primarily resulted due to delays in completing land preparation. Extended cropping seasons in the other study sites resulted from a combination of long land preparation periods and broadcast sowing of long-season paddy varieties.

Paddy Yields. According to the Agriculture Department, the new, high-yielding paddy varieties have potential grain yields of approximately 150 bu/ac. However, potential yields are seldom achieved in actual field situations. More realistic potential *yala* paddy yields would probably range from 120 to 130 bu/ac.

During 1986 *yala*, paddy yields from 109 sampled fields in the Minneriya study area (Appendix G) averaged 93 bu/ac; ranging from a low of 20.5 bu/ac to a high of 144.0 bu/ac (Table 31). The highest paddy yield occurred in a field located at the head of D28. This field was broadcast sown with a long-season paddy variety. The lowest paddy yield occurred in a field located in the tail of D28. This field was also broadcast with long-season paddy varieties.

Table 31. The maximum, minimum, and average paddy yields in the Minneriya study area (1986 *yala*).

	D13	D21Head	D21Tail	D28Head	D28Tail	D37	Overall
	bu/ac						
Maximum	116.4	140.2	122.5	144.0	126.0	110.6	144.0
Minimum	49.2	75.5	66.1	72.6	20.8	48.5	20.8
Average	86.6	109.1	92.8	113.3	81.7	79.4	93.1

Average paddy yields in the middle of the system (D21 head and D28 head) were significantly higher than those in the head and tail of the system (Table 31). Within these two study sites, nearly 75 percent of the fields produced paddy yields of more than 100 bu/ac.

The lowest average paddy yields occurred in the tail of the system (D28 tail and D37). Only 30 percent and 10 percent, respectively, of the fields in these two study sites produced paddy yields of more than 100 bu/ac. Coefficients of variation for paddy yields in these two study sites were high. In the D28 tail study site, coefficients of variation ranged from 30 percent to 130 percent. Values for the D37 study area ranged from 40 percent to 60 percent.

Variations in paddy yields in the Minneriya study area were primarily attributed to periods of inadequate soil moisture, poor weed control, and insect damage. The data also suggested that soil type was a major factor affecting paddy yields. The lowest average paddy yield occurred in the D37 study area. Soils in this study area were identified as imperfectly drained RBEs. The lower moisture holding

capacity of these soils most certainly contributed to problems the cultivators experienced in maintaining adequate soil moisture throughout the cultivation season.

There were no correlations between paddy variety or method of planting and paddy yields. Apparently, weed and insect infestations, periods of inadequate soil moisture, differences in fertilizer applications, and other individual management practices of the farmer compounded any effects of varietal differences or planting methods.

Data on threshing, drying, and storage of harvested grain was not collected. However, field observations during the harvest suggested that substantial losses, both in quality and amount of harvested grain, were incurred during threshing, drying, and transporting the harvested grain. It would not be unreasonable to expect as much as 15 percent of the harvested paddy to be lost during threshing, drying, bagging, and transportation of grain.

Note that bunds around the perimeter of the livaddas reduced the actual cropped area by 5-10 percent. Thus, when losses associated with harvesting were added to reductions in cropped area, cultivators probably only realized about 75-85 percent of the grain yields estimated by the crop cuttings of the agronomy field investigations.

4. CONCLUSIONS

While it was commonly assumed that each farm family was associated with a 5-ac (Stages I-III) or 3-ac (Stage IV) allotment on Minneriya, several factors have influenced the actual unit of cultivation. First, blocking out plans prepared during settlement indicated that the original allotment varied from 2-7 ac in Stages I-III and from 2-5 ac in Stage IV. Second, most of the allotments bordering field channel and drainage channel easements have increased in area through encroachment. Finally, increased population pressure on the land has significantly decreased the unit of land available to an individual cultivator. During the 1986 yala, the 82 allotments that comprised the study area (Stages I-IV) were cultivated by 121 individuals. Over 18 percent of these individuals cultivated 1 ac or less, and another 22 percent cultivated between 1 and 2 ac.

Soil surveys conducted by the Soil Survey Division of the Irrigation Department identified two major soil types in the study area. Reddish-brown earth soils occupied an average of 47 percent of the study site and covered from 18-100 percent of any particular study site. The majority of these soils were imperfectly drained as a result of the shallow, fluctuating water tables associated with irrigation. Although cultivation of these soils with crops other than paddy is possible, special management practices would be required to do so.

Low humic gley soils occupied approximately 53 percent of the study area and covered from 0-78 percent of any particular study site. All of these soils were poorly drained and only suitable for rice cultivation.

Although soil survey and climate information suggested that from 30-40 percent of the Minneriya command area would support crops other than paddy, approximately 91 percent of the study area was planted with paddy during the 1986 yala. Chili was the primary crop on the remaining acreage.

The kanna meeting to finalize the 1986 yala irrigation schedule was attended by less than 300 people, most of whom were vel vidanes rather than Minneriya cultivators. The irrigation schedule established during this meeting provided 30 days of continuous water issues for land preparation and 95 days of rotational issues for the cultivation of short-season paddy varieties.

However, during the 1986 yala irrigation season, it was necessary for the Irrigation Department to extend both continuous and rotational water issues by two weeks. The extensions were necessary because only 38 percent of the Minneriya cultivators completed land preparation within the scheduled period. An additional 20 days passed before 98 percent of the cultivators completed land preparation. The longer land preparation period was primarily attributed to inadequate water deliveries during land preparation, which delayed the initiation of land preparation in a major portion of the fields by 20-25 days.

Over 60 percent of the Minneriya cultivators used two-wheel tractors for land preparation. However, land preparation was rated as poor in nearly 40 percent of the Minneriya fields.

All of the cultivators in the study area planted new, high-yielding paddy varieties during 1986 yala. However, approximately 10-15 percent of the cultivators were unable to identify, or incorrectly identified, the variety of paddy they had planted.

Despite recommendations to plant short-season paddy varieties during yala, as much as 53 percent of the study area was planted with long-season paddy varieties. More importantly, at least 17 percent of the Minneriya acreage was broadcast sown with long-season paddy varieties. Broadcast, long-season paddy varieties required an irrigation season of 110-120 days and, thus, also contributed to the need to extend the irrigation season.

Less than 10 percent of the Minneriya cultivators followed the Agriculture Department's fertilizer recommendations for paddy. Although fertilizer applications in paddy fields were generally higher than expected, basal fertilizer applications were not made in 49 percent of the paddy fields. Instead, most cultivators applied a first top dressing of urea at 2-4 times the recommended rates. A significant percentage of cultivators incorrectly applied TDM as a second top dressing, and approximately 62 percent of the cultivators failed to apply the recommended third top dressing. Most of the cultivators who did apply a third top dressing applied it too late. These results suggest that the number and complexity of current top dressing recommendations need to be evaluated.

Periods of soil moisture stress occurred in all of the study sites. Although information on soil moisture stress was insufficient for evaluation, it was apparent that periods of soil moisture stress affected paddy yields in several of the sites.

The lack of weed control was regarded as a serious problem on Minneriya. Weed control, using either herbicides or weeding by hand, was attempted in 60 percent and 11 percent of the fields, respectively, in the study area. Herbicide applications were only effective in 33 percent of the fields, while hand weeding was only effective in 31 percent of the fields.

Infestations of armyworm, stemborer, thrips, whorl maggots, leaf folders, and paddy bugs were observed in nearly all of the fields in the study area. Insecticides were applied in approximately 50 percent of the fields in which insect infestations occurred. The indifferent manner in which insecticides were mixed and applied was considered a very serious problem that not only threatened the health of the individual using the insecticide, but also other family members and neighbors.

The 1986 yala paddy yields for Minneriya averaged 93 bu/ac. Within study sites, average yields ranged from 21 bu/ac to 144 bu/ac. Variations in paddy yield were attributed to deficiencies in crop management and inadequacies in water deliveries. Although periods of inadequate water deliveries occurred throughout the study area, they were more severe in the head and tail of the system.

D. ECONOMICS

1. INTRODUCTION

This section provides baseline economic data on the Minneriya Scheme. Economic data collected during 1986 yala provides insight into the farmers' economic and financial positions during this important cropping season. Such insight, together with the data provided by the other disciplines, will help in understanding the farmers' overall position. Such knowledge will also be useful in reaching judgments on the effectiveness of irrigation deliveries, support services, and financial institutions.

Specifically, the objectives of this section are to provide an understanding of the economics of the farmers' current agronomic practices, their efficiency in water use, and the equity of water distribution. Such knowledge should help the Ministry of Lands and Land Development (MLLD) identify farmers' interests and problems, and subsequently to set priorities for improvement. Such improvements could be implemented through the Irrigation Systems Management (ISM) Project, as well as by other means.

The economics report concentrates on the benefits and costs of paddy cultivation for 1986 yala. This season represents a "good" year in that water issues from the tank were said to be near design capacity, but also a "poor" year as far as farmers' feelings about paddy yields.

The economics report describes the methods used to gather and analyze data, presents and discusses the results, and draws conclusions. This format, as well as much of the text, follows that of the companion report on the 1986 yala survey of sample farmers on the Kaudulla Scheme (WMS Report 60). In fact, through the use of word processing and spreadsheet analyses, the author produced the two reports "in carbon copy," except for the differing questionnaire results and their interpretations.

2. METHODOLOGY

The information contained in this section came mostly from interviewing 75 farmers (76 were selected, but one did not give the requested information). All produced lowland rice, except one who reportedly grew chilies on lowlands and paddy on some of his highland holdings. Of the total farmers, 19 were at the head, 25 at the middle, and 31 at the tail of the system. They were served by the Yoda Ela and farmed about 2 percent of the scheme's irrigable area.

To select these farmers, the diagnostic analysis team chose six locations: one from the head, an upper and lower reach for each of two middle sections, and one from the tail of the system. The approximate distances of these locations from the main sluice gates follow in Table 32).

Table 32. Approximate distance of economic study sites from the main sluice in Minneriya (1986 yala).

Section	Distance (km)
Head	6
Middle	
upper reaches	8 and 13
lower reaches	11 and 18
Tail	22

Irrigation Department staff suggested the specific locations, giving primary emphasis to problem areas at the tail of the system and the lower reaches of the two middle sections of the system. Farmers within these locations may find themselves disadvantaged compared to other farmers when it comes to quantity and certainty of irrigation deliveries.

The team selected the other three locations to represent conditions typical of the head and upper reaches of the middle sections. Next, the team identified field channels emanating from the head, middle and tail sections of the distributaries. From a comprehensive list of the allotments pertaining to these field channels, the team selected two of every three farmers to interview.

A team of five to six field investigators, usually working in two-man teams, contacted farmers at their homesteads, which were usually separated from the lowland allotments. The field investigators based their formal interviews on a previously field-tested questionnaire of 330 items administered in two sessions of approximately two hours each. The responses were to be "closed" form; i.e., according to predetermined sets of possible answers instead of in "open-ended" form, where the responses are unrestricted. The field investigators conducted one interview following planting and another after harvest.

As is common with comprehensive, but infrequently conducted interviews of farmers, the results suffer from farmers' imperfect recall and potential bias. Problems of recall occurred when farmers were asked to estimate routine activities, such as the amount of time the family spent weeding. Problems of bias centered on farmers' reluctance to reveal personal items such as family income and land transactions -- some of which violated restrictions placed on the settlers. Notwithstanding, the team judged the responses of the 75 farmers' as reasonably good. We checked the reasonableness of several responses by comparing our results to information obtained from other sources: informal contacts, observations, and data collected by the other disciplines.

3. RESULTS AND DISCUSSION

The survey results include information on farmers' holdings, livestock, cropping patterns, cultural practices for paddy, water

management, labor inputs for paddy, use of improved practices, costs of paddy production, paddy output and disposal, paddy yields, family income, net profitability from paddy production, cash flows to the family, credit, and farmer attitudes.

a. Land Holdings

The 75 sample farmers owned 254 ac of lowlands and 128.5 ac of highlands for a total of 382.5 ac. Of the lowland amounts, the farmers reported that they had received a total of 236.25 ac as part of their original allotments, 9.75 ac from authorized encroachments, and 8 ac through purchases. The respective highland amounts reported were 112.75 ac, 12.25 ac, and 3.5 ac.

Encroachment occurs when farmers move onto lands unauthorized as part of their original settlement, including lands set aside for other purposes, such as forestry. The lands become authorized when the government formally acknowledges the farmers' rights to their use. The data on landholding may be understated, due to government restrictions on land transactions and encroachment.

The average farmer owned 3.4 ac of lowlands and 1.7 ac of highlands for a total of 5.1 ac. Tables 33 and 34 provide distributional averages of respondents' reported landholdings. Table 35 shows the combined average lowland and highland holdings. Nearly one-quarter of the respondents owned less than 3 ac, which means that a significant number of farmers were likely to have low incomes from their cropping activities. Four reported no ownership at all, which means that their holdings were rentals, mortgaged areas, or encroachments without permits. At the other extreme, five farmers -- all in the head section -- said they owned land amounting to 10 or 10.5 ac. Encroachments with permits and purchases contributed little to the overall size of holdings, at least according to farmers' reports. The agronomy report may provide more reliable data from actual measurements.

Half of the farmers reported that their lowland holdings were undivided into smaller plots. For the farmers who reported that their lowlands were divided, 23 allotments were each divided into two plots, 11 were each divided into three plots, and 3 were each divided into four or five plots.

Of the 73 farmers who reported the nature of their ownership, 11 said they were the original allottees, 10 said they were the wives of the original allottees, 38 said they were second generation owners, and 14 said they acquired the land through other means -- possibly through purchase, mortgage default, or transfers from relatives other than direct relatives. Because many of the settlers obtained their lands during the 1930s, enough time has elapsed for the second generation to take over. Passing ownership to the wife seems to be a normal process at the death of the male head of household. That so many allotments have reportedly remained with the original households might testify to the vitality of the scheme.

Table 33. Average lowlands owned as reported by the Minneriya sample farmers, 1986 *yala* (n=75).

Location	Head (n=19)	Middle (n=25)	Tail (n=31)	Total (n=75)
	acres/farmer			
Allotment	3.3	3.2	3.0	3.2
Encroachment with permit	0.1	0.1	0.2	0.1
Purchase	0.3	0	0.1	0.1
Total	3.7	3.3	3.3	3.4

Table 34. Average highlands owned as reported by the Minneriya sample farmers, 1986 *yala* (n=75).

Location	Head (n=19)	Middle (n=25)	Tail (n=31)	Total (n=75)
	acres/farmer			
Allotment	1.7	0.9	1.8	1.5
Encroachment with permit	0.4	0	0.2	0.2
Purchase	0	0	0.1	0
Total	2.1	0.9	2.1	1.7

To augment their holdings, 33 of the 75 sample farmers rented or mortgaged additional lowlands. These additions were somewhat offset by 11 farmers who rented or mortgaged portions of their lowland holdings to others. The only highland transaction reported was the renting out of a single acre. Most frequently, farmers cited money problems as their reason for renting or mortgaging their lands.

Eleven of the farmers said they had transferred portions of their lowlands to their children. None of the Minneriya farmers said they occupied encroached lands without permits. Table 36 shows that the net of reported land transactions added 1.1 ac to the average farmer's lowland holdings. Note that the middle farmers added considerably more to their holdings than the other farmers. With additions, the average size of middle farmers' lowland holdings is one-fifth larger than that of the head and tail farmers. However, by adding in the highland areas shown in Table 34, total area farmed evens out at 6.2 ac (Table 37). This result still leaves the middle farmers with an overall advantage because of the greater productivity of lowland areas.

Table 35. Combined average lowland and highland ownership by size of holdings for the Minneriya sample farmers, 1986 *yala*, (n=75).

Size (ac/farmer)	Number of Farmers) Head (n=19)	Middle (n=25)	Tail (n=31)	Total (n=75)	% of Total
< 1	2	4	1	7	9.3
1 - 1.9	3	1	2	6	8.0
2 - 2.9	0	1	2	3	4.0
3 - 3.9	1	3	2	6	8.0
4 - 4.9	0	2	4	6	8.0
5 - 5.9	3	9	7	19	25.3
6 - 6.9	2	3	1	6	8.0
7 - 7.9	3	2	3	8	10.7
8 - 8.9	0	0	9	9	12.0
9 - 9.9	0	0	0	0	0
10 - 10.9	5	0	0	5	6.7
Total	19	25	31	75	100.0

Table 36. Average net additional lowland transactions and total lowland areas reported by the Minneriya sample farmers, 1986 *yala* (n=75).

	Acres/Farmer Head (n=19)	Middle (n=25)	Tail (n=31)	Total (n=75)
Net Additions				
Net rentals	0.7	1.9	0.8	1.1
Net mortgages	-0.2	0.3	0.2	0.2
Given to children	0.1	0.2	0.2	0.2
Subtotal	0.4	2.0	0.8	1.1
Owned	3.7	3.3	3.3	3.4
Total farmed	4.1	5.3	4.1	4.5

Table 38 shows that the effect of net additions to ownership reduces the percentage of farmers with less than 2 ac from 17.3 to 4.0 percent. The maximum size of holding doubles, but the median size of holding remains within the 5-5.9 ac range. Subdivision among family members reduces somewhat the size of family holdings. Of the 75 sample farmers, 12 heads of household subdivided the land with their sons and 2 with their daughters.

Table 37. Total acreage farmed as reported by Minneriya respondents, 1986 *yala*.

	Acres/Farmer		
	Head (n=19)	Middle (n=25)	Tail (n=31)
Lowlands	4.1	5.3	4.1
Highlands	2.1	0.9	2.1
Total	6.2	6.2	6.2

Table 38. Combined lowland and highland areas farmed by the sample farmers in Minneriya, 1986 *yala* (n=75).

Size (ac/farmer)	Numbers of Farmers				% of Total
	Head (n=19)	Middle (n=25)	Tail (n=31)	Total (n=75)	
< 1*	0	0	1	1	1.3
1 - 1.9	1	0	1	2	2.7
2 - 2.9	4	3	5	12	16.0
3 - 3.9	3	0	3	6	8.0
4 - 4.9	0	4	5	9	12.0
5 - 5.9	1	8	4	13	17.4
6 - 6.9	3	4	2	9	12.0
7 - 7.9	2	2	3	7	9.3
8 - 8.9	1	1	2	4	5.3
9 - 9.9	0	2	1	3	4.0
10 - 10.9	2	0	0	2	2.7
11 - 11.9	0	0	1	1	1.3
12 - 12.9	2	0	1	3	4.0
over 13.0**	0	1	2	3	4.0
Total	19	25	31	75	100.0

* One farmer reported farming 0.5 ac.
** One farmer each reported farming 14, 15, and 18 ac.

For the 26 farmers who provided details on their rental acquisitions, the average size of transaction was 3.8 ac; 16 were for a single season, 4 were for one year, and 6 were for periods ranging from 1.5 to 5 years. Rental rates averaged Rs. 600 to Rs. 1,000/ac/season when payment was in cash and 22 bu/ac/season when payment was in kind. The rental rates in cash represent what we believe are the most likely values: farmers actually reported a much wider range of values, but some values appeared unrealistically large or small. For the six farmers who provided details on their rental of land to others, the average size of transaction was 2.1 ac; three were for a single season, two were for 2 to 5 years, and one did not provide information on the length of rental agreement. Seasonal rental rates averaged 26 bu/ac when farmers paid in kind.

The relationship between payments in cash and in kind deserves further investigation. At a market price of Rs. 77/bu, cash payments of Rs. 600 to Rs. 1,000 would be equivalent to 8 to 13 bu/ac/season. This is substantially below the reported rates for payment in kind of 22 to 26 bu/ac.

For the seven farmers who provided details on their mortgage acquisitions, the average size of transaction was 2.9 ac; two were for a single season, two for one year, and the rest were not reported. The overall value of mortgages ranged from Rs. 2,000 for 1 ac to Rs. 35,000 for 4.5 ac. For the five farmers who reported on their lands mortgaged out, the average size of transaction was 3.0 ac; one was for one season, two for one year, and two were not reported. The overall value of mortgages ranged from Rs. 1,000 for .5 ac to Rs. 40,000 for 4.0 ac.

b. Livestock

In addition to landholdings and acquisitions, farmers also derived utility and income from various types of livestock. Of outstanding importance were the farmers' buffalo, which they used for power, transportation, and food. While none of the farmers reported income from this source, buffalo provide many farmers with the means for timely cultivation. Slightly over one-half of the tail region respondents owned buffalo, but only 11 and 16 percent of the head and middle farmers, respectively, owned buffalo. All those who reported owning buffalo, however, said they had at least one pair and one farmer reported owning ten buffalo.

Of less significance were the farmers' cattle and poultry. Ten of the families owned an average of three cattle, with one owning eight and another owning seven. The latter reported a seasonal income of Rs. 400 from this source. Twelve farmers owned an average of 11 chickens. One farmer who owned 35 chickens reported a seasonal income of Rs. 800, and another who owned 20 chickens reported a seasonal income of Rs. 900. None of the other farmers reported income for either cattle or chickens.

c. Cropping Patterns

Traveling through the Polonnaruwa District, one is struck by the dominance of paddy cultivation over other farming activities. Data gathered by the field investigators supported this observation. All 75 sample farmers reported growing paddy on a total of 312 ac. Thirty-two farmers reported growing chilies on a total of 25 ac, three farmers reported growing vegetables on a total of 3 ac, and three others reported growing pulses on 2 ac. Thus, of the four crops farmers reported growing, 91 percent of the area was in paddy.

The areas reported devoted to these four crops total 342 ac. Compared to a total lowland area of 336 ac, this means the farmers must have used some of their highlands to cultivate these crops. Since all of these crops are likely to require irrigation during <u>yala</u>, some of the highlands must have been irrigated, even though highlands are not formally served by the irrigation system.

Farmers are known to convert the highlands into lowlands through excavation. The lowered surfaces can then receive irrigation deliveries. Farmers also sometimes siphon water to uncommanded areas from delivery channels. Another possible source, which the questionnaire did not cover, would be water supplied through pumping.

In addition to the four crops mentioned above, 33 farmers reported growing crops around their homestead (home gardens). The questionnaire did not reveal what these crops might be nor the amount of land devoted to this purpose.

Eighty-nine percent of the farmers preferred growing paddy, most frequently citing their reasons as the ease of production and higher profitability. Higher profitability is somewhat surprising, given the studies that show chili production to be considerably more profitable than paddy production (Skogerboe et al., 1984). A possible explanation is the farmers' unfamiliarity with chili production. Suitability of soils also accounted for some of the farmers' preferences, depending on their locations. Paddy favors the low humic gleys, whereas chilies favor the better drained, reddish brown earths.

The data show farmers devoting 110 ac to permanent crops. Of these 110 ac, farmers reported that trees per acre averaged 21 coconut, 20 banana, 3 mango, 3 jack, and 2 papaya.

d. Paddy Activities

The diagnostic analysis team identified 18 basic activities associated with yala paddy production according to the 74 farmers reporting on this crop. These activities begin with field channel cleaning and end with transporting paddy to market. Below is the list of paddy activities studied in 1986 yala:

* cleaning field channels
* plowing
* harrowing
* preparing seedbeds
* making poru ela
* cleaning and plastering bunds
* seeding
* applying fertilizers
* applying insecticides
* weeding
* managing water
* reaping
* bundling and collecting
* preparing the threshing floor
* threshing
* winnowing and bagging
* transporting from field to home
* transporting to market

Various aspects of these activities are discussed in more detail in the following sections. However, some general observations follow regarding a few of these activities.

Fifty-one farmers broadcast seed on the lowlands an average rate of 1.6 ac/day. Thirty-five farmers transplanted seedlings on the lowlands at an average rate of 0.42 ac/day. Two farmers broadcast seed on the highlands at an average rate of 0.9 ac/day and one transplanted at an unspecified rate. Based on total area reported planted in paddy, 42 percent, 15 percent, and 65 percent of the respondents transplanted paddy in the head, middle, and tail sections, respectively. All farmers reported using high-yielding varieties, with nearly 83 percent planting either BG 8/34 or BG 2/379. The remaining 17 percent were divided among BG 11, BG2/90, BG 2/94, and BG 6/34. Sixty-three percent of the farmers reported using their own seed, while another 25 percent acquired seed from their neighbors. Seeding rates averaged 2.2 bu/ac. Seed selection and seeding rates apply generally to all locations, whether head, middle, or tail.

All of the 74 farmers said they used chemical fertilizers. Forty-six percent of the respondents said they applied less than the recommended amount, 36 percent said they applied the recommended amount, and the remaining 18 percent said they applied more than the recommended amount. This pattern of use applied generally across head, middle, and tail regions. Farmers from the middle sections tended to apply relatively more than the recommended rates, compared to farmers in the head and tail regions.

Farmers said they used V1, TDM, or urea for the basal and top dressing applications. Private traders were reported to be the respondents' most common source of supply, but about 33 percent of the farmers received their fertilizers from the cooperative centers and the remaining 12 percent used the Agrarian Service centers. Most frequently, farmers said the rates they applied (whether more or less of the recommended rate) were more appropriate than the recommended rates. In about one-third of the cases, farmers gave money problems as their reason for applying less than the recommended rates.

The farmers who reported applying insecticides averaged 1.1 bottles/ac, with middle farmers applying rates somewhat less than the others. As a percentage of total area planted to paddy, 91 percent, 83 percent and 77 percent of the head, middle, and tail farmers, respectively, reported applying insecticides to their fields. The application rates and the areas covered show that the head farmers applied about 20 percent more insecticide to their fields than did the middle and tail farmers.

Farmers' reported applying insecticides to combat leaf folder and stemborers in 76 percent of the cases. Farmers' reported the brown plant hopper and the leaf-eating caterpillar to be less important. Sixty-three percent of the respondents said they applied the recommended amount of insecticide. Of those who did not, about one-half said they were unaware of the recommended rates, and the other half said they knew better than to apply what was recommended. On both

counts -- lack of knowledge or superior knowledge, if indeed true -- the farmers should benefit from better advice on pesticides. Such advice could come from the extension service, the cooperatives, the Agrarian Service centers, or knowledgeable private traders.

The majority of farmers reported using weedicides, manually weeding, or both. Eleven farmers reported no weed control efforts. Most of these farmers had transplanted their fields. Rates of weedicide application varied according to farmers' location. The rates were 3.7, 3.1, and 2.7 bottles/ac for head, middle, and tail farmers, respectively. Eighty-two percent of the farmers' responses on weed problems concerned gavari (a grass) or kuda metta (a sedge). The remaining 18 percent of the responses were about equally divided among bajari (a grass), thunessa (a sedge), and tunhiriya (a sedge).

Eighty-five percent of the farmers reported that they applied the recommended weedicide rates. The few who applied other than the recommended rates were about equally divided in their reasons, which included being unaware, knowing better than to apply the recommended rates, and having money problems. Few of the respondents supported the idea of manual weeding.

On average, farmers estimated that they spent 13 hrs/week irrigating. Differences among farmer groups did not appear significant: head, middle, and tail farmers reported spending 14, 11, and 13 hrs/week, respectively. These estimates of farmers' time spent on water management greatly exceed those the farmers estimated when considering their overall man-days of labor for paddy production.

Overall, the Minneriya sample farmers felt they were receiving adequate amounts of water: 52 thought they were, compared with 22 who thought they were not. Farmers had significantly different reactions depending on their location. Namely, only 12 percent of the head and middle farmers collectively felt they received less water than they needed, whereas 55 percent of the tail farmers felt they received less than they needed. One might expect this given the relatively long delivery routes associated with Minneriya's tail region channels. However, two of the middle section farmers were also located relatively long distances from the sluice gates.

Minneriya sample farmers' comments on water problems corresponded exactly with their comments on water availability. Even though the tail farmers at Minneriya reported water shortages, their paddy yields for the season did not appear to have been influenced by this shortage.

Almost all respondents reported costs associated with reaping, bundling and collecting, preparing the threshing floor, and threshing. All but one of the farmers reported labor costs for winnowing and bagging. Only 28 of the respondents reported costs for winnowing fans. Eleven of these were from the head, nine were from the middle, and eight were from the tail section.

Seventy percent of the farmers reported labor and tractor costs for transporting paddy from the field to the homestead. Within farmer

groups, head farmers incurred somewhat fewer costs than the other two groups.

Forty-nine of the 74 farmers reported spending time to market their paddy. Many Minneriya farmers own tractors. By owning their own means of transportation, Minneriya farmers may be more inclined to deliver their paddy to the local market than to rely on buyers coming to their door.

e. Paddy Labor

This section concentrates on the amount of labor reported required to do the foregoing activities. Included are estimates of man-day requirements for each activity. Values are given for head, middle, and tail farmers; for family, hired, and contract labor; and for male and female workers. To focus the reader's attention, we present labor requirements for the typical set of farming activities. We also provide seasonal labor estimates for other sets of activities. The section closes with a comparison of these requirements and the availability of family labor.

Requirements. The sample farmers meet their labor requirements for paddy production through that available from their own households and by hiring laborers daily or through contracts to perform specified activities. We assumed that farmers exchange labor at times of special need. While we do not have specific information on such communal activities, we have assumed that the net effect was to even out farmers' labor requirements rather than to increase or decrease the amount. Table 39 lists the average farmers' labor requirements overall according to their location at the head, middle, and tail of the system. The heaviest labor requirement was for transplanting; labor required for broadcasting was relatively small. Reaping, manual weeding, threshing, and bundling and collecting also required considerable amounts of labor.

Comparisons among head, middle, and tail farmers showed only minor differences in practices, as would be expected. Exceptions were the greater use of buffalo by the tail farmers and the greater percentage of middle farmers who broadcast. Over one-half of the tail farmers used buffalo, compared with one-third or less of the head and middle farmers. About 85 percent of the middle farmers broadcast paddy, whereas about 60 percent of the head and tail farmers resorted to this method. Table 39 appears to show that the middle farmers supplied considerably more labor for reaping than did the others (i.e., 40.04 man-days compared with 29.72 (head) and 25.90 man-days (tail)). However, the differences are not large per acre.

The farmers' estimate of 7.15 man-days for water management does not agree with their responses to the days per week (3.8) and hours per day (3.4) spent on this activity. These differences might be explained by the way the farmers viewed their water management activities. They might manage their irrigation water while also performing other duties, and consequently did not think of water management as a separate

activity. Also, the larger figure could represent the amount of time spent managing water during the height of the irrigation season.

Table 39. Average labor requirements for paddy production -- overall and by head, middle, and tail farmers, as reported by Minneriya respondents, 1986 *yala*.

Activities	Man-Days/Farmer*			
	Head (n=18)	Middle (n=25)	Tail (n=31)	Overall (n=74)
Cleaning field channels	2.27(15)	1.96	2.02(30)	2.05(70)
First plowing				
tractor	4.31(16)	5.36(22)	4.63(12)	4.85(50)
buffalo	5.17(6)	6.33(3)	5.90(20)	5.79(29)
Second plowing				
tractor	4.25(16)	4.78(23)	3.91(16)	4.37(55)
buffalo	7.17(6)	5.00(2)	5.44(16)	5.83(24)
Harrowing				
tractor	3.75(14)	4.58(20)	3.64(11)	4.09(45)
buffalo	6.50(6)	3.20(5)	4.37(19)	4.60(30)
Preparing seedbeds (for transplanting)	2.60(10)	3.83(6)	2.45(20)	2.72(36)
Making poru ela (for broadcasting)	17.82(11)	14.52(23)	7.00(23)	12.12(57)
Cleaning and plastering bunds	22.81	26.08	22.06	23.60
Seeding				
transplanting	63.22(9)	72.00(6)	66.47(19)	66.59(34)
broadcasting	2.32(11)	4.19(21)	1.50(18)	2.81(50)
Applying fertilizers	3.64	3.54	2.81	3.25
Applying insecticides	2.71(17)	1.88(21)	2.00(21)	2.16(59)
Weeding				
weedicides	2.27(11)	1.96(24)	2.16(19)	2.09(54)
manually	27.00(8)	30.36(11)	16.35(13)	23.83(32)
Managing water	7.78	6.40	7.39	7.15
Reaping	29.72	40.04	25.90	31.61
Bundling and collecting	19.28	22.80	14.03	18.27
Preparing the threshing floor	4.50(16)	4.63(24)	3.62(29)	4.17(69)
Threshing	19.22	24.36	15.26	19.30
Winnowing and bagging	10.00	12.50(24)	9.10	10.44(73)
Transporting from field to homestead	3.67(9)	3.76(17)	3.41(22)	3.58(48)

*Average area planted in paddy by location: 4.21 ac for head, 5.17 ac for middle, 3.51 ac for tail, and 4.27 ac overall. Values in () are numbers of farmers. Where no value is shown, the amount equals the value in the header.

Table 40 tells whether the labor was supplied by the farmer's family, hired daily, or provided through contract. Hired labor played the dominant role among the Minneriya sample farmers. In 10 of the 20 cases for which information is available, hired labor's input exceeded that of family labor. Hired labor substantially exceeded the family's inputs in making poru ela, cleaning and plastering bunds, transplanting, manual weeding, reaping, bundling and collecting, threshing, and winnowing and bagging. Contract laborers worked during transplanting, reaping, and bundling and collecting.

Table 40. Average labor requirements for paddy production by source of supply as reported by Minneriya respondents, 1986 yala.*

Activities	Family	Hired	Contract	Total
	man-days/farmer			
Cleaning field channel	1.89(59)	2.64(13)	0	2.05(70)
First plowing				
tractor	--	--	--	4.85(50)
buffalo	4.48(21)	6.73(11)	0	5.79(29)
Second plowing				
tractor	--	--	--	4.37(55)
buffalo	5.00(18)	6.25(8)	0	5.83(24)
Harrowing				
tractor	--	--	--	4.09(45)
buffalo	3.31(24)	5.32(11)	0	4.60(30)
Preparing seedbeds (for transplanting)	2.10(31)	4.13(8)	0	2.72(36)
Making poru ela (for broadcasting)	4.44(43)	10.42(48)	0	12.12(57)
Cleaning and plastering bunds	9.65(55)	23.38(52)	0	23.60(74)
Seeding				
transplanting	10.57(22)	56.60(26)	93.33(6)	66.59(34)
broadcasting	1.90(43)	2.92(20)	0	2.81(50)
Applying fertilizers	2.40(64)	3.23(26)	0	3.25(73)
Applying insecticides	1.74(51)	1.70(23)	0	2.16(59)
Weeding				
with weedicides	1.84(46)	1.36(21)	0	2.09(54)
manually	12.55(19)	24.95(21)	0	23.83(32)
Managing water	7.14(73)	8.00(1)	0	7.15(74)
Reaping	7.93(41)	26.95(56)	31.56(16)	31.61(74)
Bundling and collecting	5.98(43)	16.35(52)	17.50(14)	18.27(74)
Preparing the threshing floor	2.84(51)	4.47(32)	0	4.17(69)
Threshing	5.51(51)	16.62(69)	0	19.30(74)
Winnowing and bagging	4.25(52)	8.59(63)	0	10.44(73)
Transporting from field to home	2.50(32)	3.17(29)	0	3.58(48)

*Average area planted in paddy is 4.27 ac. Values in () are numbers of farmers. Numbers across may not total since some farmers use more than one source of labor.

Table 41 shows the division of farmers' labor according to gender. Compared with men's inputs, the only major contribution women are reported to make is in transplanting. Women were reported to contribute to reaping and bundling and collecting, but to a considerably lesser extent than do men.

Table 41. Average labor requirements for paddy production by gender as reported by Minneriya respondents, 1986 yala.

Activities	Male	Female	Total
	---------man-days/farmer----------		
Cleaning field channels	2.05(70)	0	2.05(70)
First plowing			
tractor	4.85(50)	0	4.85(50)
buffalo	5.79(29)	0	5.79(29)
Second plowing			
tractor	4.37(55)	0	4.37(55)
buffalo	5.83(24)	0	5.83(24)
Harrowing by			
tractor	4.09(45)	0	4.09(45)
buffalo	4.60(30)	0	4.60(30)
Preparing seedbeds (for transplanting)	2.72(36)	0	2.72(36)
Making poru ela (for broadcasting)	12.12(57)	0	12.12(57)
Cleaning and plastering bunds	23.60(74)	0	23.60(74)
Seeding			
transplanting	16.17(18)	63.65(31)	66.59(34)
broadcasting	2.81(50)	0	2.81(50)
Applying fertilizers	3.25(73)	0	3.25(73)
Applying insecticides	2.16(59)	0	2.16(59)
Weeding			
with weedicides	2.09(54)	0	2.09(54)
manually	3.50(10)	26.94(27)	23.83(32)
Managing water	7.15(74)	0	7.15(74)
Reaping	27.57(40)	8.79(34)	31.61(74)
Bundling and collecting	15.93(72)	7.07(29)	18.27(74)
Preparing the threshing floor	4.17(69)	0	4.17(69)
Threshing	19.30(74)	0	19.30(74)
Winnowing and bagging	10.44(73)	0	10.44(73)
Transporting from field to home	3.58(48)	0	3.58(48)

*Average area planted in paddy is 4.27 ac. Values in () are numbers of farmers. Numbers across may not total since some farmers use more than one source of labor.

To gain a fuller understanding of the labor requirements depicted in Tables 39 and 41, one must know more about the characteristics of farmers' practices. Table 42 provides a breakdown of the 74 sample farmers' responses based on whether they cultivated with tractors or buffalo and whether they transplanted or broadcast their paddy fields. The table also reveals the extent to which they applied weedicides and relied on insecticides, both of which reflect elements of modern agricultural practices. We do not show the breakdown of chemical fertilizer application, since all of the farmers reported their use.

Table 42. Cultural practices reported by the sample farmers in Minneriya, 1986 *yala* (n=74).

Traction	Insect and Weed Control	Seedling Method: Transplant	Broadcast	Both	Total Farmers
		-------Number of Farmers-------			
Total farmers using tractors only		13	26	7	46
	Weedicides only	5	15	3	23
	Weedc./manual	1	9	3	13
	Manual only	3	1	1	5
	No weeding	4	1	0	5
	Insecticides	13	21	6	40
	No insecticides	0	5	1	6
Total farmers using buffalo only		7	8	4	19
	Weedicides only	1	3	1	5
	Weedc./manual	1	4	1	6
	Manual only	2	0	1	3
	No weeding	3	1	1	5
	Insecticides	4	7	3	14
	No insecticides	3	1	1	5
Total farmers using tractors and buffalo		3	5	1	9
	Weedicides only	1	2	0	3
	Weedc./manual	2	2	0	4
	Manual only	0	1	0	1
	No weeding	0	0	1	1
	Insecticides	1	4	0	5
	No insecticides	2	1	1	4
Total farmers		23	39	12	74

The dominant practice is the combination of tractor use and broadcast paddy. The table indicates that 35 percent of the sample farmers reported relying only on this approach. The percentage of farmers using tractors and broadcasting at least some of their fields was 53 percent of the total (i.e., the 26 mentioned above plus 7 who used tractors and transplant and broadcast, the three who used tractors and buffalo and broadcast, and the one who used both methods of traction and seeding). Those farmers who plowed and harrowed with tractors, broadcast paddy, and applied weedicides followed the most labor-saving approach. Such a preference conforms with the farmers' heavy reliance on hired and contract labor and their probable desire to reduce such dependency. Access to tractors, however, means that some of the sample farmers, or others in the area, have sufficient wealth or income to finance their purchase.

Table 43 shows that the farmers who relied on tractors, broadcast, and used fertilizers, pesticides, and weedicides averaged 155.91 man-days for the 1986 vala. Considering that the average farmer had 4.27 ac of paddy under cultivation, this labor requirement comes to 37 man-days/ac. On a per-acre basis, this is nearly 20 percent less than the labor saving alternative. At least part of the savings could be expected to result from economies of scale associated with the larger holdings of the Minneriya farmers.

Sixty percent of the typical Minneriya farmers' labor requirements were from four activities: cleaning and plastering bunds, reaping, bundling and collecting, and threshing (Table 40). Of the total labor requirements, only one-third came from the family's own sources. The rest was either hired or contracted. In reaching this estimate of family labor, we have assumed for want of specific information that 50 percent of the labor for plowing and harrowing came from the family.

Females' contributions to the typical set of farming activities were less than five percent for those farms that relied only on weedicides (15 of the 26 cases shown in Table 42). However, for those 10 cases in which the families weed manually, the female's contribution rose to 19 percent of the labor total, since they performed 95 percent of this labor intensive activity (Table 41).

This small contribution from women is surprising and may be the result of the way the questionnaire was constructed in addition to the fact that men were interviewed to obtain this information. The farmers were asked to list female labor for only transplanting, weeding, reaping, bundling, and collecting. Since the most representative farmer broadcast rather than transplanted, and often relied on weedicides instead of manual weeding, women's labor contribution in many cases may have been limited to reaping and bundling and collecting. However, to the extent that women probably engage, at least marginally, in some of the other activities, their overall contribution would be larger than the percentages stated above. In fact, the farm women interviewed by the women in development component reported much higher agricultural participation.

Table 43. Comparison between the most common and the most labor-intensive approaches to paddy production reported by sample farmers at Minneriya, 1986 *yala* (n=74).

Activities	Most Common	Labor Intensive
	---Man-days/Season*---	
Cleaning field channels	2.05	2.05
First plowing		
tractors	4.85	0
buffalo	0	5.79
Second plowing		
tractors	4.37	0
buffalo	0	5.83
Harrowing		
tractor	4.09	0
buffalo	0	4.60
Preparing seedbeds (for transplanting)	0	2.72
Making poru ela (for broadcasting)	12.12	0
Cleaning and plastering bunds	23.60	23.60
Seeding		
transplanting	0	66.59
broadcasting	2.81	0
Applying fertilizers	3.25	3.25
Applying insecticides	2.16	2.16
Weeding		
with weedicides	2.09	0
manually	0	23.83
Managing water	7.15	7.15
Reaping	31.61	31.61
Bundling and collecting	18.27	18.27
Preparing the threshing floor	4.17	4.17
Threshing	19.30	19.30
Winnowing and bagging	10.44	10.44
Transplanting from field to homestead	3.58	3.58
Totals	155.91	234.94

*Based on overall values for 74 farmers, as shown in Table 39, and on an average paddy area per farmer of 4.27 ac.

The labor intensive approach (farmers using buffalo, transplanted paddy, and manual weeding) calls for 235 man-days of effort, which is 50 percent greater than the typical situation. Farmers who might be expected to follow these practices are those with ample family labor relative to the area planted in paddy, but with limited cash or credit facilities.

Supply. The questionnaire did not provide information on family size or household labor available for paddy production. The Government's Consumer Finance and Social Economic Survey for 1981-82, however, indicated that family size for the whole of Zone II, which

includes Polonnaruwa, was 5.3 (Central Bank of Ceylon, 1984). Considering that rural families might be somewhat larger than urban families, Minneriya farmers might have an average family size of 5.5 members. Thus, two full-time adult workers might be a reasonable estimate of available family labor. This estimate would allow for a male head of household, inputs from an elder son, and occasional inputs from the wife. Over the irrigation season (mid-April through August), the family would therefore have about 220 days of labor available. This estimate allows for one day of rest each week and a few days for holidays or other occasions when farmers customarily do not work.

The cropping requirements for the typical situation, shown in Table 43, is 156 man-days. Considering that the sample farmers provided only about one-third of this input (using data from Table 40), then the family's supply of labor exceeds its input by more than four times (220 divided by one-third of 156 = 4.2). This ratio seems ample, even when allowing for the unevenness of labor requirements and farmers' other interests and responsibilities. That these farmers, who live on relatively low incomes, rely so much on hired and contract labor suggests that family labor must be a constraint during periods when laborers are in high demand. The rather rigid irrigation regimes and their resulting impact on land preparation, planting, harvesting, and other activities probably contributes to these peak labor periods.

Future diagnostic teams might wish to explore this topic more intensively. In doing so, the team would need to learn more about the availability of family labor, weekly labor requirements, and the particular needs of individual cropping activities.

Paddy Costs. This section provides information on the costs of paddy production as reported by the 74 sample farmers. These costs concern purchased materials, hired and contract labor, the services of buffalo and equipment, and the family's own labor. For family labor and where the farmers used their own tractors and buffalo, the costs do not represent actual cash expenditures. Rather, the costs reported on the questionnaires represent what economists call "opportunity costs"; i.e., the value of an item in its best alternative use. For example, by assigning the current daily wage of Rs. 30 for family labor, we assume that a family laborer could earn this amount were he or she able to hire out instead of participating in the family's paddy production. Similarly, where farmers own buffalo or tractors, the production costs represent what these assets could earn were the farmers to rent them out instead of using them for their own paddy production. In a subsequent section we modify this approach as we investigate the sample farmers' economic and financial positions. At that time we take account of the sample farmers' various sources of income and costs other than those directly related to paddy production.

Table 44 shows average costs by type of input for each of the activities. Since the area planted to paddy averaged 4.27 ac/family, the costs per acre would be about one-quarter of those shown in the table. Major cost items are plowing and harrowing, transplanting, and fertilizer purchases. Also important to a lesser extent are the costs of cleaning and plastering bunds, manual weeding, and reaping.

Table 44. Average variable cost of producing paddy on 4.27 ac as reported by the sample farmers, Minneriya, 1986 *yala* (n=74).

Activities	Labor	Materials	Equipment & Buffalo
	----------Rs./farmer----------		
Cleaning field channels	79(70)*	NA	NA
First plowing			
tractors**		NA	1,593(50)
buffalo		NA	667(24)***
Second plowing			
tractors**		NA	1,443(55)
buffalo		NA	628(19)***
Harrowing			
tractors**		NA	784(45)
buffalo		NA	471(28)
Preparing seedbeds for transplanting	97(35)	NA	NA
Making poru ela for broadcasting	364(57)	NA	NA
Cleaning and plastering bunds	910(74)	NA	NA
Seeding		917(74)	NA
transplanting	2,263(35)		
broadcasting	117(52)		
Fertilizing	121(74)		NA
basal		818(72)	
first top dressing		921(72)	
second top dressing		782(63)	
Applying insecticides	80(57)	334(57)	105(50)
Weeding			
with weedicides	76(54)	855(52)	169(46)
manually	727(31)	NA	NA
Managing water	215(74)	NA	NA
Reaping	1,279(74)	NA	NA
Bundling and collecting	771(74)	NA	NA
Preparing the threshing floor	159(69)	NA	NA
Threshing**	741	NA	640
Winnowing and bagging	386(73)		259(28)
Transporting from field to homestead**	129(52)	NA	238(52)

NA = Not applicable

*Numbers in () are numbers of farmers. Occasionally minor differences occur between the number of farmers reported here and in Tables 39 and 41 due to incomplete reporting on the questionnaire.

**Fuel, lubricants, and operators contribute to tractor costs.

***Labor is included as part of buffalo costs.

To give these individual costs more meaning, consider the dominant characteristics of the head, middle, and tail farmers. the dominant practice among farmers in the head, occurring 39 percent of the time, was the combination of transplanting and use of tractors. The practice of broadcasting and tractor use was a close second at 33 percent. The dominant practice among middle farmers, occurring 60 percent of the time, was the combination of broadcasting and use of tractors. The reader may recall that the combination of broadcasting and traction with tractors was the dominant practice for the overall group. In contrast, practices among tail farmers were diffused, with only 23 percent of them transplanting and using buffalo.

As noted earlier, the sample farmers customarily used weedicides. However, the percentage of farmers differed according to their location. The head farmers used weedicides (as well as weeding manually) 72 percent of the time. By contrast, the middle farmers followed this practice 92 percent of the time, while the tail farmers did so only 55 percent of the time.

Costs associated with the predominant practice (i.e., tractors, broadcasting, and weedicides) amount to Rs. 15,285, which -- for the average farm size of 4.27 ac -- comes to Rs. 3,580/ac. Table 45 provides the details. This result comes close to the design team's estimate of Rs. 2,950/ac of paddy for the Irrigation Systems Management Project (Skogerboe et al., 1984). Adjusting for inflation brings these values close together, although individual costs occasionally differ significantly.

Thirty-six percent of total costs were for labor. Next of importance were equipment costs -- nearly three-fourths of which were for plowing and harrowing. How many of the farmers owned their own tractors could not be told from the questionnaire. Fertilizers accounted for over half of material costs. Combined, family labor (one-third of total labor), tractor expenses, and fertilizers accounted for over half of the total costs.

Costs for conditions predominating among head farmers (i.e., tractors, transplanting, and weedicides) came to Rs. 17,164/farmer or Rs. 4,020/ac. To arrive at this estimate, we deducted the costs of <u>poru ela</u> and broadcasting, and added the costs of preparing the seedbed and transplanting. Also common among those who transplanted was the practice of not weeding -- neither with weedicides nor manually. Deducting the costs of weedicides reduced these costs by Rs. 1,100/farmer or Rs. 3,762/ac total).

Costs for conditions predominating among tail farmers (i.e., buffalo, transplanting, and weedicides) came to Rs. 15,110/farmer or Rs. 3,539/ac. By removing weeding costs, these costs were reduced to Rs. 14,010/farmer or Rs. 3,281/ac.

Table 45. Average variable costs of producing paddy for Minneriya farmers who followed the predominant practice,* based on an average farm size of 4.27 acres.

Activity	Type of Cost			Total
	Labor	Materials	Equipment	
	Rs./farmer			
Cleaning field channels	79	NA	NA	79
Two tractor plowings	**	NA	3,036	3,036
Harrowing with tractors	**	NA	784	784
Making poru ela for broadcasting	364	NA	NA	364
Cleaning and plastering bunds	910	NA	NA	910
Broadcasting seed	117	917	NA	1,034
Three fertilizer applications	121	2,521	NA	2,642
Applying insecticides	80	334	105	519
Weeding with weedicides	76	855	169	1,024
Managing water	215	NA	NA	215
Reaping	1,279	NA	NA	1,279
Bundling and collecting	771	NA	NA	771
Preparing the threshing floor	159	NA	NA	159
Threshing	741	NA	640	1,381
Winnowing and bagging	386	***	259	731
Transporting from field to homestead	129	NA	238	367
Total	5,427	4,627	5,231	15,285

NA = Not applicable
*Farmers who used tractors, broadcasted, and applied weedicides.
**Labor is included as part of buffalo costs.
***The questionnaire did not obtain information on bagging costs.

The least cost alternative of all, which only 8 of the 74 farmers practiced, was the combination of buffalo, broadcasting, and weedicides. This approach cost the Minneriya farmers only Rs. 13,231/farmer or Rs. 3,099/ac.

The Minneriya sample farmers' general preference for tractors result in larger apparent costs than if they were to use buffalo. In fact, the data show tractors costing Rs. 2,054 more per farm than buffalo used for traction. The daily rates for tractors average nearly Rs. 300, compared with the daily rates for buffalo of about Rs. 100. Partially offsetting these higher daily rates for tractors was the less time they require. The average length of time to plow and harrow with tractors ran just over four days, compared to six days for buffalo. However, given the farmers' larger holdings and the accompanying

limitations of family labor, this preference for tractors was probably justified, especially if planting was delayed for lack of available buffalo. Also, tractors reduce some of the drudgery of farming, are frequently used for transportation, and are probably a symbol of affluence.

Paddy Production. According to information supplied by sample farmers, output on the 316 ac planted in paddy averaged 58 bu/ac. (The agronomy section of this report gives estimated yields from crop cuttings.) Of particular interest is the commonality of yields among the head, middle, and tail groups, especially in light of their differences in practices. Average yields for the head, middle, and tail farmers were reported to be 59, 57, and 59 bu/ac, respectively. The individual high from the 74 sample farmers was 100 bu/ac and the individual low was 13 bu/ac. The overall average of 58 bu/ac was 17 percent less than the nationwide average of 70 bu/ac and about half of USAID/Colombo's (1986) estimate of 110 to 120 bu/ac as a realizable potential. Note that the sample farmers claimed that yields during the 1986 yala were below those of the previous maha and the 1985 yala. (The yield for the middle group was lowered by 1 bu/ac due to 4 ac that were planted but not harvested. These results, for what farmers say was a poor season relative to the previous year, suggest that Minneriya farmers are probably able to obtain yields approximating the national average.

The majority of the farmers attributed their low yields during 1986 yala to the prevalence of wind during pollination. They also cited pests in general and during pollination as contributing factors.

Table 46 provides the yields for head, middle, and tail farmers according to whether they transplanted or broadcast paddy. Because farmers reported the disposition of their output, yields per acre of harvested area had to account for losses during harvesting and initial post-harvest. The table shows that transplanted paddy yields are higher than broadcast paddy yields in all three locations. Note that the yields for transplanted paddy in the middle section were lowered because one-sixth of the area planted was not harvested.

Overall differences in yields between transplanted and broadcast paddy were significant at the 1 percent level. Also, the coefficients of variation for the two methods of planting were virtually the same -- 27.8 and 28.3 percent --thereby indicating strong similarity in the spread in yields within each group. A test of the standard deviation for the two methods of planting failed to show a difference at the five percent level of significance. The wisdom of transplanting rather than broadcasting, however, requires comparisons between the value of the larger yields and the higher costs of transplanting. This comparison is made in a subsequent section.

Table 46. Average net paddy yields for sample farmers according to their location and method of seeding, Minneriya, 1986 *yala*.

	Head		Middle		Tail		Overall	
	T*	B	T	B	T	B	T	B
Number of farmers**	7	9	2	19	12	12	21	40
Total production (bu)	1,695	1,853	700	5,581	3,774	1,304	6,169	8,738
Area planted (ac)	27.5	36.3	12.0	99.8	57.5	26.5	97.0	162.6
Yields (bu/ac)	61.6	51.1	58.3	56.2	65.3	49.2	63.6	53.7
Combined yields (bu/ac)	55.7		56.5		60.5		57.4	
Area harvested (% of planted)	100	100	83	98	100	100	98	99

*T - Transplanted; B - Broadcast

**Omitted are the results for 13 farmers who used both methods of seeding because yields could not be associated with one of the two methods. These omissions cause the combined yields to be slightly different from those reported earlier.

Why transplanted yields should be higher than broadcast yields is a subject worth exploring to learn if such differences persist across time and areas, or whether or not this was simply a local, one-time occurrence.

Disposal of Output. Combining the average yield for each farmer (58.2 bu/ac) and the average land planted in paddy during the 1986 *yala* (4.27 ac) produces an average output by each family of 248.5 bu. Of this total, the farmers paid out an average of 11.5 bu for leasing arrangements and 0.1 bu for the *vel yidane*, and kept 8.6 bu for seed; leaving a net output of 228.3 bu. Of this amount, the farmers set aside an average of 44.3 bu for consumption, sold 100.2 bu, and retained 83.8 bu for future sale.

Ninety percent of the farmers sold their paddy through private traders, most of whom were from the local area. Only four of the 61 farmers who reported on their sales outlets sold through the Paddy Marketing Board or the cooperatives. Three sold to the seed farm. Farmers' preference for private traders centered on the traders' acceptance of the farmers' paddy without penalties for low quality, the ease with which farmers obtained payment, farmers general dissatisfaction with official marketing sources, and the low or no transportation

costs associated with paddy sales. Concerning transportation costs, farmers said they paid less than an average of Rs. 1/bu sold.

The amount farmers reported set aside for consumption represents an average daily per capita consumption of 0.63 kg of rice per day, 70 percent more than the apparent combined consumption of rice and rice flour for Sri Lanka from 1978-82 as reported by the Ministry of Finance and Planning (1984). Our estimate of the sample farmers' consumption derives from the following values and assumptions: 20.87 kg/bu, 0.68 conversion factor from paddy to rice, two paddy plantings each year so that each season's paddy set aside represents one-half of the year, and an average family size of 5.5 members. We could not tell from the data why the farmers set aside more rice than the national average. Possible reasons include greater than average consumption, a preference to have more withheld during this yala than other seasons, and losses during storage.

Having a marketable surplus of 184 bu/season, compared with the 44 bu set aside for consumption and an expected consumption rate of 26 bu, means that these farmers are active participants in the market economy. Also, by holding 84 bu off the market, the sample farmers are better able to demand a more competitive price for their paddy than were they forced to sell all, or most, of their paddy immediately following harvest. Such activity probably explains the farmers' use of purchased inputs (pesticides and fertilizers), as well as their employment of labor and purchases of tractor and buffalo services. Given their current market activity, introducing improved practices to Minneriya farmers ought to be an easier task than often occurs in developing countries. (Where small-scale agriculture is largely subsistence, farmers find it difficult to accept changes that require cash outlays.

Table 47 divides these overall figures into those representative for the head, middle, and tail farmers. This locational breakdown reveals that the head and middle farmers held more for consumption and sold more than the tail farmers but retained less for future disposal. All sold considerably more than they withheld for consumption, and all retained substantial amounts for future disposal.

Family Income. During yala, family income is derived primarily from paddy sales because farmers prefer this crop and because of moisture limitations on the highlands. However, the family also derived income by additional means, such as from selling other crops planted on lowlands or highlands, renting tractors and buffalo to others, and obtaining off-farm sources. Below are survey findings for both paddy production and other income sources.

1. Value of Paddy Production

Table 48 reveals that the average net value of paddy production for the sample farmers as a group amounted to Rs. 17,616. This value is the product of the farmers' net output as shown in Table 47, and the average farm gate price less any transportation costs. Before comparing this value with the cost of production, we must adjust for the cost

of seed. In Table 44, the Rs. 917 for seed was imputed at the rate of Rs. 101/bu of paddy equivalent. However, farmers supplied 95 percent of this amount from stocks held over from previous harvests. Thus, seeding costs would double were we to use the costs from Table 45 and the net output from Table 47. To correct for this overlap, we deducted 95 percent of the seed cost from the total cost of production. This lowers total costs by Rs. 871 (0.95 x Rs. 917), giving an adjusted cost of production for comparison purposes of Rs. 14,414 (Rs. 15,285 - Rs. 871).

Table 47. Average disposition of paddy overall and by head, middle, and tail farmers, Minneriya, 1986 *yala*.

Item	Head (n=18)	Middle (n=25)	Tail (n=31)	Overall (n=74)
	bu/family			
Total production	249.3	298.8	208.3	248.5
Less amounts for				
rent	3.3	28.3	2.7	11.5
seed	6.3	12.2	7.0	8.6
vel vidane	0.1	0.2	0.1	0.1
Net output	239.6	258.1	198.5	228.3
Less amounts held for consumption	51.4	49.0	36.3	44.3
Marketable surplus	188.2	209.1	162.2	184.0
Sales to date	111.7	129.0	70.3	100.2
Retained	76.5	80.1	91.9	83.8

Table 48. Average values of paddy production overall and by head, middle, and tail farmers on Minneriya.

	Head (n=18)	Middle (n=25)	Tail (n=31)	Overall (n=74)
Net output (bu)	239.6	258.1	198.5	228.3
Farm-gate price (Rs./bu)	81.5	77.9	74.0	77.1
Less transportation charge (Rs./bu)	0.2	0.4	0.4	0.3
Net price (Rs./bu)	81.3	77.5	73.6	76.8
Value (Rs.)	19,479	20,003	14,610	17,533
Amount sold (%)	46.6	50.0	35.4	43.8
Assumed cash receipts (Rs.)	9,077	10,002	5,172	7,680

This value of production exceeds the adjusted variable costs of production by 22 percent (Rs. 17,533 is 122 percent of Rs. 14,414). The difference between the value of production and the variable and fixed costs represents a return to the farmers' land, capital, and management, but not labor. The cost of the family's labor input was imputed at the going rate of Rs. 30/day. Considering that farmers' claimed the current season's yields were below those for the preceeding year, net returns to Minneriya farmers would usually be even higher. Whether or not these returns to the farmers' non-labor factors of production are adequate given prevailing market values calls for more information than can be extracted from the questionnaires. In any case, the sample farmers from Minneriya are at least covering their variable costs of production, including a satisfactory return for their labor input.

The paddy prices these income estimates are based on averaged Rs. 77.1/bu overall. The highest prices ranged between Rs. 95 and Rs. 100/bu for paddy sold to the seed farm. Otherwise, the highest price, mentioned by one of the tail farmers, was Rs. 92/bu, and the lowest price, also mentioned by one of the tail farmers, was Rs. 63/bu. In both cases, these farmers sold to private, local traders. Supposedly, farmers can receive a guaranteed price of Rs. 70/bu from official sources such as the Paddy Marketing Board. However, farmers' net price from official sources may be less because of deductions for excessive moisture, rejections due to poor quality, and associated transportation costs. For these reasons, farmers often feel they obtain as good a price from the local traders, even though these traders at times pay them less than the guaranteed price.

Larger areas planted in paddy and higher prices combined to give the head and middle farmers an income advantage of one-third or more over the tail farmers. Moreover, the tail farmers did not have a cost advantage. Although they relied more on the buffalo, they also transplanted more than did the other farmers.

The highest paddy incomes among head, middle, and tail farmers were Rs. 83,600 (10 ac), Rs. 41,400 (14 ac), and Rs. 73,300 (14 ac), respectively. The lowest paddy incomes for these same groups were Rs. 800 (2 ac), Rs. 2900 (1.5 ac), and Rs. 1,400 (0.5 ac), respectively.

Studying the cultural practices of these six farmers showed little difference in traction, seed type, source, or method of planting. However, in terms of agricultural chemicals, the two groups differed -- sometimes substantially. The high income group made ample use of insecticides, whereas the low income group's use was negligible. Also, the high income group appeared to pay substantial attention to weed control compared with the low income group, who did not -- even though they mostly relied on broadcasting. Finally, the high income group reported using one-third more bags of fertilizer per acre than did the low income group. Thus, the use of agro-chemicals appears to be an important distinction between the two groups.

These differences show in average yields for the high income group of 79 bu/ac compared to 29 bu/ac for the low income group, and they compound the differences due to size of holdings. In this instance, the smaller holdings did not increase the families' attention to their cropping activities. One might argue that the families' limited incomes restricts their use of purchased inputs, but this does not explain their failure to weed manually.

The cash receipts the farmers recieve amount to their sales plus whatever portion of the retained amounts are sold. At the time of the survey, the average family had sold 44 percent of its net output for a cash value of about Rs. 7,700. We use these values later when discussing the farmers' financial positions.

Before closing this section, we wish to comment on the head and tail farmers' preference for transplanting. Table 46 showed that the yields from transplanted paddy averaged 9.9 bu/ac more than for broadcast paddy. At an average paddy price of Rs. 76.8/bu, transplanting gives an income advantage of Rs. 760/ac. The extra costs of transplanting, Rs. 440/ac, leave a net advantage from transplanting of Rs. 320/ac. Table 49 shows this cost difference for an average size farm of 4.27 ac based on data from Table 44.

Table 49. Cost difference between transplanting and broadcasting paddy, Minneriya, 1986 *yala*.

Item	Rs.
Costs per farmer for transplanting	
Seedbed preparation	97
Transplanting	2,263
Total	2,360
Costs per farmer for broadcasting	
Making poru ela	364
Broadcasting	117
Total	481
Difference/farmer	1,879
Difference/ac at 4.27 ac/farmer	440

Provided farmers have the cash or family labor, transplanting under Minneriya's 1986 *yala* conditions seemed to pay off. We have neglected any incrementally higher costs associated with harvesting larger yields, but we doubt that this would diminish the advantage significantly. Note that broadcasting was preferred over transplanting on another nearby system (Kaudulla). This difference indicates that the profitability of transplanting versus broadcasting deserves further study.

2. Other Income

Fifty-eight of the sample farmers received income averaging Rs. 10,963 during 1986 yala from sources other than paddy. This amount is 63 percent of that from paddy production received by the group as a whole (the Rs. 17,533 shown in Table 48). These other sources, shown in Table 50, include the value of subsidiary crop and home garden production, off-farm wages and salaries to the farm families, pensions, tractor rentals, and revenues from livestock.

Table 50 shows that over one-quarter of the farmers (21 out of 74) earned an average of Rs. 19,609 from tractor rentals. Of course, part of this income probably went for loan payments or to recover investment and to operate and maintain the tractors. Reports from Polonnaruwa indicate that a two-wheeled Japanese tractor complete with attachments might cost Rs. 70,000. Considering the investment, labor, operation, maintenance, and repair costs, the reported Rs. 19,609 for the season do not seem out of line.

Table 50. Average other income accruing to the sample farmers during 1986 yala, Minneriya.

Source	Head(18)*	Middle(25)	Tail(31)	Total(74)
	Rs./farmer			
Subsidiary crops	6,022(9)	1,642(3)	5,708(7)	5,215(19)
Home gardens	981(6)	881(11)	839(16)	879(33)
Wage labor	0	540(1)	1,713(10)	1,606(11)
Permanent jobs	7,040(5)	11,089(3)	2,760(1)	7,914(9)
Pensions	0	6,000(1)	0	6,000(1)
Other family earnings	0	3,750(1)	1,983(3)	2,425(4)
Tractor rentals	13,480(7)	21,529(8)	24,200(6)	19,609(21)
Livestock	400(1)	225(4)	800(1)	350(6)
Averages	12,070(15)	12,126(19)	9,351(24)	10,963(58)
Highest value	40,500	80,000	110,800	110,800
Lowest non-Zero value	540	240	90	90

*Values in () are the number of farmers.

Note that nearly half of the total additional income (47.5 percent), accrued to five farmers, mostly for tractor rental. If we remove this income for the five farmers because of its distorting effect on the averages, we come up with the income for the head, middle, and tail farmers shown in Table 51.

Table 51 shows that the majority of farmers from each group received additional income. As with paddy production (Table 48) tail farmers receive less income than the other groups. When we combine the income from paddy and other field crops, as shown in Table 52, we find

that the resulting average income for the tail farmers ranges between 70 and 74 percent of the averages for the head and middle farmers, respectively.

We recognize that the value of paddy production applies to all 74 farmers, while the value for other income applies to 53 farmers, but the results provide a general picture of the farmers' relative positions. Considering that 16 of the farmers reported no additional income at all, and that five of the farmers reported an average of Rs. 60,430 for the season, the spread in incomes among the group is extreme. Further research might well explore these and other outlying cases to gain a more complete picture of income distribution within Minneriya. Of particular interest would be those farmers at the low end of the income spectrum.

Table 51. Adjusted average other income according to reports by sample farmers, Minneriya, 1986 *yala* (n=53).

	Head	Middle	Tail	Overall
	Rs.			
Total of other income	181,100	230,400	224,400	635,900
Less income for five farmers	69,300	122,000	110,800	302,100
Adjusted other income	111,800	108,400	113,600	333,800
Numbers of farmers	13	17	23	53
Average per farmer	8,600	6,380	4,940	6,300

Table 52. Combined 1986 *yala* incomes for the sample farmers at Minneriya (n=74).

	Head	Middle	Tail	Overall
	Rs./farmer			
Average value of paddy production	19,479	20,003	14,610	17,533
Average value of other income	8,600	6,380	4,940	6,300
Total income	28,079	26,383	19,550	23,833

Farmers' Net Income. The sample farmers' average net income can be estimated by deducting those costs not directly related to paddy production from the foregoing estimates of total income. The results provide us with insight on the returns to family resources, including labor, and the family's financial position.

1. Additional Costs

The additional costs include land rentals and mortgages, interest payments on seasonal and long-term credit, operation and maintenance (O&M) fees, expenses of growing subsidiary crops and home gardens, and tool and equipment purchases. The questionnaire contains some information on these costs, but in other cases we have used our judgment to arrive at what we hope are realistic estimates.

Sixty-five percent of the sample farmers engaged in land rentals or mortgages (14, 17, and 17 of the head, middle, and tail farmers, respectively. Subtracting cash inflows and outflows, the result yields an average net cash inflow of Rs. 2,030 for the 14 head farmers and average net cash outflows of Rs. 7,120 for the 17 middle farmers and Rs. 1,140 for the 17 tail farmers. For the 48 farmers as a group, the amount averaged Rs. 2,340. Recall that we have already accounted for rental payments in kind.

The majority of the farmers received credit during the season (44 of 74), with the percentage of farmers among the head, middle, and tail farmers being about the same. The most frequent source of credit for the Minneriya sample farmers was the bank. Seventeen of the 44 farmers received credit from this source. Relatives were the second most important source -- 14 farmers reported receiving credit from relatives. Combined, cooperatives and traders supplied credit to 11 of the farmers.

Loan size averaged Rs. 6,400. All but 6 percent of the loans were paid in cash rather than in kind. For those farmers who did not obtain credit from the banks or cooperatives, seven said they had defaulted on earlier loans, six said obtaining loans from others was easier, and four each said they either did not own the land or did not have the required identification documents. Most of the farmers said they used the loans for cultivation purposes, but six said they used the loans for consumption, and two reported using the loans for farm improvements or equipment purchases. The farmers reported annual equivalent interest rates ranging from 8 to 240 percent. Below is the distribution of these rates, which reveals just how high these charges can be (Table 53).

Farmers reported paying an average of Rs. 600/loan as an insurance premium, or about 7.5 percent of the loan's value.

Over half (41 of 74) of the farmers said they paid the 1985 O&M fee of Rs. 100/year. Of those who did not pay, 12 said they were not the owners, ten claimed they had money problems, eight felt service from the Irrigation Department was poor, and three felt the rate was

too high or that they should not pay if others did not. Only eight had paid their 1986 O&M fee, but 14 said they planned to pay later.

Table 53. Interest rates reported by Minneriya sample farmers, 1986 *yala*.

Annual Rate (%)	Number of Farmers
8-12	21
50	4
20-144	3
180	8
240	6

As noted earlier, the questionnaire does not provide information on the costs of producing subsidiary crops and home gardens. Because the value of output for subsidiary crops is small, we have lumped their value of production and costs with other sources of farmers' income. Home gardens, however, are valuable to nearly one-half of the farmers (33 of 74). Thus, we have looked at these costs more closely. Because the family probably applies more of its own labor and relies less on purchased inputs, the cost of producing home gardens is probably less than the 82 percent of the value of production derived for paddy. Accordingly, we have estimated that the costs of producing home gardens is 60 percent of their value.

The questionnaire contained no information on the farmers' seasonal purchases of tools and only one reference about credit to obtain equipment. For want of more specific information, we have left out costs associated with tool and equipment purchases except for the interest charges already noted. This understates the farmers' seasonal costs, but not significantly. However, this is another subject that should be investigated in future studies.

Table 54 summarizes the costs implied above. Except where the questionnaire provides data by farmers' location, we have not attempted to distinguish unit costs according to head, middle, and tail sections. In presenting these values, we recognize our heavy reliance on assumptions and, consequently, the potential weakness of the conclusions drawn. Nevertheless, we feel that the insight we have gained about the farmers' position justifies the risk of error.

We can now construct a composite of a representative farmer from the sample group. This composite will show central tendencies based on conditions experienced by many, if not always most, of the farmers. To do this, we selected appropriate values from previous tables.

Because the number of farmers who produce income from various activities is small for each of the individual cases, we have chosen not to include them. For example, only 26 percent (19 of 74) of the farmers reported income from subsidiary crops, only 15 percent (11 of 74) of the farmers reported income from wage labor, and so on. However, because most of the farmers had some additional income from

these various sources, we added a net amount of Rs. 2,000 to their income to represent an average of these other sources. In arriving at this average we omitted income from tractor rentals on the assumption that such income represents the real cost of ownership and consequently, does not contribute to the family's income beyond that already incorporated in the value of paddy production.

Table 54. Summary of the Minneriya sample farmers' costs that were additional to those involving paddy production, 1986 *yala*.

Type of Cost	Head	Middle	Tail	Total
	Rs./farmer			
Net of land rentals and mortgages	-2,030*(14)**	7,120(17)	1,140(17)	2,340(48)
Interest payments***	1,860(10)	1,680(14)	860(20)	1,350(44)
O&M fees	50(3)	50(15)	50(23)	50(41)
Home gardens	590(6)	530(11)	500(16)	530(33)

*Represents a cash inflow rather than a cost.
**Values in () are the numbers of farmers.
***Includes insurance premiums on bank loans.

The estimate of interest payments resulted from the farmers' statements as to the amount borrowed and multiplied by the interest rate. To obtain the seasonal figure, we assumed that the average length of loan was 3 months. This estimate accounts for the farmers' needs for credit to finance cash outlays over the growing season and for some reasonable amount of time to elapse between harvesting and sales.

Finally, other income and costs are received by too few farmers to make them representative of the whole. However, their accrual to a few farmers serves to increase the large spread in net incomes. This conclusion applies with special force when comparing the incomes of the 21 farmers who rent out their tractors with those who have few or no outside sources of income.

Table 55 shows that the net profit for the composite farmer representative of conditions in Minneriya might be roughly Rs. 1,538 for the season. This result suggests that the sample farmers in Minneriya did not fare particularly well during 1986 *yala*. By incorporating income from sources other than paddy, they were able to cover their costs of production with little left over for returns to their own (unrented) land, management, or capital other than tractors. We recognize that the sample farmers claimed yields were poor compared with those for the previous year and that, normally, net profits might be higher.

The foregoing conclusions were based on an estimated value of family labor of Rs. 30/day -- equal to the going market wage. A more meaningful way to evaluate a farmer's position is to look at the returns to the family's resources to see how much income the family

generates as a unit. This result can then be compared to per capita income for the economy as a whole.

Table 55. Net profit for the Minneriya composite farmer, 1986 yala.

	Rs.
Income	
Paddy production	17,533
From other sources	3,000
Home garden production	879
Total	21,412
Expenditures	
Paddy production	14,414
Costs for other income sources	1,000
Home garden production	720
Rentals and mortgages	2,340
Interest	1,350
O&M fee	50
Total	19,874
Net Profit	1,538

2. Returns to Family Resources

To calculate the returns to family resources, we must deduct costs of family resources from our earlier estimate of production costs. For this composite case, we only need to subtract the cost of family labor because we have not charged for the farmer's own land or tools, we have reduced output by the amount of seed kept over for planting, and we have assumed that tractor costs represent the out-of-pocket costs to the farmer. Charges for buffalo traction do not enter into this composite case.

Earlier, we estimated that family labor was about one-third of total labor costs for the set of predominant paddy practices. Applying this percentage to the total labor costs of Rs. 5,427 (Table 44) produces a value for family labor of Rs. 1,809. If we assume that family labor accounts for one-half of the costs of home gardens, family labor earns another Rs. 360 (0.5 x Rs. 720). By combining these two values with the net profit of Rs. 1,538, we come up with net returns to the family's resources, exclusive of tractors, of Rs. 3,707. For want of more precise information, we have assumed that net returns during maha are 25 percent greater than during yala. Using these values and an assumed family size of 5.5 members, we estimated annual per capita income as shown below:

Returns during *yala*	Rs. 3,707
Returns during *maha* at 25 percent more than *yala*	Rs. 4,634
Assumed total for the year	Rs. 8,341
Per capita income for family of 5.5	Rs. 1,517

This result is exceptionally low, being only 16 percent of the 1985 per capita income for Sri Lanka as a whole (Rs. 9,430). (The per capita national income was derived from a gross domestic product of Rs. 149 billion and a population of 15.8 million (Central Bank of Sri Lanka, 1986)).

While some percentiles within an economy may be this low, one would not expect this to occur among farmers who irrigate. Perhaps the answer lies with the farmers' understatement of other income sources, the high interest and rental charges, or their reference to low yields. At 59 bu/ac, the respondents' average yields would be 16 percent below the national average. Even so, raising paddy yields to the national average of 70 bu/ac would raise the family's income to approximately 20 percent of the national average -- still a low result.

Such a finding suggests that farmer incentive for growing paddy would be low. However, because rice is the farmers' staple food and paddy their traditional crop, they continue growing paddy even though benefits from doing so are limited. This outcome calls for further study of the sample farmers' overall economic and financial positions to ascertain the validity of these findings.

3. Returns to Family Labor

The results of the economics analysis can be considered from another vantage point: returns to family labor employed in paddy production. By assuming that all of the returns from paddy production accrue to family labor and that the costs of rentals, mortgages, interest, and O&M fees are associated with paddy production, we found that the family's own labor would have earned a daily wage of Rs. 22.80. We obtained this estimate by dividing the net returns to paddy production by the man-days of family input as can be seen in Table 56.

An imputed daily wage of Rs. 22.80 is about three-fourths of the current market wage of Rs. 30, which is a reasonably good wage for family labor. Shadow wages for farmers operating under similar conditions often approximate 50 percent of the market wage. However, in arriving at this estimate of the shadow wage, we have attributed all of the surplus income to labor and nothing to the family's other inputs. In this respect, the wage is overstated. On the other hand, we have also attributed all of the rental, mortgage, interest, and O&M fees to paddy production, whereas some of these costs might rightfully be attributed to the costs of producing other crops. On balance, then, this estimate is probably a reasonable approximation of the imputed wage the family received for its labor input.

Table 56. Average returns to family labor in Minneriya in rupees, 1986 *yala*.

Value of paddy production		17,533
Less costs of		
Paddy production	14,414	
Rentals and mortgages	2,340	
Interest	1,350	
O&M fees	50	
Subtotal		18,154
Net (loss)		621
Imputed cost to family labor (1/3 of Rs. 5,427, Table 44)		1,809
Returns to family labor		1,188
Man-days of family labor (1/3 of 156, Table 41)		52
Imputed daily wage		22.80

4. Financing Production

By paying usurious rates that are equivalent to 240 percent per year, farmers reveal an urgent need for credit. The length of time the loan is out, however, plays an important part in determining the true meaning of this rate. Were the lending period only one month, the farmer would pay 20 percent on the amount of the loan. A 20 percent charge for some critical period could be a reasonable amount for the farmer and a justifiable charge for servicing the loan and accounting for the lender's risk. The questionnaire did not clarify for how long farmers were borrowing money. However, an indication of the lending period can be gained from the farmers' outlays for hired and contract labor, materials, and tractor and buffalo services, as noted previously. We believe our assumption of three months for an average length is reasonable.

We can learn of the composite farmer's general financial position by looking at the family's cash inflows and outflows. Cash inflows would be primarily from actual and potential sales of paddy, sales of subsidiary crops and home gardens, and income from other sources. Cash outflows other than for debt servicing would be primarily the associated costs for crop production, land rentals, the O&M fee, and costs associated with income from other sources. In allowing for the cash flows associated with home gardens, we have assumed that cash from sales offset purchased inputs.

Table 57 shows that the composite farmer was in a marginally negative cash position in terms of ability to cover the interest costs of production. That is, the cash surplus of Rs. 1,136 from operations was less than the estimated interest charge of Rs. 1,350. Considering the crudeness with which some of the values were estimated, the farmers' position is roughly at the breakeven point as far as cash flows are concerned. This does not allow for family or other requirements. Thus, we conclude that the farmers' financial position is critical. Certainly, this is another area deserving further study.

Table 57. Net cash flow for the Minneriya composite farmer for 1986 yala.

	Rs.
Cash inflows	
Paddy sales to date (100.2 bu x Rs. 76.80/bu)	7,695
Potential paddy sales (amount retained) (83.8 bu x Rs. 76.80/bu)	6,436
Other sources of income	3,000
Total	17,131
Cash requirements	
Paddy production	12,605
Other sources of income	1,000
Rent	2,340
O&M fee	50
Total	15,995
Net cash inflow	1,136

4. SUMMARY AND CONCLUSIONS

According to farmer responses, original allotments for the 75 sample farmers averaged 3.4 ac of lowland and 1.7 ac of highland. To this lowland amount farmers reportedly added an average of 0.2 ac through purchases and authorized encroachments and 1.1 ac through rentals and mortgages. Offsetting these additions somewhat were the reported average of 0.2 ac of lowlands that they passed on to their children. Thus, the net lowlands under production for 1986 yala averaged 4.5 ac.

During yala, all but one farmer grew paddy, on an average of 4.27 ac/farmer. Nearly all of the paddy production was on lowlands. Farmers also reported growing an average of 0.33 ac of chilies and 0.07 ac of vegetables and pulses. The excess of cropped area over lowland area, amounting to 0.17 ac, implies that some crops were planted on highlands. Such subsidiary crops and home gardens complemented the

farmers' production of paddy, but not greatly so because of the lack of rainfall typical of yala.

Cultivation with tractors and broadcasting paddy formed the most common set of practices. Looked at individually, 46 farmers relied only on tractors compared to 19 farmers who relied only on buffaloes, and 39 farmers only broadcast paddy compared to 23 farmers who only transplanted paddy. The remaining farmers used both methods of traction and/or seeding.

The survey did not report tractor ownership so we did not know the extent to which farmers controlled their means of traction. The predominant tractor in use was a two-wheeler produced by the Japanese that, complete with attachments, costs about Rs. 70,000.

All of the farmers reported using fertilizers; all but 20 said they used weedicides; and only 15 said they did not use insecticides. Thus, the sample farmers appeared to follow good cultural practices, except for their reliance on their own rather than certified seed.

When the current market rates were applied to the various inputs, the overall cost of production for the most common set of cultural practices came to Rs. 3,580/ac. An analysis of alternative cultural practices shows that broadcasting costs less than transplanting, using buffalo costs less than using tractors, and weedicides cost less than manual weeding. Thus, farmers who follow the most common set of practices were employing the least-cost approach, except for their use of tractors. Considering the advantages of tractors, farmers were undoubtedly justified in preferring them to buffalo.

Production costs for the typical practice (tractors, transplanting, and use of weedicides) among head farmers came to Rs. 4,020/ac. When these farmers omitted weedicides, costs reduced to Rs. 3,762/ac. Production costs for the typical practice (buffalo, transplanting, with weedicides) among tail farmers came to Rs. 3,539. Without weedicides, the value reduced to Rs. 3,281/ac. The least cost solution -- buffalo, broadcasting, and weedicides -- came to Rs. 3,099/ac.

The dominant cultural practice required an average of 155 man-days for the season. Only by omitting weed control entirely would labor requirements be less. Of the total labor requirements, the family supplied one-third; the rest came primarily from hired labor, with contract labor completing the requirement. The regimented schedule set by the Irrigation Department for land preparation, water deliveries, and the resulting peak labor periods help to explain the farmers' reliance on hired and contracted labor.

The overall yield for the season averaged 58 bu/ac, which was about 83 percent of the national average of 70 bu/ac. In verifying the reasonableness of this estimated difference, farmers commented that yields during 1986 yala were lower than in the previous year's maha and yala.

Farmers reported that they used the recommended rates of fertilizers and pesticides, although we do not know from the data how they knew what the requirements ought to be. One might speculate that lack of water could explain the lower yields, but most of the farmers reported that they received enough water for their cultivation needs. Farmers blamed lower yields on winds and pests during the pollination period. In addition, they relied on their own and neighbors' seed, rather than on certified seed.

Yields by location showed that head, middle, and tail farmers all averaged about 58 bu/ac. While overall yields were similar, differences at the one percent confidence level occurred between transplanted and broadcast paddy. Transplanted paddy averaged nearly 9.9 bu/ac more than broadcast paddy. Given an average sales price for paddy of about Rs. 77/bu, the extra yield offsets the extra costs of transplanting by an average of Rs. 320/ac. Variances in yields between the two seeding methods were remarkably close, with coefficients of variation both rounding off to 28 percent.

Farmers disposed of this output (which averaged 249 bu/farm) by setting 44 bu aside for family consumption, selling 100 bu, holding 84 bu for future disposal (probably for sale), and applying the rest for seed and for payments in kind for rent and the vel vidane's fee. The amount farmers withheld for consumption exceeds the average apparent per capita rice consumption for Sri Lankans by about 70 percent. The reason for this discrepancy could not be ascertained from the farmers' responses to the questionnaire.

By covering their consumptive needs, holding stocks off the market, and eventually selling nearly 75 percent of their production, these farmers demonstrated considerable market activity and strength. Their market involvement undoubtedly explains the farmers' widespread use of improved technologies, such as agricultural chemicals, and their reliance on hired and contract labor. From this, we concluded that these farmers would be open to other improvements in technology, including changes in water management practices.

The foregoing suggests that the farmers are relatively well off. They are doing well in terms of being self-sufficient in paddy production; otherwise they are not. At full costing of variable inputs for the predominant set of cultural practices, paddy income exceeded direct production costs by Rs. 3,119. However, this fails to cover the combined cost of rent, interest, and the O&M fee, leaving a deficit of Rs. 621 for the season. Only by attributing net income to home gardens and by considering other incomes does the representative farmer show a net return, amounting to Rs. 1,538. Note that the costs going into this result do not include a return to the farmers' own land and management, nor do they provide an allowance for tools, miscellaneous farm expenses, or household purchases.

In 55 of 61 reported cases, the farmers made their sales through private traders rather than government sources. While government sources generally offered a guaranteed price of Rs. 70/bu, farmers often realize less than this amount because of adjustments for quality

and for the costs of transportation. Thus, the sample farmers reported that by dealing with private traders they were able to do better than had they taken the Government support price.

The farmers' poor economic showing rests in part with the high interest charges, some of which cost the farmer 20 percent/month, and in part by assuming that their opportunity cost of labor is Rs. 30/day. Seldom can one assume that all of an area's farmers are able, or willing, to earn the going daily wage were they to leave their farm and seek work elsewhere.

By deducting the costs of family labor along with the seed adjustment, and assuming values for other farming activities during the season, the typical farmer earned an average wage of Rs. 24/day. This represents a shadow wage of 80 percent of the market wage, which is a rather high value for family labor of the type found in Sri Lanka. But, as noted above, these calculations make no allowance for the farmers' own land, tools, or miscellaneous expenses. By assigning values to these, the resulting shadow wage would obviously drop below the 80 percent level.

Another indication of the family's poor situation is the return to their resources. This measure takes the total family's income (cash and imputed earnings) during yala, assumes values for a typical maha, and deducts the costs of purchased inputs. The result applied to an assumed family size of 5.5 members yields a per capita income of only Rs. 1,517 -- which is only 16 percent of the national average (Rs. 9,430). In making these calculations, we assumed other income sources and home gardens contributed only Rs. 2,000 and Rs. 519, respectively, to family income. Some families' incomes were augmented far more than this -- especially the five farmers whose incomes including tractor rentals averaged nearly Rs. 60,000 for the season.

Comparing the farmers' seasonal cash inflows and outflows, net of financial charges, shows that they generate a cash surplus of only Rs. 1,136. This surplus fails to cover the farmers' interest charges of Rs. 1,350. However, given the crudeness of some of our estimates, this shortfall is probably not significant. More important is the indication that the sample farmers are in a tight financial position. Not only must they depend on credit to finance much of their purchased inputs, but they apparently must depend on off-farm sources of income to cover interest payments.

To close, the sample farmers appeared to follow good, cost effective practices through ample use of fertilizers and pesticides. However, because of heavy reliance on purchased inputs, occasionally high interest charges, and rental costs, their incomes and cash positions for 1986 yala were not good. And, because we are dealing with averages, approximately half of the farmers would have incomes below this level. Some respondents provided information indicative of extremely low incomes. Such poor outcomes for many of the sample farmers certainly call for closer scrutiny by future researchers.

E. SOCIOLOGY

1. INTRODUCTION AND METHODOLOGY

Sociology researchers who participated in the diagnostic analysis of Minneriya Scheme conducted a comprehensive investigation during 1986 yala. These investigators used a sample household survey and a series of in-depth, qualitative interviews with technical assistants, work supervisors, patrol laborers, farmer representatives, vel vidanes, irrigation engineers, and project managers. This section of the report presents the findings of the sociology component of the diagnostic analysis.

The study focused attention on the following areas:

* Socio-economic background of the farm families interviewed.
* Problems associated with water supply and distribution.
* Specific issues relating to irrigation.
* Relationships between irrigators and irrigation officials.
* The role of farmer representatives and farmer organizations.
* System maintenance and the project committee system.

It was estimated that there were 4,500 families in the scheme at the time of the study. To represent different hydrological conditions within the scheme, a sample of 80 families was selected from several sites located in the head, middle, and tail areas of the system (Tables 58 and 59). The household survey was conducted during June and July, 1986, and covered 77 of the 80 households selected. The respondents in the remaining three households were absent and could not be contacted. Note that the survey data was gathered during yala. Since the use of inputs and agricultural practices may differ between seasons, the results in this report should not be related to maha activities.

Table 58. Distribution of respondents in Minneriya by hydrological position within the system, 1986 yala (n=77).

Position of Allotment	Number of Respondents	Percent
Head	19	25
Middle	28	34
Tail	32	42

Since only cultivators were used as the sample frame, it might be unrealistic to claim that the sample selected (which is about 2 percent of the total number of families) was representative of the total population in Minneriya Scheme. Nevertheless, since the respondents came from different parts of the system, it may be reasonable to assume that they represented the different conditions under which water users operate in Minneriya.

Table 59. Location of respondents by field channel areas in Minneriya, 1986 yala (n=77).

Location	Number of Respondents	Percent
Head	24	31
Middle	20	26
Tail	33	43

A structured questionnaire containing some open-ended questions was used to survey the sample households. In-depth interviews also elicited qualitative data to supplement the information gathered through the household survey. The household interviews and most of the in-depth interviews were conducted by two social science university graduates under the guidance and supervision of the sociology coordinator.

In-depth interviews were conducted during November-December, 1986. The respondents in Minneriya were very cooperative with the researchers. Although the interview was directed mainly to the chief householder, other family members also took part in the interview when relevant or necessary. Note that bias may have been introduced by either the investigators or the respondents. It was generally felt that responses to sensitive questions -- particularly those relating to personal finances, land ownership, and tenurial arrangements -- may not have been reliable.

The survey data were coded by the two field investigators, and were analyzed by the sociology coordinator using MicrostatTM (a statistical software package) on a CompaqTM microcomputer. The statistical functions used were frequency distribution and cross tabulations.

In addition to the sample survey of farm households and the in-depth interviews of irrigation officials, the two social science researchers also made observations about the irrigation system. These observations, coupled with the other data, provided a more complete picture of the Minneriya Scheme.

2. RESULTS AND DISCUSSION

a. Socio-Economic Characteristics of Minneriya Farmers

All the households surveyed were Sinhalese. Sixty-four percent of the respondents were below 50 years of age, while 38 percent were below 40 years of age (Table 60).

Table 60. Age distribution of respondents in Minneriya, 1986 *yala* (n=77).

Age	Number of Responses	Percent
20-30	9	12
31-40	20	26
41-50	20	26
51-60	18	23
> 60	10	13

The majority of the sample originated from Polonnaruwa, Kandy, Kurunagala and Kegalle. The largest numbers of respondents were originally from Kegalle and Polonnaruwa. Over 90 percent of the sample farmers arrived prior to 1965. Of these, 66 percent came before 1955. Eighty percent of the respondents were male, and 20 percent were female. Sixty-one farmers were married and 9 were single. The remainder (7) of the sample farmers were widowed.

Of the 77 farmers interviewed, only 7 had not received any formal education. Nearly 60 percent of the respondents had received up to 8 years of schooling. Only three respondents said they had reached or surpassed the GCE advanced level of education. Forty-eight percent of the respondents said that they read daily newspapers, and 67 percent reported that they read weekly papers. In addition, seventy of the 77 respondents reported that they possessed radios and 28 sample farmers reported that they owned television sets.

Landholding. There were only 10 original allottees among the 77 respondents interviewed (Table 61), while 45 of the respondents were descendants of the original allottee. Seven women had inherited allotments after the death of the original allottees. The others who held land were lessees, sharecroppers, mortgage holders, and encroachers.

Table 61. Settler status of Minneriya respondents, 1986 *yala* (n=77).

Status	Number of Responses	Percent
Original allottee	10	13
Second generation of original allottee	45	58
Spouse of original allottee	7	9
Other		
Ande/wee porunduwa	6	8
Purchase	4	5
Lease	3	4
Mortgage	1	1
Encroach	1	1

Many settlers in Minneriya cultivated only a small part of the highland plots. Fifty-five percent of the respondents cultivated less than .5 ac of highland (Table 62). Another 16 percent reported that they cultivated between .5 - 1 ac of highland. The small amount of cultivation appeared to be mainly due to the unavailability of water to irrigate crops.

Table 62. Extent of highland cultivated as reported by Minneriya respondents, 1986 yala (n=77).

Extent (ac)	Number of Responses	Percent
0.00 - 0.50	42	55
0.51 - 1.00	12	16
1.01 - 3.00	16	21
3.01 - 5.00	4	5
> 5.00	3	4

It appeared that there was a certain degree of inequality in terms of land originally given to the allottees. The data in Table 63 indicate that 11 farmers (14 percent) reported that they originally acquired 1 ac or less of lowland. Four farmers (5 percent) stated that they acquired over 6 ac. About 49 percent of the respondents said that they originally acquired 4 to 6 ac of lowland. The designed land allotment for settler families in Stages I-III was 5 ac of lowland and 3 ac of highland, and for settler families in Stage IV -- 4 ac of lowland and 2 ac of highland. This picture can be compared with the distribution of land currently cultivated by the settlers (Table 64).

Table 63. Extent of original lowland acquired as reported by Minneriya respondents, 1986 yala (n=77).

Extent (ac)	Number of Responses	Percent
0 - 1.00	11	14
1.01 - 3.00	9	12
3.01 - 4.00	15	20
4.01 - 5.00	11	14
5.01 - 6.00	27	35
> 6.00	4	5

Table 64. Extent of lowland cultivated as reported by respondents in Minneriya, 1986 yala (n=77).

Extent (ac)	Number of Responses	Percent
0 - 1.00	5	7
1.01 - 3.00	25	33
3.01 - 5.00	16	21
5.01 - 6.00	4	5
6.01 - 10.00	19	25
> 10.00	8	10

The data in Table 64 indicate that there has been a significant change in the distribution of lowland over the years. Forty percent of the sample farmers reported cultivating less than 3 ac, compared to the 26 percent who originally acquired less than 3 ac. In addition to the originally acquired land allotments, almost half of the respondents also acquired land through other means such as lease, mortgage, wee porunduwa, and outright purchase (Table 65). Eight respondents said they currently cultivate over 10 ac (Table 64).

Table 65. Other forms of lowland tenure reported by Minneriya respondents, 1986 yala (n=38).

Type of Tenure	Number of Responses*
Wee porunduwa	14
Mortgage	8
Lease	6
Granted by state	5
Encroach	3
Purchase	3

*Multiple responses were possible.

Another important aspect of landholdings in Minneriya was land fragmentation or subdivision. Such fragmentation can adversely affect farmers' incomes and water distribution at the field channel level. Thirty-two respondents (42 percent) reported that their original holdings were subdivided. The majority of the holdings were reported to be shared by two persons. While a few farmers appeared to have lost some of their land to others through mortgage or sale, a large number of respondents (40 percent) reported that they have acquired additional land over and above their original allotments.

Agricultural Practices and Inputs. Some information collected by the sociologists relating to agricultural practices and inputs was included here because it may be helpful to better understanding the behavior of Minneriya farmers. However, for a more complete and extensive discussion concerning agricultural practices and inputs, the reader is referred to the agronomy and economics sections of this report.

Seventy-five respondents reported that they used tractors for agricultural operations. Thirty-three farmers used buffalo for farming activities, usually in conjunction with tractors. Thirty-nine respondents (51 percent) reported that they transplanted paddy during 1986 yala, and 56 percent said that they use high-yielding varieties. All the respondents reported the use of chemical fertilizers.

Thirty-one respondents in Minneriya said that they owned two-wheel tractors, ten farmers reported that they owned four-wheel tractors, and 30 percent of the respondents reported that they owned buffalo. While

42 percent of the respondents said that they owned agro-chemical sprayers, another 8 farmers reported that they owned other agricultural implements as well. It appears that the Minneriya farmers generally possessed more productive resources than farmers in the other systems investigated in Polonnaruwa District.

Ninety percent of the respondents said that they employed wage labor for agricultural work. Only seven respondents (9 percent) said that they did not use wage labor. Most of those farmers not employing wage labor reported that they have enough family labor. Those who employed wage labor mostly reported hiring seasonal migrant workers who move into the area during the peak months of the agricultural season, rather than hiring local laborers.

Farmers' Disposition of Paddy. The sociologists also asked questions regarding rice consumption and agricultural earnings. Over 97 percent of the respondents reported that they set aside sufficient paddy for their own consumption. However, 68 percent said that they would have to sell at least part of what they kept for consumption to raise needed capital. Such farmers and their families faced potential food shortages. Half of the respondents said that their farm incomes were adequate. Sixty-eight percent of the farmers interviewed, however, said that they have additional sources of income and subsistence.

Source of Income. Seventy-three respondents (95 percent) reported that their main source of income was farming and fifty-two respondents (68 percent) reported that they had other income sources besides paddy farming. The most common second sources of income reported were cultivation of subsidiary crops and permanent crops, wage labor, and trade. Permanent employment outside agriculture was the main source of income for three respondents, including one farmer who depended mainly on trading.

A number of Minneriya farmers said that they did not want their children to continue with farming as their main occupation. The majority of these farmers said that they wanted to give their children a good education that would enable them to find white collar employment in the public sector. Yet, there appeared to be a gap between their desire and actual achievement. Only a few adult children had actually moved away from the area to work.

The original allottees and their children are not the only categories of residents found in Minneriya. Nearly 50 percent of the respondents reported that outsiders have acquired land by leasing, mortgaging, outright purchase, and encroachment. Thus, the composition of the community and land tenure patterns are more complex today than when the scheme began. These complexities can directly affect irrigation system performance. Owners of subdivided land often must rely on the same field outlet for irrigation water. Additionally, a number of farmers who claim ownership on different terms (ande, wee porunduwa, mortgage) are required to share water from the same outlet. When water is scarce, the individual parcel holders must cooperate with each other

to share whatever water is available, or this situation can lead to disputes.

b. Irrigation Water Supply and Distribution

Though the farmers in major irrigation systems usually obtain water from field channels, this is not necessarily true in all cases. In Minneriya, 65 farmers reported that they obtained water from field channels, and 13 farmers responded that they had access to water through branch canals and drainage channels (Table 66). A few farmers reported receiving water from more than one source.

Table 66. Sources of water as reported by Minneriya respondents, 1986 yala (n=76).

Source	Number of Responses*
Field channel	65
Branch canal	12
From adjoining fields	4
Drainage channel	1

*Multiple responses were possible.

Water Supply. Farmers were asked about specific water problems. As the data in Table 67 indicate, 25 responses related to water shortage. A number of respondents also reported problems with rotation and timing. The main reasons given by the respondents for receiving an inadequate water supply were illicit tapping, damaged structures, irrigation officials' failure to supply adequate water on time, and insufficient discharge of water from the tank.

Table 67. Types of water problems reported by Minneriya respondents, 1986 yala (n=28).

Water Problem	Number of Responses*
Shortage	25
Rotational problems	9
Timing difficulties	7
Excess water	0

*Multiple responses were possible.

When respondents were asked where they believed water problems occurred most often within their field channel areas, the majority felt that the tail regions experienced water problems most often (Table 68). Twelve farmers stated that there were no water problems in their field channel and three farmers said that water problems occurred along the entire channel.

Table 68. Minneriya respondents' perceptions of where water problems most often occur in field channels, 1986 yala (n=76).

Location	Number of Responses*
Head	7
Middle	2
Tail	55
Along field channel	3
No water problems	12

*Multiple responses were possible.

Those who responded to the question on the location of water problems in the field channel area gave diverse reasons for the above distribution. Among them were:

* Insufficient water supply.
* Farmers at the head use more water.
* Lack of proper maintenance of field channels, erosion, and silting of channels.
* Expansion of the area under cultivation.
* Illicit tapping.
* Improper layout of the channels.
* Lack of proper water management.

An attempt was also made to ascertain whether there was an association between the location of an allotment and reported water shortages. The result of the cross-tabulation between these two variables is presented in Table 69.

Table 69. Water problems as reported by Minneriya respondents by hydrological location of allotment, 1986 yala (n=72).

Do you experience water shortage?	Location of Allotment on Field Channel			
	Head	Middle	Tail	Total
	----------number of responses*----------			
Yes	14 (60)	13 (72)	18 (58)	45 (62)
No	9 (40)	5 (28)	13 (42)	27 (38)

*() = Relative percent of responses.

There was no significant variation between different hydrological locations within the system with respect to reported water problems. However, a majority of farmers in all field channel locations reported that they faced water problems (60 percent of the respondents in the head, 72 percent in the middle, and 58 percent in the tail).

Half of the respondents in Minneriya felt that not all of the water users received an equitable supply of water. They identified the following as contributing to inequitable water supply:

* Not enough water flowing in the canals.
* Damaged structures and illicit tapping.
* Poor water management.
* Improper placement of turnout pipes.
* Size of allotments.
* Silting of canals and channels.
* Creation of additional field outlets.

Water Rotation. Almost all the farmers interviewed reported that they received water on a rotation at the D-channel level. Most respondents also reported that officials do not inform them when there is a change in the D-channel rotation schedule. As the data in Table 70 indicate, 40 farmers (53 percent) stated that they only know the rotation schedule has changed when there is no water in the D-channel. An additional 15 respondents (20 percent) reported that there is no formal system of rotation. Others said they learned about the rotation change through the patrol laborer, the vel vidane, notices posted at public places, and informal messages. These data indicate that often no advance notification of D-channel rotation changes is given to farmers.

Table 70. Minneriya respondents' report of how they know the D-channel rotation schedule has changed, 1986 yala (n=75).

Source/Method	Frequency	Relative %
Vel vidane	3	4
When D-channel is dry	40	53
Patrol laborer	9	12
Informal messages	1	1
Notices	3	4
Rotation system does not change	4	5
No D-channel rotation system	15	20

Most farmers in Minneriya felt that they had little influence concerning the D-channel rotation system. Table 71 indicates that most of the respondents believed that rotation changes were made by higher authorities, such as the irrigation engineer and the government agent, with little consultation with the water users. Though many farmers identified the importance of the pre-cultivation meeting (kanna) for decision-making, Table 72 indicates that 75 percent of the respondents felt that the kanna meeting was dominated by officials. Only two sample farmers stated that farmers determined the D-channel rotation. Because the farmers may not feel they have power to affect decision-making, They may not take an active part in the kanna meeting.

Table 71. Minneriya respondents' perception of who makes changes in the D-channel rotation system, 1986 yala (n=76).

	Number of Responses*
Irrigation engineer	30
Kanna meeting	24
Government agent	20
Don't know	8
Mahaweli Authority	7

*Multiple responses were possible.

Table 72. Minneriya respondents' perceptions of who influences the D-channel rotation system, 1986 yala (n=76).

Individual	Number of Responses	Relative %
Officers at kanna meeting	57	75
Farmers	2	3
Irrigation engineer	2	3
Government agent	4	5
Don't know	8	11
Mahaweli Authority	3	4

All the respondents seemed to think that water control above the field channel was the prerogative of the Irrigation Department officers. The farmers contended that the legitimate territory of authority for the local community representatives, such as the vel vidane and the ela niyojitha, was the field channel area.

c. Farmer Irrigation Behavior

Irrigation problems cannot be dealt with in isolation for they are interconnected with other issues. Farmers do not just attribute water supply problems to inefficiency of the irrigation establishment or limitations in the capacity of the tank. As previously indicated, farmers identified a range of issues which they felt affected their irrigation behavior. These included highland cultivation, land fragmentation, tenure, illicit tapping, damaged structures, encroachments, and lack of proper maintenance of physical structures.

Highland Cultivation. Sixty-one percent of the Minneriya respondents reported that other farmers cultivated highland plots using irrigation water. The data in Table 73 indicate that most of the farmers who do so were reported to divert water from field channels. A significant number of farmers were reported to take water directly from branch canals, and a few farmers were reported to tap water from the main canal as well. Many farmers, however, recognized that highland

cultivation using irrigation water creates problems for the main system.

Table 73. Methods of obtaining highland irrigation as reported by Minneriya respondents, 1986 yala (n=47).

Method	Number of Responses	Relative %
Lift irrigator	1	2
Field channel	27	58
Branch canal	7	15
Drainage channel	2	4
Distributary channel	6	13
Other	4	9

Irrigation water diverted for highland cultivation is often used for paddy, which requires a great deal more water than other subsidiary crops that may be grown on the highland allotment.

Land Fragmentation and Tenure. Apart from the subdivision of family holdings among descendants, parcels of land have also been given in tenurial arrangements such as share-cropping (ande), leasing, and mortgaging. These tenurial arrangements are more significant than the subdivision of family holdings among children from a water management and water sharing point of view. Outsiders who have acquired parcels of land, particularly when the arrangement is temporary, may be more interested in immediate gains rather than long-term issues such as the condition of the physical structures. As a result, they may be less careful and less conscientious in their management of irrigation water and physical structures.

Yet, an increasing number of farmers have given parcels of land to non-allottees on lease, ande, mortgage, and wee porunduwa. The reasons for this are many. Some farmers are unable to cultivate due to financial difficulties, sickness, non-availability of family labor, and employment outside the area. Those farmers who acquire parcels in a tenurial arrangement want to make sure that they get enough water. Yet, since many of them are not permanent cultivators, they may not feel responsible for maintaining the physical structures. The land owners felt that maintenance was the responsibility of the person farming the land; thus, no one feels responsible for maintaining the system where tenure arrangements are prevalent.

Illicit Tapping. Illicit tapping was identified as an issue of importance by most respondents in Minneriya. Table 74 indicates that 78 percent of the respondents reported illicit tapping in their area. Note that illicit tapping was reported from all regions of the irrigation system, and that differences between reports from the head, middle, and tail regions were not significant. Reported reasons for illicit tapping varied. Some farmers cannot legitimately secure sufficient water for their allotment due to shortages or structural

defects in the canals, and they may turn to illicit tapping as a solution.

Table 74. Reports of illicit tapping from Minneriya respondents by hydrological region, 1986 yala (n=77).

Illicit Tapping	Head	Middle	Tail	Total
	----------numbers of responses*----------			
Yes	17 (71)	14 (70)	29 (88)	60 (78)
No	5 (21)	6 (30)	3 (9)	14 (18)
Do not know	2 (8)	0	1 (3)	3 (4)

*() = relative percentage.

Those farmers who cultivate reservations, encroached land, and highland plots often have no legitimate access to water from field channels, so they often divert water from field channels. Most farmers reported that illicit tappers took water from field channels, although many respondents reported water tapping from branch canals and the main canal.

Diverse methods of tapping water were reported. The most common methods reported were drilling holes in the channel bund, blocking the channel flow, breaking channel gates and outlets, and siphoning. These methods usually lead to the deterioration of physical structures.

When asked if water tapping was a punishable offense, 75 percent of the respondents were aware of penalties, but 17 percent said that they did not know. When asked to indicate the punishment, 41 percent of the respondents did not know. The other respondents said the following were punishments for illicit tapping:

* Offenders are required to pay damages and a fine.
* Offenders are denied water for a few days.
* Offenders are taken to court for legal action.

Most of the respondents who specified punishments felt that the punishment was adequate and reasonable, but said punishment was infrequently and unsystematically enforced. The respondents cited the following inadequacies of authorities:

* Some officials are weak, corrupt, or partially negligent.
* Offenders are only warned and discharged.
* Procedures and specified rules are unclear.

About 50 percent of the respondents said that they reported illicit tapping to authorities. Many of them (61 percent) stated that

they reported to the vel vidane and the cultivation officer. Only 35 percent of the farmers said that they reported infractions to irrigation officers such as work supervisors and technical assistants.

Overall, there appeared to be substantial confusion among respondents concerning the reporting of irrigation infractions. Although the majority of respondents reported that they contacted either the vel vidane or the cultivation officer, neither of these individuals technically have authority to enforce or punish irrigation offenders. On the other hand, irrigation officers were not often contacted about irrigation offences. These actions may be the result of accessibility and social restraints between farmers and irrigation officials.

When asked who has the authority to punish offenders, 31 respondents reported that it was irrigation officials, and 25 others reported that the vel vidane and the cultivation officer had this authority (Table 75). Sixteen respondents did not know who possessed such authority.

All of these responses indicated that confusion existed about reporting illicit tapping. This confusion is further exacerbated when no action is taken in regard to illicit tapping. When this happens, violators may appear to be evading punishment by influencing higher authorities.

Table 75. Perceptions of Minneriya respondents regarding authority to punish irrigation offenders, 1986 yala (n=76).

Authority	Number of Responses	Relative %
Irrigation Department officers	31	41
Agrarian Services officers*	25	33
Colonization officer	3	4
Court of law	1	1
Ela nijojitha	0	0
Don't know	16	21

*Includes cultivation officers and vel vidanes.

Damaged Structures. Structural damage can be caused by human and natural causes. While some damages are caused by people intentionally, as when a channel bund is cut to divert water, others are not the result of deliberate human action. Yet, whatever the cause, the effect of structural damage is more or less the same -- water distribution within the irrigation system is affected.

Over 90 percent of the Minneriya respondents reported that some physical structures in their locality had been damaged. Forty-seven respondents (61 percent) also stated that such damage occurred frequently. Table 76 shows where the structural damages occurred as reported by the respondents. Some of the specific causes of structural damage identified by the respondents are given in Table 77. Buffalo

were cited in 64 responses as a cause of structural damage. Nearly 50 percent of the farmers said that most damage occurs during maha. Also, while 12 respondents (16 percent) stated that there was no difference between maha and yala in this regard, 21 respondents (27 percent) felt that most damage occurs during yala.

Table 76. Minneriya respondents' report of irrigation structural damage by location, 1986 yala (n=70).

Structure Location	Number of Responses*
Field channel	68
Branch canal	53
Distributary channel	46

*Multiple responses were possible.

Table 77. Causes of structural damage as reported by Minneriya respondents, 1986 yala (n=70).

Case	Number of Responses*
Buffalo	64
Lack of maintenance	61
Tractors	56
Illicit tapping	43
Erosion	39

*Multiple responses were possible.

A majority of respondents (90 percent) said that damaged structures affect water supply. Of the farmers who felt that damaged structures affected water supply, 78 percent said that damaged channels were unable to carry water to full capacity. Others said that damaged structures wasted water and led to water shortages.

When asked if farmers reported damaged structures to officials, about 50 percent of the respondents answered affirmatively. Of those who said yes, 44 percent said that farmers reported such damage to the vel vidane and the cultivation officer, while 35 percent said that the farmers reported this information to irrigation officers.

When asked whether they themselves reported damaged structures, only 23 (32 percent) respondents said yes. Most of them said they had reported damaged structures to irrigation and Agrarian Service officers, but only 10 farmers claimed that action had been taken against the offenders. The main reasons given by the respondents for in-action were:

* Officials were not concerned.
* Offenders were just warned and discharged.
* Local officers did not want to take action against local people.

Farmers in Minneriya seemed confident that damage to irrigation structures could be prevented. A large number of respondents (67 percent) suggested the following preventive measures: concrete lining of canal and channel bunds, providing facilities for washing tractors, keeping buffalo away from irrigation canals, and introducing and enforcing strict rules and regulations. Other measures suggested by the farmers were:

* Provide adequate water to prevent illicit tapping, and punish offenders.
* Build bridges across waterways so that the tractors and buffalo can be taken across without damaging bunds.
* Rehabilitate structures and educate farmers as to the value of the irrigation structures.
* Give farmers the responsibility for protecting irrigation structures in keeping with a set of clearly defined rules and regulations.
* Appoint a special officer from the Irrigation Department with the sole responsibility of protecting irrigation structures.

Encroachment. Encroachment constitutes a major problem in most major irrigation schemes which have operated for several decades. The renovated Minneriya Scheme, now 50 years old, has already felt the pressure of a growing population. Consequently, the original allotments have been increasingly subdivided and fragmented. Moreover, many early settlers, as well as newcomers, have gradually encroached onto whatever land was available in the vicinity, including land reserved for various purposes.

The cultivation of reservations (i.e., land reserved for bund protection, drainage, roads, and pastures for cattle),[1] has serious implications for the functioning of the irrigation system. A few of the problems observed and reported were:

* Work animals graze freely since areas formerly reserved for pasture have been encroached. This grazing damages physical structures, bunds, and crops.

* When drainage areas are blocked for cultivation by encroachers, fields cannot properly drain and flooding may also occur.

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[1]Encroachment on land reservations in Sri Lanka is illegal according to the provisions of state legislation relating to state-owned land and property (State Land Ordinance of 1947, No. 8, and State Regulation of 1948.10.15, No. 9912, Regulation No. 11). These enactments define such reservations and their boundaries.

* The cultivation of reserved land has added to the command area, creating an extra burden on the irrigation system.

In Minneriya, 70 percent of the respondents identified encroachment as a major problem in the area. The majority of the respondents also reported that the encroachers were mostly farmers from the field channel area itself. Only four respondents (5 percent) said that encroachers were exclusively outsiders.

The farmers interviewed in Minneriya were asked about the spatial distribution of encroachments. The data in Table 78 indicate that respondents believed that encroachments were not confined to any particular area, though many farmers felt that encroachments were concentrated in the tail areas of field channels. Most farmers reported that the land surrounding drainage channels and channel bunds had been encroached. Only 23 farmers (30 percent) said that highland areas had been encroached.

Table 78. Location of encroached land as perceived by Minneriya respondents, 1986 *yala*, (n=57).

Location on field channel	Number of Responses	Relative %
Along field channel	28	49
Tail	22	39
Head	6	11
Middle	1	2

Encroachers also depend on the main system to irrigate encroached plots. When asked how encroachers obtained water, 21 percent of the respondents believed that encroachers resort to illicit tapping and 79 percent of the farmers interviewed reported that encroachers take water from field channels. Some encroachers were reported to tap water directly from branch canals. A number of respondents mentioned that encroached parcels also depend on drainage water.

The sample farmers in Minneriya were asked whether or not they themselves cultivated encroached land. Since encroachment was illegal, a certain degree of underreporting was expected. Yet, 23 respondents (30 percent) admitted cultivating encroached land.

Most respondents felt that encroachment affected water supply. Fifty-six farmers (73 percent) said that encroachments were a burden on the irrigation system. Those who said that encroachments depend on drainage water felt that this did not affect water supply. Some respondents also expressed the view that encroached land only constitutes a small proportion of the total command area. Other respondents said that encroachment leads to disputes among water users.

Disputes and conflicts over land and water rights constituted a significant issue at Minneriya. The data gathered through the household survey indicated that disputes over water rights seemed more prevalent than those related to land rights. For instance, while 23 farmers said they were personally involved in water disputes, only 12 farmers said that they were involved in land disputes.

In many cases, no one mediated for disputing parties. In the 12 land disputes, a third party had intervened in eight cases. As one might expect, the mediating parties were reportedly those with some authority, such as the cultivation officer, the colonization officer, and the Government Agent. In the 23 water-related cases, a third party had mediated in only nine cases. The mediators in these instances were irrigation officials, vel vidanes, cultivation officers, grama sevaka, and farmers themselves.

The water users in Minneriya did not seem satisfied concerning the existing adjudication of water disputes. This was partly due to the absence of an institutional arrangement at the local level to deal with water disputes. Many farmers complained that there was no standard procedure to follow or particular authority to contact. (Appendix H gives an organizational chart showing the relationships of different departments and their officers to one another and to the farmers.)

d. Irrigation Organization, Farmers, and Farmer Associations

The human organization of an irrigation system is more complex than its physical organization. The human organization consists not only of various officials and farmers who are interrelated through a network of formal and informal contacts, but also the values, expectations, rights and duties, rules and regulations, formal and informal agreements and contracts, sanctions, and ethical codes.

The actual functioning of an irrigation system depends on both the human and physical aspects of organization. Moreover, the evolution of a system is a result of the interplay between these two components. In the process, both the human organization and the physical structures change.

The irrigation organization extends from the system-level authorities through intermediate-level officers to field-level functionaries. As salaried officials who have their own interests, expectations, grievances, values, status, and roles, they cannot be expected to think or act in the same manner as irrigators whose interests, values, and expectations, are different from those of the officials. If one asked officials what their major problems were, they might cite low wages, poor working conditions, and inadequate transport facilities. If irrigators were asked to mention some of their serious problems, they might cite inefficiency and negligence of officers, water shortage, and lack of proper maintenance of physical structures. This difference of opinion and emphasis indicates the possibility for conflict of interest and misunderstanding between irrigators and irrigation officials.

Farmers are not necessarily passive users of water. They often display a capacity to adjust under varying conditions. In the process, they may violate formal rules and regulations -- particularly when the latter prevent them from achieving their objectives. They may also become highly individualistic or highly communal, depending on various factors and circumstances. They may follow official instructions in some situations and reject them in others.

In view of the above, a gap could be expected to exist between the irrigation bureaucracy and farmers in terms of behavior, opinions, attitudes, expectations, and interests. This difference often leads to a situation where the two parties blame each other for the shortcomings associated with the irrigation system.

In this last section of the Minneriya sociology report, some aspects of the relationships between water users and the irrigation organization are discussed, including the interaction between water users and irrigation officers, the role of functionaries such as the vel vidane and Agrarian Service officers, farmer participation in the management of irrigation affairs, and water users' assessment of the irrigation system.

Relationship Between Irrigation Organization and Water Users. When asked whether they had ever met with irrigation officers, 33 respondents (43 percent) answered affirmatively. The officer mentioned by most respondents was the work supervisor. Others had met with a patrol laborer, a technical officer, or the Irrigation Engineer. Most farmers had met the officers in their offices, but a few farmers had met with officers in the field.

Nineteen respondents in Minneriya (25 percent) reported meeting irrigation officers to discuss irrigation matters during the last yala. Most of them reported meeting with the work supervisor, mostly to discuss water shortages. Farmers had also met with officers regarding illicit tapping, maintenance, and rotational issues.

When asked if farmers cultivated personal relationships with officials, 21 farmers said that they associated with officials. Farmers reported that they have developed informal social contacts with the work supervisors. A few also mentioned social contacts with technical assistants and patrol laborers.

How do the farmers assess the performance of the irrigation officers? While 38 respondents (49 percent) felt that the officers performed their functions properly, 36 respondents (47 percent) felt that this was not the case. Fifty-seven farmers in Minneriya (74 percent) thought that local irrigation officials were impartial. Only 15 respondents (19 percent) said that they were partial, while 3 farmers stated that they did not know.

Twenty-six respondents (34 percent) reported meeting the vel vidane during the last yala. When asked to judge the importance of the vel vidane in irrigation matters, only 21 respondents (27 percent) felt he was important and 43 respondents (56 percent) felt that the vel

vidane was not important. (Note here that recent institutional changes, such as the introduction of the project committee system, may have made the vel vidane less significant locally. Though the vel vidane position has not been abolished, some farmers seemed confused about the current and future role of the vel vidane. For example, many farmers have stopped paying a fee to the vel vidane.)

Local water management involves many participants: irrigation officers, the vel vidane, the cultivation officer, farmers, and farmer leaders. This multitude at times creates confusion about responsibilities for duties. For example, field-level irrigation officers are not comfortable with the position of the cultivation officer, who is affiliated with the Department of Agrarian Services. The irrigation officers seemed to think that irrigation matters should be handled by irrigation officers. Furthermore, irrigation officers claimed that the cultivation officer does not perform his duties properly. On the other hand, others claim irrigation officers are negligent, partial, and corrupt.

Water users often do not know who to turn to when they have a problem. Because the vel vidane lives in the village, he is usually the most accessible person, but he has little technical authority to settle irrigation problems. Therefore, he is seldom able to solve many issues that farmers face.

To bring order to the above situation, authorities have sought to formulate strategies that promoted farmer participation in irrigation management. Though these strategies have changed over time, the underlying principle has been to delegate more responsibility to farmer representatives and local organizations and to increase farmer participation in the management of irrigation affairs, particularly at the local level.

With the revival of the cultivation committee, which consisted of elected representatives at the village level, under the Agricultural Productivity Act of 1972, the position of vel vidane was abolished and replaced by the irrigation representative, who was assigned the task of attending to local irrigation matters in collaboration with departmental officials. In the late 1970s, with the enactment of the Agrarian Services Act, the position of vel vidane was restored. For the vel vidanes' services, farmers were required to pay him a fee commonly known as salaris, the standard rate being 1 bu of paddy per acre.

The above changes did not necessarily lead to increased farmer participation in Minneriya or elsewhere. Irrigators continued to face many problems as usual. The managers also continued to encounter difficulties relating to water distribution, system maintenance, and conflict resolution. There were often communication gaps between officials and water users which sometimes led to disputes between the two parties. To rectify this situation by promoting farmer participation in irrigation management at the local and intermediate levels, a new system of management known as the project committee system was introduced in 1984.

With the project committee system, a three-tier organizational structure was established which consisted of a project committee at the system level, a project subcommittee at the intermediate level, and a turnout group at the field channel level. The turnout group consisted of all the farmers in a field channel area who were represented by an elected representative (ela niyojitha). The elected representative was a member of the project subcommittee, which consisted of field channel representatives and intermediate irrigation officials. The project committee consisted of representatives from all the project subcommittees, the project manager, system-level officers, and the government agent.

Under this system, an operations and maintenance (O&M) fee of Rs. 100/ac/yr was payable to a maintenance fund by each water user. The farmers were to pay this fee to the cultivation officer who was to give it to the project manager. The project manager was to deposit it in an operations and maintenance fund account. The funds thus raised were to be spent to maintain the physical structures in each locality.

The project committee system has operated in Minneriya for about 2 years. To gather some information about any changes due to the new system, a few questions were asked of the farmers.

Only 29 percent of the respondents in Minneriya reported that they knew of the project subcommittee. Twenty-one of these respondents said that they knew the subcommittee representative in their area. However, while 6 respondents said that the subcommittee representative was appointed by the government, 13 said that he was elected by the farmers. Eleven sample farmers said that they were satisfied with the representative. Most of those respondents who stated that they were not satisfied with the representative said they were dissatisfied because no maintenance work had been done. Most of those who were aware of the project subcommittee said that they were not satisfied with it as they have yet to see any benefits.

The data gathered through informal, in-depth interviews with farmers, vel vidanes, irrigation officials, and others indicated that the project committee system has had no significant impact in Minneriya. Those farmers interviewed who knew about the project committee system had a limited understanding of its objectives, functions, and composition. When the O&M fees were introduced, most farmers paid. However, when no tangible results were seen, many farmers no longer wanted to pay the O&M fee. In 1984, the total amount paid for the O&M fee was about Rs. 377,000. The amount paid in 1985 was about Rs. 170,000, while in 1986, payment had decreased to just over Rs. 88,000.

O&M fees were to be spent to maintain and repair structures in respective field channel areas. The farmer who represents the members of a turnout group is expected to prepare a list of maintenance activities needed in his field channel area and give them to a technical assistant who prepares a cost estimate. The cost estimate is then submitted to the project subcommittee, which in turn submits it to the project committee. The project committee decides how to allocate funds and assigns tasks. For activities involving small sums of money,

contracts can be directly awarded to farmer organizations. Larger operations are undertaken by the Irrigation Department.

Though the project committee system allows water users to take part in maintenance decisions, the procedure described above tends to delay the actual maintenance. Farmers' refusal to pay O&M fees in Minneriya is probably largely due to these shortcomings. Many farmers also said that they did not pay the O&M fee because those who do not pay are not punished and receive the same privileges as those farmers who do pay.

Introducing an O&M fee has had other consequences. Though the fee was meant to support maintenance and repair work, farmers appeared to think that the fee also covered regular cleaning of field channels. This was largely due to the farmers' lack of understanding regarding the new system. Though field channel cleaning continued to be the responsibility of the water users, many farmers appeared to expect the Irrigation Department to clean the field channels for them. Their impression was that, since they pay O&M fees, they do not now have to contribute to regular cleaning of channels. Field-level irrigation officials complained that the Minneriya farmers are now reluctant to attend to such responsibilities.

We mentioned earlier that the position of vel vidane has become less important in the eyes of the water users and that some farmers no longer pay the vel vidane fee. Some of the vel vidanes said that they do not want to work because they are not paid their dues. While some vel vidanes continue to receive salaris from some farmers, those who do not said that they continue to perform their duties as an honorary service.

With all of the problems mentioned above, the project committee system has not fulfilled its intended role. One option for change that farmers have discussed is to make the current informal turnout group a full-fledged water users' association capable of handling the diverse issues found in a locality.

At the time of the study, no field channel level farmer associations existed in Minneriya. Yet, 74 percent of the farmers interviewed said there was a need for such an organizational arrangement. Sixty-eight farmers interviewed (88 percent) said that they would join a local farmer organization if one was formed. Only 9 percent of the sample farmers said that they would not join (two of these held encroached land). Only one farmer said that a farmer organization would not solve farmers' problems.

Respondents in Minneriya identified a number of functions for a farmer organization (Table 79). A majority of the respondents said that officers in a formal water users' organization should be elected by the vote of all the farmers in the area concerned. A few farmers said organization officers should be selected by officials.

Table 79. Responsibilities proposed by sample farmers for a formal water users' organization at the field channel level in Minneriya, 1986 yala (n=77).

Suggested Responsibility	Number of Responses*
Distribute water at the field channel level	56
Maintain physical structures in the field channel area	52
Settle disputes	51
Prevent illicit tapping	50
Rehabilitate physical structures	39
Punish offenders	37
Supply agricultural inputs	5
Provide agricultural extension	4

*Multiple responses were possible.

Respondents were asked whether or not the relevant officers (cultivation officer, vel vidane, irrigation officers) should be members of the farmer organization. Forty-nine respondents (64 percent) answered affirmatively. Most of those who responded affirmatively thought that technical officers and work supervisors should be members of the farmer organization in order to establish closer links with the officers and to use them as a link to communicate with higher officers. Six sample farmers (8 percent) felt that these officers should not be members. They felt that a farmers' organization membership should be restricted to farmers. Others said that the officers would not be impartial and would have different views from the farmers.

Forty-nine percent of the respondents in Minneriya thought that the vel vidane should be a member of the local farmers' organization. Most of these respondents said the vel vidane should be a member because of experience in irrigation matters. Some also said that the vel vidane's presence would be useful because of contacts with irrigation officers. Most of those who were against the membership of the vel vidane said this was because the vel vidane "did not perform his functions well."

What sort of authority should the farmer organization possess? Minneriya respondents suggested several areas of authority for a farmers' organization. They were:

* Authority to solve farmers' problems.
* Authority to handle irrigation matters in the field channel area.
* Authority to punish offenders (those who damage structures and steal water).
* Authority to prevent poor water management practices.

In the absence of local water user associations, the survey data suggests that the majority of Minneriya water users may have developed collective or joint agreements with neighboring farmers to solve water problems over the years. Forty-nine (63 percent) farmers reported that they have joint agreements with others to share water when there is a water shortage or other such problem. Some farmers, however, complained that there was no unity among farmers.

Water Users' Assessment of the Irrigation System and the Issue of System Maintenance. System maintenance is a major issue facing any centrally organized irrigation system involving a large number of individual water users scattered over a large geographical area, particularly when the water users are small-holding farmers who are unable or unwilling to contribute substantially towards system maintenance. Moreover, the field-level officers who are often entrusted with the responsibility of safeguarding and maintaining physical structures, are not always motivated and dedicated due to unsatisfactory working conditions, among other things.

The physical condition of an irrigation system is a product of interactive forces; namely, men, machines, and animals. If damages are regularly repaired and routine maintenance work is done, then physical structures should remain in good condition. If this does not happen, then the deterioration of the system is a likely result.

The Irrigation Department is responsible for regularly maintaining the physical structures in the irrigation system. They are faced with a limited budget, however, and find it difficult to regularly do all the needed maintenance work. As a result, many canal structures throughout the system remain in disrepair. In addition, due to irregular cleaning of the field channels, which is the responsibility of the water users themselves, field channels are often in poor condition.

As part of the sociology component of the diagnostic analysis, an attempt was made to elicit farmers' opinions on the current condition of the irrigation structures. Table 80 summarizes their responses. The majority of the respondents (65 percent) thought that the physical structures were badly damaged. Only 4 respondents (5 percent) thought that structures were in good condition.

Table 80. Condition of irrigation structures as perceived by Minneriya respondents, 1986 yala (n=75).

Structure Condition	Number of Responses	Relative %
Very good	0	0
Good	4	5
Damaged	22	29
Badly damaged	49	65

As the data in Table 81 show, sample farmers indicated that physical structures have deteriorated over time because of tractors and buffalo, lack of regular maintenance, and deliberate damage by farmers. Another factor identified was encroachment onto reserved land.

Table 81. Reasons for the current condition of physical structures as perceived by Minneriya respondents, 1986 yala (n=71).

Reason	Number of Responses*
Tractors/buffalo	48
Lack of proper maintenance	40
Deliberate damage by farmers	31
Natural causes	29
Encroachment onto canal bund	4

*Multiple responses were possible.

The water users were concerned about how the prevailing condition of the irrigation structures adversely affected the supply of irrigation water. When asked whose responsibility it was to maintain physical structures, water users in Minneriya said that they should contribute towards the maintenance of the irrigation system, particularly at the field channel level. Thirty-six respondents (47 percent) thought that a local farmer organization should maintain physical structures in a field channel area. Thirteen farmers (17 percent) said that structural maintenance in the field channels was currently the responsibility of the vel vidane, and 26 respondents (38 percent) felt that irrigation officers were responsible for field channel maintenance.

Only 26 respondents (38 percent) felt that the maintenance of branch canals should be undertaken by a farmer organization, while 48 respondents (62 percent) said that branch canal maintenance was the responsibility of irrigation officials. With regard to maintaining distributary and main canals, only 7 sample farmers (9 percent) said that a farmer organization should be involved, while over 90 percent felt this was the responsibility of the Irrigation Department.

What was the current involvement of the farmers in maintenance? Sixty-nine respondents (90 percent) reported that regular cleaning of the field channels was done by the water users themselves. However, this may have been a "courtesy" response, as observations indicated that there were no significant collective efforts to do regular maintenance work in Minneriya. Only 17 sample farmers (22 percent) said that they organized shramadana (volunteer labor) for maintenance work. Fifty-four sample farmers (70 percent) reported that cleaning the demarcated sections along the field channel was actually undertaken by individual water users.

3. SUMMARY AND CONCLUSIONS

Earlier, a brief account of the socio-economic background of the sample farmers was presented. As shown, the land allotments that were

originally distributed among settlers have been steadily moving into the hands of descendants and others and have become increasingly subdivided and fragmented. Although the sizes of fragmented holdings were not as small compared to many settlement schemes in the region, about 60 percent of the sample farmers' lowland holdings were currently below 5 ac. Of this, 39 percent were below 3 ac. The original lowland allotment varied from 5 to 4 ac. Many fragmented parcels have passed into the hands of non-allottees (those who were not given original allotments) through share-cropping arrangement, lease, mortgage and sale. There were 15 non-allottees in the sample of farmers selected for the household survey. This occurrance of land subdivision and fragmentation may complicate efficient distribution of irrigation water.

As mentioned, not all of the irrigators in Minneriya reported obtaining water from field channels. Seventeen farmers obtained water from other sources such as branch canals, drainage channels, and adjoining fields. This indicates that not all farmers relied entirely on field channels for regular supplies of irrigation water.

The most frequently cited water problem in Minneriya was shortage of water. The main reasons given by respondents for not receiving an adequate supply were illicit tapping, damaged structures, and the failure of officials to issue sufficient water. Other problems identified were related to the rotation system and timing.

Half of the respondents felt that not all water users received an equitable water supply. They attributed this inequity largely to the distribution system, particularly the physical structures.

Farmers felt that they had little influence concerning decisions about water allocation, distribution, and rotation scheduling of irrigation water. The only forum where they felt that they might air their views appeared to be the kanna meeting. Even so, farmers viewed kanna meetings as officers conveying their decisions to the water users, rather than an opportunity for communication. This attitude may have resulted in reduced farmer participation at kanna meetings.

On the other hand, many officials complained that farmers did not attend or express their views at the kanna meeting. It also appeared that farmers were not as concerned with the overall issues discussed at the kanna meeting as they were with water shortage, damaged structures, and illicit tapping at the local level.

Even though farmers are not supposed to use irrigation water for highland cultivation, many farmers in Minneriya irrigate their highland plots. While some obtained water illicitly from field channels, others relied on drainage water. Highland cultivation has become a considerable burden on the irrigation system since it has increased the area under cultivation.

While land fragmentation has implications for water distribution and sharing, the diverse cultivation rights involved have increased the complexity of these issues. Those who cultivate plots owned by others,

particularly on a seasonal basis, may be more interested in their personal short-term gains, and therefore, may act in a way that is detrimental to the irrigation system. For instance, they may cut the field channel bund to divert water. Moreover, they may not feel obliged to contribute to the maintenance of the system.

Farmers, under conditions of water shortage, were reported to resort to illicit tapping. Illicit tapping was reportedly more prevalent in the tail areas. Some of the methods reportedly used by illicit tappers to extract water can damage physical structures. Yet, even when reported, respondents said that action is seldom taken against the offenders by the authorities.

Structural damages can be caused by natural causes and intentional and unintentional human action. The main causes of damage reported in Minneriya were tractors, work animals, and illicit tappers. Lack of proper and regular maintenance, coupled with the above factors, contributes to the deterioration of the irrigation system. Farmers were highly concerned about damaged structures since this directly affects the irrigation water supply.

Encroachment constituted a major issue in Minneriya because of the affect on the irrigation system. At the system-level, encroachment was a problem because it expanded the command area of the irrigation system. At the local level, encroachment interfered with the distribution and sharing of water and contributed to illicit tapping and disputes over water rights. Note that some of the land that has been encroached was reserved for non-cultivation purposes such as bund protection, drainage, roads, and pasture.

The Irrigation Department expects the water users to follow formal rules and regulations and conform to standard practices. Some water users deviate from these rules, regulations, and norms, particularly if they obstruct the achievement of a particular farmer's individual objectives and desires. An example of this is farmers taking water out of turn during rotation. Respondents also complained that the officials did not enforce formal rules and regulations.

Minneriya Scheme, as it exists today, has deviated from the configuration envisaged by the planners. The command area has increased substantially over the years; the distribution network has been altered; reserved land has been cultivated; water has been taken out of turn; physical structures have been damaged; some water users have not fulfilled their obligations, particularly in the area of maintenance; the social composition of the settler community has changed; and land tenure patterns have been altered.

In view of this situation, the project committee system was introduced to increase the participation of water users in the operation and maintenance of the irrigation system. Overall, respondents' awareness of the project committee system was very low in Minneriya. Understanding of its scope and functions was also minimal. Respondents felt that no significant or visible activities have been carried out by the project committee system. The project committee system, however,

has leaned towards centralized decision-making. Water users are still unable to solve problems at the local level because the turnout groups (which have yet to be formed in most parts of Minneriya) have no constituted authority. Instead, water users are required to take their problems to a mediary (such as the project subcommittee), which reduces efficiency and the farmers' expectancy for problem solution. Although the project committee system has attempted to represent the views and interests of water users, in general the respondents felt that a formally constituted organization at the field channel level would better serve their specific local concerns.

F. WOMEN IN DEVELOPMENT

1. INTRODUCTION

In Sri Lanka, the national government and international donors such as USAID are increasingly promoting the development and improvement of irrigation systems, large and small alike, as a means for increasing agricultural production. Parallel to this is a greater awareness of the importance of women's roles in agricultural production. Despite the noticeably greater attention given to farm women in recent development projects, understanding of women's roles in irrigated agriculture and their interaction with the irrigation system is minimal.

Therefore, a component relating to women's roles in an irrigated agricultural production system was included as a part of the Diagnostic Analysis Project. The women in development (WID) component sought to gather the following specific information:

1. Women's activities on- and off-farm, agricultural and non-agricultural.

2. Sources of agricultural information for women.

3. Information about home gardening and permanent tree crop production.

4. The income and expenditure patterns and preferences of the household, including the role of women in family resource management.

5. The participation of women in community organizations and informal groups.

The study made an effort to cover many broad topics of interest and was basically exploratory in nature. It was not expected that all questions relating to women's roles in irrigated agriculture would be conclusively answered, but that important and significant areas would be identified. Information from the study was aimed toward providing the Diagnostic Analysis Project with an additional dimension to understanding the complex operation and interaction of the irrigated agricultural system and the farm household.

The funding for the WID component of the Diagnostic Analysis Project was derived from the USAID/Colombo Mission. Initially, only two irrigation schemes (Parakrama Samudra and Giritale) were included for WID studies. However, some additional funding allowed the inclusion of Kaudulla and Minneriya schemes. This additional funding was significantly less than for the initial PSS and Giritale studies. Therefore, the WID studies on Kaudulla and Minneriya were more limited in scope and detail than the PSS and Giritale studies.

2. METHODOLOGY

The Minneriya Scheme was investigated by the Diagnostic Analysis Project during the 1986 yala. The head, middle, and tail sites on the irrigation system were chosen by the engineering and agronomy components to represent expected hydrological differences. The WID sample was composed of farm households with field allotments from head and tail field channels on the distributary channels named in Table 82.

Table 82. Field sites for the 1986 yala WID study on Minneriya.

Region	Distributary	Households (Economics)	Households (Sociology)
Head	D13	19	19
Middle	D21, D28	25	28
Tail	D37	31	32
Total		75	77

While hydrological locations may exhibit significant social and economic differences, correlation was determined to be less important for the WID component than for disciplines such as engineering. Therefore, only data relating to domestic water were analyzed according to hydrological location.

The actual number of households in Minneriya were unknown. However, based on the original number of allottees, and adjusted for the second generation, a sample of approximately 2-3 percent of the estimated population was obtained. Efforts were made to include only those households engaged in cultivation during the 1986 yala. However, due to the complexity of land tenure arrangements and restrictions imposed by the hydrological selection of the sample, some households that had leased or mortgaged their fields to others were also surveyed. In addition, some households were cultivating more than one allotment, but were only interviewed about activities and information relating to one holding. Within each household, the selection of the female respondent was based on availability, accessibility, and the subjective opinion of the field investigator as to which female family member could best provide the information requested.

Because of limited funding, assistance from the other discipline components was necessary. The economics component and the sociology component collected various information for the WID study. Due to logistical problems involved in implementing a study of this scope, precise replication and coordination among all of the disciplines was difficult to achieve.

Although 80 households were actually selected for interviews by the WID, economic, and sociology components, only 75 were interviewed by the economics component and 77 by the sociology component. There-

fore, in some cases the size and composition of the WID sample varied, depending on whether the information was collected by the economics or the sociology component. These discrepancies in sample size are noted in the heading of the respective tables.

The economic and sociology field investigators, supervised by the WID coordinator and the WID field leader, administered the WID questionnaires. These investigators were all previously involved in the Parakrama Samudra and Giritale studies, and had worked closely with the WID field investigators. Although all of the economic and sociology investigators were males, their prior experiences with the WID investigators served to sensitize them to issues concerning women and methods and techniques for administering the questionnaire to women. THe WID field leader accompanied the economic and sociology investigators to the field, observed interviews, and assisted in resolving any problems.

The WID questionnaires were based largely on previous workshops and studies conducted in Sri Lanka (1983 Diagnostic Analysis Workshop: System H of the Mahaweli, 1984 Diagnostic Analysis Workshop: Parakrama Samudra System, and Kilkelly, 1986). The actual design, construction, and testing of the questionnaire is detailed in previous reports (Kilkelly, 1986; Nelson et al., 1987a and 1987b). All questionnaires were administered in Sinhala. Because of limited funding, the questionnaire for Minneriya was considerably reduced from those used in the PSS and Giritale studies. Although most of the questions were restricted to specified responses, a few "open-ended" questions involving discussion were also included.

The questionnaires were administered in a single session by the economic and sociology investigators, during the same survey in which economic or sociology interviews were conducted. In previous studies, investigators noted that male family members tended to intrude on the WID interview. However, investigators in this study reported that they were able to resolve this problem.

Field investigators were issued tabulation forms and coding sheets. Coded data were verified by the WID field supervisor and the WID coordinator. The coded data were entered on a Compaq™ microcomputer for analysis using Microstat™ -- a statistical analysis software program. In addition, some of the open-ended discussion questions found to be incompatible with computer analysis were hand tabulated. Basically, a one-way frequency analysis was used for most variables and the arithmetic mean for other variables. A cross-tabulation of one variable was performed.

3. RESULTS AND DISCUSSION

a. Demographic Information

The family position of Minneriya women respondents and their marital status is given in Table 83. The status of the woman within the family is an important variable when topics such as decision-making and work responsibilities are examined. The largest proportion of

women interviewed were the daughters-in-law of original allottees. In fact, the second generation women in the sample considerably outnumbered the first-generation settler women. In addition, the number of widowed women in the sample was probably a good indicator of the age of the Minneriya Scheme, one of the oldest in the Polonnaruwa District. While most of the women were related to original allottees, 12 percent of the sample were not. Those bearing no relationship to original allottees were related to encroachers, purchasers, or tenants. Although sale, mortgage, or fragmentation of the allotment is technically prohibited in the resettlement scheme, in reality a variety of complex tenurial relationships exist.

Table 83. Family position and marital status of Minneriya respondents, 1986 *yala* (n=75).

	Number of Responses	Percent
Familial Relationship		
Wife of allottee	14	19
Widow of allottee	9	12
Daughter of allottee	10	13
Daughter-in-law of allottee	32	43
Female allottee	1	1
Not related to allottee	9	12
Marital Status		
Married	65	87
Unmarried	1	1
Divorced/separated	0	0
Widowed	9	12

The age and educational level of the women interviewed is shown in Table 84. The age of the women ranged from 24 to 73 years with an overall average of 42 years of age. The settlement of the Minneriya Scheme began in the 1930s, and undoubtedly this influenced the age distribution of the sample, with a quarter of the women over 50 years of age.

The educational level of the women interviewed ranged from none to 12 years of formal schooling, with an overall average of 6 years. Approximately 27 percent of the sample had received at least 10 years of schooling (GCE), a fairly high level for a rural area.

Table 84. Age and education of Minneriya respondents, 1986 *yala* (n=75).

Age (yrs)	Percent	Education	Percent
< 20	0	None	13
21-30	12	1-5 years	32
31-40	36	6-9 years	28
41-50	27	(GCE)'O'*	23
> 50	25	(GCE'A'**	4

*GCE'O' = General Certificate of Education - ordinary level (10 years of schooling plus exam)
**GCE'A' = General Certificate of Education - advanced level (12 years of schooling plus exam)

b. Activities of Minneriya Women

A general description of activities reported by the women interviewed is found in Table 85. Overall, even though women were primarily responsible for the majority of household duties, almost 80 percent were also involved in some form of agricultural work. Three women were engaged in full-time employment outside of the home as a teacher, an assistant registrar, and a bank clerk.

Table 85. Primary activities of Minneriya respondents, 1986 *yala* (n=75).

Activity	Number of Responses	Percent
Mainly housework	12	16
House/fieldwork	59	79
House/job	3	4

Although funds were not available to gather detailed information concerning specific activities associated with the various stages of irrigated crop production, some general information about the type of agricultural activities performed by Minneriya women is reported in Table 86.

Table 86. Agricultural activities of Minneriya respondents, 1986 *yala* (n=75).

Activity	Number of Responses*
Home vegetable garden	26
Highland crop	4
Family fields	58
Other's fields	16
No agricultural work	16

*Multiple responses were possible.

Twenty-one percent of the women interviewed reported that they performed no agricultural work at all. However, the majority of women (77 percent) were engaged in agricultural work on their own family fields. In addition to work in their own fields, women also worked in other's fields (11 women), home gardens and highland crops (22 women), or both (5 women).

The 16 women (21 percent) engaged in off-farm, agricultural work reported that this was primarily attam (a form of exchange labor), casual wage labor, or shramadana (volunteer work) as shown in Table 87.

Table 87. Off-farm, agricultural work of Minneriya respondents, 1986 yala (n=16).

Off-farm work	Number of Responses*	Type of activity	Number of Responses*
Attam	12	Transplanting paddy	14
Wage labor	13	Weeding paddy	9
Shramadana	2	Harvest paddy	7
		Harvest other field crops	1

*Multiple responses were possible.

Almost all of the off-farm, agricultural work was in paddy cultivation. Because the labor intensive activity of paddy transplanting is done solely by women, many households either exchanged labor with neighbors or hired local teams of women. In fact, local female labor is generally insufficient to meet the labor demands during transplanting, and crews of women from outside the area are contracted for this particular activity. Local women usually provide most of the labor for weeding throughout the cultivation season, either by attam or casual wage labor. Harvesting the paddy crop is another labor intensive activity, but both men and women commonly work together. Although harvesting also requires outside hired labor, the crews are composed primarily of men. Shramadana is generally associated with non-agricultural work such as community projects, but two women reported that they had donated their time to assist others with agricultural work.

Besides agricultural work, 14 women (19 percent) reported that they performed off-farm, non-agricultural work (Table 88). This work primarily involved shramadana, business, or a job. Those engaged in performing shramadana reported their work as road repair, cleaning irrigation channels, or community work. Although shramadana is technically termed volunteer work, often there is some type of payment, such as canned food, offered by local government agencies. The three women with full-time jobs included one school teacher, a women employed as an assistant registrar, and a bank clerk. Note that none of the Minneriya women reported working as wage laborers in non-agricultural activities. This may be a reflection of the better economic conditions

noted on the Minneriya Scheme compared to other schemes studied (see economics component).

Table 88. Off-farm, non-agricultural activities of Minneriya respondents, 1986 yala (n=14).

	Number of Responses*
Shramadana	11
Road repair	9
Channel maintenance	2
Community work	4
Business/job	3
Teacher	1
Clerical	2

*Multiple responses were possible.

c. Home Gardens and Permanent Tree Crops

The highland allotment can be considered an important production unit that contributes toward the support of the farm family. During yala, however, home gardening is limited due to insufficient rainfall and the absence of a water delivery system to the highlands. Even then, 48 percent of the households reported that they maintained home gardens. Information concerning 1986 yala home gardens on Minneriya is presented in Table 89. Unavailability of water, lack of time or labor, and poor health were the most common reasons cited for not having a vegetable garden. In addition, some women also mentioned that limited available space, poor soil, or animal damage prevented them from growing a garden.

Despite the lack of water, most gardens were located on the highland around the house. A number of women reported that they also grew vegetables in their fields, usually around the perimeter, on the bunds, or on the vacant threshing floor. These field gardens were then able to receive the benefit of the irrigation water supplied to the paddy crop. While 19 women reported that their gardens were located in the fields, 24 women reported that their gardens were watered from a nearby irrigation channel. In some locations within the Minneriya Scheme, the highland allotment can be easily irrigated from a nearby channel. The irrigation of these allotments is a sensitive subject since it is illegal to do so. While the farm household may realize definite benefits from irrigating highland allotments, it is incompatible with the design of the irrigation system and undoubtedly affects the delivery of irrigation water to the fields.

These small plots of vegetables were usually consumed at home and only occasionally sold. Consequently, the care of these gardens was often not considered "agricultural" work, and women often neglected to mention the existence of these gardens. In addition, throughout the study there was difficulty in defining "home gardens." The home garden

Table 89. Minneriya gardening activities, 1986 *yala* (n=75).

	Number of Responses*
Vegetable gardens	
Yes	36 (48)**
No	39 (52)
Why not	
Inadequate water	16
No time/labor/poor health	16
Poor soil	2
Uneconomical	2
No space/land available	4
Animal damage	1
Location	
Highland/house	22
Fields/bunds/threshing floor	19
Care	
Females only	4
Females/males	26
Males only	6
Water	
Well/tap	11
Irrigation channel	24
River	3
Use	
Home only	29
Home/sale	7
Sale only	0

*Multiple responses were possible.
**() = Percent.

was usually limited in scope, contained a diverse mix of vegetables, and was used primarily for home consumption. However, women occasionally assumed that the interviewer was only interested in "highland crops," a larger and more homogeneous stand of vegetables than the home garden commonly grown during *maha* (wet season) on the highland. Furthermore, the highland crop had economic connotations not associated with the home garden. For these reasons, women may not have indicated that they were growing a few vegetables around the house for the family. Only through successive probing and conversation on the part of the interviewer was information on home gardening obtained. Therefore, the data in Table 89 may underestimate the home gardening of Minneriya respondents for 1986 *yala*.

Seventy-two percent of the home gardens were tended by both men and women, rather than by one family member exclusively. Since the irrigated paddy crop generally receives priority, labor for the home

garden relied on contributions from all family members. All of the home gardens were grown for family consumption. In addition, a few households sold produce from the home garden.

Ninety-two percent of the Minneriya sample households cultivated permanent trees on the highland or around the house (Table 90). While the majority of women stated that fruits were used solely for home consumption, 23 percent of those with trees replied that they occasionally sold the produce when cash was required and a surplus of produce (primarily coconuts) existed. However, no regular marketing of produce was identified. One woman noted that although she had planted permanent trees, due to poor growing conditions no produce had been obtained. Again, because care of the trees comes only after the labor requirements of the irrigated paddy crop are met, all family members contributed to the care of permanent tree crops.

Table 90. Permanent tree crops on Minneriya, 1986 yala (n=75).

	Number of Responses*
Permanent Tree Crops	
Yes	69 (92)**
No	6 (8)
Why Not	
Poor soil	2
No water	1
No space	2
No response	1
Care	
Females only	1
Females/males	43
Males only	25
Use	
Home only	51
Home/sale	17
Sale only	0
No produce	1

*Multiple responses were possible.
**() = Percent

d. Domestic Water

The farm women normally assumed the responsibility for obtaining water for domestic use. While the majority of families were able to obtain domestic water from a shallow hand-dug well on their own highland, a significant number of women reported that they used a neighbor's well, a community well, or a tank (reservoir). Observations suggested that most of the highland wells depended on recharge provided by seepage from the nearest irrigation channel. It may be that some households were not as conveniently located (close to an irrigation

channel) as other households and could not obtain a reliable source of domestic water.

Approximately 60 percent of the women interviewed reported that they had some difficulty with their wells during yala (Table 91). The most common complaint was low water level, which often meant decreased quality of the well water. However, 28 percent of those experiencing problems indicated that the well actually dried up during the latter part of yala, requiring an alternative source of domestic water.

Table 91. Information about domestic water, as reported by Minneriya respondents, 1986 yala (n=76).

Domestic Water	Number of Responses	Percent
Source		
Highland well	57	75
Neighbor's well	14	18
Community well	1	1
Tank	4	5
Problems		
No	30	40
Yes	46	60
What		
Low water level	28	61*
Occasionally dry	13	28*
Poor water quality	10	22*

*Relative percentage

Problems with domestic wells at the sampled households increased in number from the head region to the tail region of the system (Table 92). This may be due to lower volumes of water, lower flow rates of water in channels, or delayed issues. Towards the end of yala cultivation, irrigation issues are normally reduced to coincide with harvesting activities. During this period wells may be inadequate for supplying domestic water.

Table 92. Distribution of well problems by hydrological location as reported by Minneriya respondents, 1986 yala (n=76).

Domestic Water	Head (n=19)		Middle (n=25)		Tail (n=32)	
	Freq.	Rel %	Freq.	Rel %	Freq.	Rel %
No problems	12	63	9	36	9	28
Well problems	7	37	16	64	23	72

e. Agricultural Information

Overwhelmingly, women indicated that their main source of agricultural knowledge came from traditional experiences. Most women reported that what they knew of agriculture was gained through their mothers, sisters, or other family members. In fact, "informal" sources of agricultural knowledge (husband, neighbors, and other farmers) surpassed any other sources of agricultural information for women (Table 93).

Table 93. Primary sources of agricultural information for Minneriya respondents, 1986 yala (n=76).

Source	Number of Responses*
Traditional	70
Husband/son/brother	50
Neighbor/farmer	51
Radio	14
Newspaper	10
Private traders	5
Pamphlets	2
Ag. Extension staff	7
No information obtained	6

*Multiple responses were possible.

Over a third of the sample indicated that they had used the mass media to obtain information about agriculture. Considering the relatively high education level of the Minneriya women sampled, the mass media (especially printed material) could be a means of extending agricultural information to women. While seven women cited the agricultural extension staff as a source of information, only three women had responded positively to an earlier question about personal contact with the KVS (agricultural extension agent). Two of those three women reported that they had met with the KVS in their fields, while one woman had traveled to the office of the KVS to seek agricultural advice. The agricultural problems mentioned by the three women were related to water, crop pests, and crop diseases. All three women indicated that they were satisfied with the responses of the KVS concerning their agricultural problem. Two of the three women also reported that they had previously attended farmer training classes sponsored by the local Agriculture Department office. Although the agricultural extension staff are also charged with providing information about home gardening and tree crop production, there were no reports of extension visits from the Minneriya women interviewed.

Upon further questioning, a number of women reported that they occasionally listened to agricultural radio programs and read information about agriculture in the local newspapers, but did not rely on or seek these as their main source of agricultural information (Table 94). Radio programs such as Sarabumi (sponsored by the Agriculture Depart-

ment), agricultural quiz shows, and advertisements were specifically cited, as well as newspaper articles.

Table 94. Occasional sources of agricultural information for Minneriya respondents, 1986 yala (n=76).

Source	Number of Responses	Percent
Radio programs		
No	51	67
Yes	25	32
What*		
Sarabumi	10	
Ag. quiz shows	14	
Drama	1	
Newspapers		
No	52	68
Yes	24	32

*Multiple responses were possible.

Information concerning the irrigation schedule, cropping calendar, and other general agricultural information is disseminated at the seasonal kanna (pre-cultivation) meeting. No women reported that they had attended the kanna meeting for 1986 yala. While a relatively high proportion of male family members reported that they attended this meeting, informal observations at a few of the kanna meetings in the Polonnaruwa District indicated that the number of farmers attending kanna meetings was minimal. The magnitude of the survey response was probably the result of a "courtesy response" since, technically, all farmers on the irrigation scheme are supposed to attend kanna meetings.

f. Family Finances

Although the primary source of family income was generally from paddy cultivation, other supplemental sources of income usually existed. Day-to-day household expenses managed by women were met by cash obtained from a variety of sources (Table 95). The majority of women reported that they obtained cash from their husband, son, or other family member. However, a significant number of women (40 percent of the Minneriya sample) also indicated that they alone provided and managed the cash for day-to-day expenses.

Fruits, vegetables, livestock, poultry, or animal products were also a significant means of supplementing family income. This type of income was difficult to quantify because most women could not recall or estimate the cash received through these occasional sales. Without some sort of record-keeping system, it would be difficult to identify the economic contribution of the highland.

Table 95. Sources of cash for day-to-day expenses of Minneriya households, 1986 *yala* (n=75).

Source	Number of Responses*
Husband/son/family	49
Woman's own source	31
Borrow from boutique	8
Borrow from neighbors	2
Fruit/vegetables/coconuts	22
Animals/products	4
Sale of subsidiary crops	1

*Multiple responses were possible.

Note that significantly fewer women from Minneriya reported borrowing cash from neighbors or boutiques compared to the other schemes studied. This may be related to the overall better economic status of Minneriya households (see economics component).

The management of resources (especially cash) within the family is a complex process and not always readily revealed to outsiders. Therefore, a number of questions about general purchases were included. In this manner, the individuals actually conducting the purchase were identified. While this does not account for the actual management of cash, Table 96 may offer insights into the purchasing power of various family members.

Table 96. Purchase of day-to-day items by Minneriya households, 1986 *yala* (n=75).

Purchaser	Number of Responses	Percent
Males only	21	28
Males/females	29	39
Females only	25	33

Overall, in 72 percent of the sampled households women participated in the purchase of daily items. However, it appeared that daily purchases were made by a number of family members, and purchase of goods was not restricted by gender. One factor influencing the participation of women as purchasers is the distance to shops and markets. On the Minneriya Scheme, many of the houses are clustered near a major road, which is lined with stores. Therefore, the travel constraints encountered in some of the more remote schemes are not a limitation for Minneriya women.

In approximately 73 percent of the households, individuals earning cash contributed all of their earnings to the family (Table 97). When women were asked about the management of family cash, the responses indicated that management was shared between males and females in a

significant number of families (Table 97). In addition, in a relatively large number (28 percent) of the Minneriya households, women reported that they alone managed the family cash. Many of these women were widows or female heads of households.

Table 97. Management of cash resources in Minneriya households, 1986 yala (n=75).

Individual Earnings	Number of Responses*	Cash Management	Number of Responses*
Keep all	0 (0)	Females only	21 (28)
Contribute part	20 (27)	Females/males	30 (40)
Contribute all	55 (73)	Males only	24 (32)

*() = Percent.

When women were asked about personal access to cash, over half reported that they have their own source of cash to spend as they wish (Table 98). The most common source cited by women for obtaining personal cash was their own wage labor earnings. Other sources of personal cash for women included vegetable or fruit sales, operating a small business, sale of animals or animal products, and a job. Eight women also indicated that as heads-of-household, they retained the income from the paddy cultivation associated with their allotment.

Table 98. Personal cash sources for Minneriya women, 1986 yala (n=75).

	Number of Responses*
Own source of cash	
No	37 (49)**
Yes	38 (51)
What	
Wage labor	13
Vegetable/fruit	8
Head of household	8
Business/boutique	4
Animals/products	4
Job	3
Savings	1

*Multiple responses were possible.
**() = Percent.

The majority of family expenses revolved around family subsistence and agricultural input needs. No doubt, these probably compete in households of limited finances. One opportunity to reduce family expenses is by establishing a vegetable garden for home consumption. During yala, the price of vegetables locally is quite high, and most of the women (52 percent) reported that they had to purchase all of their vegetables for family meals (Table 99). While those women with gardens

were able to use the produce for family meals, only two women reported that their home gardens were sufficient to supply their entire vegetable requirement.

Table 99. Vegetable sources for Minneriya households, 1986 *yala* (n=75).

Source	Number of Responses	Percent
Own garden only	2	3
Garden/purchase	34	45
Purchase only	39	52

When asked what an unexpected, large sum of cash (such as a lottery winning) would be used for, the majority of women responded with new home construction or improvement of the existing home (Table 100). Their second preference was for purchase of agricultural equipment and educating children. These preferences were followed by: purchasing or leasing in additional land for cultivation; establishing a savings; giving cash gifts to relatives, the temple, or community; and starting or improving a business.

Table 100. Spending preferences of Minneriya respondents, 1986 *yala* (n=75).

Use of Lottery Winnings	Number of Responses	Percent
House construction/repair	18	24
Agricultural equipment	15	20
Purchase/lease in land	11	15
Child's education	15	20
Gift to relatives/temple/community	6	8
Savings	6	8
Business investment	4	5

g. Society Membership

When women were asked about their membership in local organizations, 55 percent reported that they were members of some society (Table 101). The most popular society appeared to be the cooperatives. This was followed by both formal and informal temple societies, the Rural Development Society (RDS), and Sarvodaya (a voluntary service group). Membership in the RDS is not restricted to men, but a special chapter of the RDS for women, the Kantha Samithi, also exists. On some irrigation schemes studied, women preferred membership in Kantha Samithi rather than the RDS, but this apparently was not the case on Minneriya Scheme. A few other women cited membership in the Death Donation Society (where dues are paid to a fund for the funerals of contributing members), and the Young Farmers Club.

Table 101. Participation of Minneriya respondents in local societies, 1986 yala (n=76).

Society	Number of Responses*
Not a member	34 (45)**
Member	42 (55)
Which	
Cooperative	17
Temple	12
Rural Development Society	11
Sarvodaya	4
Death Donation	3
Kantha Samithi	3
Young Farmers Club	1

*Multiple responses were possible.
**() = Percent

4. CONCLUSIONS

The Minneriya Scheme is one of the oldest renovated irrigation schemes in the Polonnaruwa District. Therefore, it was not surprising that the largest proportion of women in the WID survey sample were second generation, such as daughters and daughters-in-law. In addition, 12 percent of the WID survey sample were widows of the original allottee.

An overall average of 6 years of schooling among the women sampled represented a relatively high level of education for a rural area.

While most women were usually responsible for household duties, 80 percent were also involved in some form of agricultural work. Women were primarily engaged in work on their own family fields, but 21 percent of the respondents reported off-farm agricultural work such as attam, wage labor, and shramadana. Off-farm agricultural work mainly involved activities in paddy cultivation such as transplanting, weeding, and harvesting.

In addition, 19 percent of the Minneriya women interviewed reported that they also performed off-farm, non-agricultural work. This work primarily involved shramadana, operation of a business, or a job. Note that none of the Minneriya women interviewed reported working as wage laborers in non-agricultural activities. This may be a reflection of the better economic conditions noted on the Minneriya Scheme compared to other schemes studied.

Forty-eight percent of the Minneriya households interviewed maintained a home garden during 1986 yala. While all gardens were used

for home consumption (with seven households selling some produce from the garden) only two of the gardens were sufficient to provide the entire vegetable requirement for family needs. Generally, both men and women cared for the garden. Some of the highland gardens were illegally watered by tapping water from nearby irrigation channels.

Ninety-two percent of the households were cultivating permanent tree crops on the highland or around the house. Trees were usually cared for by both men and women. Although the majority of produce was consumed at home, 23 percent of those with trees occasionally sold produce when a surplus existed (primarily coconuts).

Most households obtained domestic water from shallow, hand-dug wells on the highland, but 25 percent of the households reported their domestic water source as a neighbors' well, a community well, or the tank (reservoir). Sixty percent of the women interviewed reported some well-water problems during yala. Most of those reporting problems indicated that low water levels and poor water quality were problems, but 28 percent reported that the well occasionally dried up during the latter part of yala. The number of households reporting well-water problems in yala increased going from head to middle to tail regions of the irrigation system.

The main source of agricultural information was through traditional experiences or "informal" sources such as the husband, son, neighbors, or other farmers. Over a third of the women interviewed indicated that they had obtained agricultural information through the mass media (newspapers, radio, and pamphlets). While seven women cited the agricultural extension staff as a source of information, only three women had responded positively to an earlier question about personal contact with the KVS.

Day-to-day household expenses were met from a variety of sources. While the majority of women reported that they obtained cash from their husband, son, or other family member, 40 percent of the Minneriya women interviewed indicated that they alone provided and managed the cash for day-to-day expenses.

Although in many households the management of cash was considered a responsibility of male family members, the most common response was that men and women shared in the management of family finances.

Over half of the women interviewed reported that they had their own sources of personal cash, including wage labor, the sale of vegetables, fruits, animals and animal products, operating a small business, and holding a job. In addition, eight women indicated that as heads of household they retained the income from the paddy cultivation associated with their allotment.

House construction or improvement was most often cited by Minneriya respondents when asked about spending preferences. This was closely followed by purchasing agricultural equipment and educating children.

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V. APPENDICES

APPENDIX A

RICE EVAPOTRANSPIRATION IN POLONNARUWA REGION, SRI LANKA (1986 YALA)

(Estimated using method of Jensen and Haise)

Julian Date	Mean Temp. (C)	Solar Radiation (langleys)	ETo (mm/day)	Kc	ET (mm/day)
151	30.6	561	8.45	1.15	9.72
152	30.6	529	7.97	1.15	9.17
153	31.1	579	8.87	1.15	10.20
154	30.6	535	8.06	1.15	9.27
155	30.0	485	7.19	1.15	8.27
156	30.6	475	7.16	1.15	8.23
157	31.1	519	7.95	1.15	9.14
158	31.1	462	7.19	1.15	8.15
159	31.1	481	7.36	1.15	8.47
160	30.0	370	4.89	1.15	5.62
161	30.0	440	6.53	1.15	7.50
162	31.1	467	7.15	1.15	8.22
163	31.1	521	8.13	1.15	9.35
164	30.6	529	7.97	1.15	9.17
165	30.0	471	7.28	1.15	8.37
166	30.0	331	5.65	1.15	6.50
167	28.9	300	4.30	1.15	4.95
168	28.9	434	7.09	1.15	8.15
169	28.9	577	8.28	1.15	9.52
170	28.3	503	7.13	1.15	8.16
171	28.9	516	7.40	1.15	8.51
172	28.3	489	6.90	1.15	7.93
173	28.9	554	7.95	1.15	9.14
174	28.9	556	7.98	1.15	9.17
175	28.3	496	7.00	1.15	8.05
176	28.9	477	6.84	1.15	7.87
177	28.3	485	6.81	1.15	7.84
178	28.3	476	6.72	1.15	7.72
179	28.9	514	7.38	1.15	8.48
180	27.8	512	7.16	1.15	8.26
181	28.3	502	7.08	1.15	8.14
182	28.9	553	7.91	1.15	9.11
183	28.9	528	7.72	1.15	8.88
184	28.9	536	7.98	1.15	9.17
185	28.3	531	7.07	1.15	8.13
186	28.3	625	8.82	1.15	10.14
187	28.9	521	7.48	1.15	8.60
188	28.3	464	6.58	1.15	7.57
189	27.8	440	6.10	1.15	7.02
190	28.9	557	7.99	1.15	9.19
191	28.3	553	7.80	1.15	8.97
192	28.9	529	7.59	1.15	8.72
193	27.2	12	6.28	1.15	7.24
194	27.8	506	7.02	1.15	8.07
195	27.2	350	4.77	1.15	5.48
196	27.2	317	4.32	1.15	4.97

Appendix A (continued)

Julian Date	Mean Temp. (C)	Solar Radiation (langleys)	ETo (mm/day)	Kc	ET (mm/day)
197	27.9	502	6.96	1.10	7.66
198	28.3	522	7.36	1.10	8.10
199	27.8	512	7.10	1.10	7.81
200	27.8	534	7.40	1.10	8.15
201	28.9	562	8.06	1.10	8.87
202	27.8	560	7.77	1.10	8.54
203	27.8	508	7.04	1.10	7.75
204	27.8	557	7.72	1.10	8.50
205	28.3	575	8.11	1.10	8.92
206	28.3	551	7.77	1.10	8.55
207	28.9	570	8.18	1.10	9.00
208	28.3	572	8.07	1.10	8.88
209	28.3	532	7.51	1.10	8.26
210	28.3	567	8.00	1.10	8.80
211	27.2	502	6.84	1.10	7.52
212	26.1	240	3.15	1.10	3.47
213	27.2	579	7.89	1.10	8.68
214	27.8	517	7.17	1.10	7.89
215	27.8	418	5.80	1.10	6.38
216	27.2	374	5.10	1.10	5.61
217	27.2	415	5.65	1.10	6.22
218	27.8	505	7.00	1.10	7.70
219	26.7	448	6.00	1.10	6.60
220	26.7	388	5.19	1.10	5.71
221	26.1	350	4.60	1.10	5.06
222	27.2	448	6.10	1.10	6.71
223	27.2	471	6.42	1.10	7.06
224	27.8	503	6.97	1.10	7.67
225	27.2	522	7.11	1.10	7.82
226	27.8	524	7.27	1.10	7.99
227	28.9	578	8.29	1.10	9.12
228	28.9	541	7.76	1.00	7.76
229	27.8	572	7.93	1.00	7.93
230	28.3	557	7.86	1.00	7.86
231	28.9	564	8.09	1.00	8.09
232	28.9	584	8.38	1.00	8.38
233	29.4	580	8.46	1.00	8.46
234	28.3	496	7.00	1.00	7.00
235	28.3	546	7.70	1.00	7.70
236	27.8	503	6.97	1.00	6.97
237	27.8	600	8.32	1.00	8.32
238	27.8	561	7.88	1.00	7.88
239	27.8	408	5.66	1.00	5.66
240	28.3	576	8.13	1.00	8.13
241	28.3	566	7.99	1.00	7.99
242	27.8	552	7.65	1.00	7.65
243	28.3	534	7.53	1.00	7.53
244	27.8	545	7.56	1.00	7.56

Appendix A (continued)

Julian Date	Mean Temp. (C)	Solar Radiation (langleys)	ETo (mm/day)	Kc	ET (mm/day)
245	28.3	535	7.55	1.00	7.55
246	28.9	541	7.76	1.00	7.76
247	28.3	572	8.07	1.00	8.07
248	28.3	472	6.66	1.00	6.66
249	27.8	367	5.09	1.00	5.09
250	28.3	507	7.15	1.00	7.15
251	28.3	498	7.03	1.00	7.03
252	28.3	499	7.04	1.00	7.04
253	28.3	521	7.35	1.00	7.35
254	28.9	540	7.75	1.00	7.75
255	28.9	557	7.99	1.00	7.99
256	28.9	504	7.23	1.00	7.23
257	27.2	409	5.57	1.00	5.57
258	27.2	368	5.01	1.00	5.01
259	26.7	412	5.51	1.00	5.51
260	27.8	434	6.02	1.00	6.02
261	27.8	461	6.39	1.00	6.39
262	28.3	575	8.11	1.00	8.11
263	28.9	576	8.26	1.00	8.26
264	28.3	450	6.35	1.00	6.35
265	28.3	530	7.48	1.00	7.48
266	28.9	546	7.83	1.00	7.83
267	28.3	508	7.17	1.00	7.17
268	28.3	470	6.63	1.00	6.63
269	28.9	478	6.86	1.00	6.86
270	30.0	563	8.35	1.00	8.35
271	29.4	567	8.27	1.00	8.27

APPENDIX B

PRESENTATION OF REDUCED DATA FOR MINNERIYA SCHEME (1986 YALA)

Location	Area (acres)	Distance (ft)	Daily Supply Rates Average (mm/day)	Daily Supply Rates Std. Dev. (mm/day)	Daily Supply Rates C.V.	Weekly Supply Rates Average (mm/day)	Weekly Supply Rates Std. Dev. (mm/day)	Weekly Supply Rates C.V.
Sluice	26597	0	7.113	1.359	0.191	7.264	0.810	0.111
MC Ds/D5	11829	5450	11.988	1.636	0.136	12.133	0.884	0.073
MC Ds/D22	6601	39560	14.363	3.688	0.257	14.460	2.347	0.162
MC DS/D31	1452	57900	20.812	10.928	0.525	21.180	3.819	0.180
D2	10	800	67.989	26.509	0.390	69.644	10.618	0.152
D3	70	1400	22.358	13.002	0.582	22.600	4.970	0.220
D4	25	3800	12.635	4.267	0.338	12.724	3.166	0.249
D5	7	5200	16.927	7.210	0.426	16.866	5.790	0.343
D6	65	6480	30.280	16.174	0.534	29.889	4.886	0.163
D7	34	7480	24.760	15.775	0.637	25.304	5.296	0.209
D8	93	8480	16.686	11.213	0.672	17.115	3.786	0.221
D9	50	11160	22.373	10.180	0.455	23.179	6.944	0.300
D10	13	15060	24.501	13.636	0.557	25.048	7.111	0.284
D11	24	21420	10.726	6.561	0.612	11.650	2.358	0.202
D12	50	23320	12.144	4.714	0.388	12.211	1.929	0.158
D13	456	24820	16.704	12.162	0.728	16.577	2.162	0.130
D14	46	26020	3.341	9.634	2.884	3.319	3.234	0.975
D15	36	27300	35.621	21.467	0.603	36.118	7.292	0.202
D16	182	28500	9.760	4.564	0.468	9.987	1.692	0.169
D17	107	30700	13.767	11.966	0.869	14.046	7.843	0.558
D19	12	36680	10.306	3.908	0.379	10.460	2.486	0.238
D20	23	37710	20.761	16.958	0.817	21.436	5.779	0.270
D21	2948	37825	12.515	6.727	0.538	12.808	2.131	0.166
D22	1100	39360	21.348	16.617	0.778	21.992	3.936	0.179
D23	52	40760	26.196	8.424	0.322	27.568	6.590	0.239
D24	80	44240	18.002	10.928	0.607	18.691	3.733	0.200
D25	12	44440	125.860	110.002	0.874	129.034	14.307	0.111
D27	27	48020	5.713	8.371	1.465	5.361	3.757	0.701
D28	3367	49320	13.243	8.030	0.606	13.508	2.171	0.161
D29	62	51600	38.653	30.303	0.784	38.390	8.753	0.228
D30	119	55000	18.928	17.045	0.901	18.872	4.641	0.246
D31	1431	57800	10.520	10.705	1.018	10.803	4.751	0.440
D31A	247	58080	13.363	8.295	0.621	13.389	2.682	0.200
D33	34	67610	23.909	18.346	0.767	23.372	8.205	0.351
D34	30	70540	13.862	8.660	0.625	14.311	4.469	0.312
D36	14	75480	65.212	46.026	0.706	65.409	18.517	0.283
D36A	31	76570	3.807	3.117	0.819	3.669	1.442	0.393
D37	925	76620	5.652	3.895	0.689	5.693	2.032	0.357
RB1 of D2	160	50420	13.159	12.073	0.918	13.378	2.745	0.205
RB1 of D8	20	8685	22.683	19.354	0.853	22.856	9.778	0.428
LB3 of D8	15	9070	26.986	18.783	0.696	26.765	9.759	0.365
LB5 of D8	20	9962	13.365	11.076	0.829	12.960	5.847	0.451
End of D8	20	10262	5.449	6.799	1.248	6.323	5.560	0.879
LB-1 / D8	5	8540	16.988	17.512	1.031	16.295	6.946	0.426
LB-2 / D8	10	8601	6.606	5.663	0.857	6.486	3.786	0.584
RB-2 / D8	3	8695	11.079	19.904	1.796	10.523	9.492	0.902

APPENDIX C

REGRESSION ANALYSIS OF MINNERIYA DATA FOR 1986 YALA

Weekly Average Supply vs Distance

Regression Output:

Constant	19.537
Std Err of Y Est	21.144
R Squared	0.003
No. of Observations	46.000
Degrees of Freedom	44.000
X Coefficient(s)	0.000
Std Err of Coef.	0.000

Regression Model:

Weekly Average Supply =
(X Coeff.) * Distance + Constant

This is a linear model only

Weekly Coeff. Variation vs Distance

Regression Output:

Constant	0.335
Std Err of Y Est	0.210
R Squared	0.007
No. of Observations	46.000
Degrees of Freedom	44.000
X Coefficient(s)	-0.000
Std Err of Coef.	0.000

Regression Model:

Weekly Coeff. Variation =
(X Coeff.) * Distance + Constant

This is a linear model only

Daily Coeff. Variation vs Distance

Regression Output:

Constant	0.692
Std Err of Y Est	0.450
R Squared	0.005
No. of Observations	46.000
Degrees of Freedom	44.000
X Coefficient(s)	0.000
Std Err of Coef.	0.000

Regression Model:

Daily Coeff. Variation =
(X Coeff.) * Distance + Constant

This is a linear model only

Weekly Std. Dev. of Supply vs Distance

Regression Output:

Constant	5.146
Std Err of Y Est	3.584
R Squared	0.000
No. of Observations	46.000
Degrees of Freedom	44.000
X Coefficient(s)	0.000
Std Err of Coef.	0.000

Regression Model:

Weekly Standard Dev. of Supply =
(X Coeff.) * Distance + Constant

This is a linear model only

APPENDIX D

WATER DELIVERY MEASUREMENT SITES FOR THE DIAGNOSTIC ANALYSIS OF MINNERIYA SCHEME, 1986 YALA

Site Number	Flume Numbers	Site Location	Command Area (acre) Rice	Other
1	1	Head of farm channel LB2, canal D-13	11.67	0.00
2	2	Head of farm channel RB4, canal D-13	26.24	1.08
3	3	Allotment A, farm channel RB4, canal D-13	3.96	0.46
4	4	Allotment B, farm channel RB4, canal D-13	5.58	0.00
5	5	Allotment C, farm channel RB4, canal D-13	5.68	0.62
6	(6A+6B)	Head of farm channel LB8, canal D-13	25.04	1.88
7	7	Allotment A2, farm channel LB8, canal D-13	2.17	0.70
8	8	Head of farm channel RB10, canal D-13	15.33	1.45
9	9	Allotment C, farm channel RB10, canal D-13	4.67	0.00
10	10	Allotment B1, farm channel RB10, canal D-13	4.48	0.00
11	(11A+11B+13)	Head of farm channel RB2, canal D-21	25.96	1.28
12	12	Allotment 44/7, farm channel RB2, canal D-21	4.46	0.56
13	13	Allotment 59/7, farm channel RB2, canal D-21	3.68	0.00
14	14	Allotment 61/7, farm channel RB2, canal D-21	3.28	0.00
15	15	Allotment 145/1, farm channel LB2, canal D-21	1.52	1.04
16	16	Allotment 145/2, farm channel LB2, canal D-21	2.08	0.00
17	18	Allotment 88, farm channel LP04, canal D-21	3.60	0.88
18	19	Allotment 87, farm channel LP04, canal D-21	3.20	0.40
19	21	Head of farm channel LP014, canal D-21	16.56	0.00
20	22	Head of farm channel LP016, canal D-21	32.40	0.00
21	23	Allotment 1066, farm channel LP016, canal D-21	4.24	0.00
22	24	Allotment 801, farm channel RP017, canal D-21	6.00	0.00
23	27	Allotments 1136 & 1139, farm channel LP022. canal D-21	9.12	0.00
24	32	Allotment 30, farm channel RB1/FC1, canal D-28	4.32	0.31
25	33	Allotment 28, farm channel RB1/FC1, canal D-28	5.79	0.00
26	34	Head of farm channel RB1/FC3, canal D-28	6.91	0.96
27	(35A+35B)	Head of farm channel RB1/FC5, canal D-28	28.49	6.34
28	36	Allotment 22, farm channel RB1/FC5, canal D-28	5.56	0.37
29	37	Allotment 18, farm channel RB1/FC5, canal D-28	3.31	1.95
30	38	Head of farm channel RB1/END, canal D-28	12.35	0.00
31	39	Allotment 9, farm channel RB1/END, canal D-28	5.60	0.00
32	40	Allotment 8, farm channel RB1/END, canal D-28	6.75	0.00
33	41	Head of farm channel LB9/FC1, canal D-28	14.33	1.92
34	42	Allotments 112 & 113, farm channel LB9/FC1, canal D-28	9.98	1.92
35	43	Allotment 111, farm channel LB9/FC1	5.35	0.00
36	44	Head of farm channel LB9/FC2, canal D-28	10.01	0.38
37	45	Head of farm channel LB9/FC3, canal D-28	9.05	1.92
38	(45-46)	Allotment 72, farm channel LB9/FC3, canal D-28	4.94	0.69
39	46	Allotment 73, farm channel LB9/FC3, canal D-28	4.11	1.23
40	47	Head of farm channel LB9/FC4, canal D-28	23.52	1.92
41	48	Allotment 76, farm channel LB9/FC4, canal D-28	3.98	0.00
42	51	Head of farm channel FC1, canal D-37	10.83	0.00
43	(51-52)	Allotment 696, farm channel FC1, canal D-37	3.70	0.00
44	(53-54)	Head of farm channel FC2, canal D-37	13.03	0.00
45	55	Head of farm channel FC3, canal D-37	14.43	0.00
46	56	Allotment 692, farm channel FC3, canal D-37	5.80	0.00
47	57	Head of farm channel FC4, canal D-37	15.43	1.20

APPENDIX E

RAINFALL RECORDED IN MINNERIYA SCHEME, 1986 YALA

Date	Julian Day	Rainfall (mm)	Date	Julian Day	Rainfall (mm)	Date	Julian Day	Rainfall (mm)
April 18	108	10.7		156	0.0		204	0.0
	109	0.0		157	0.0		205	0.0
	110	0.0		158	0.0		206	0.0
	111	0.0		159	0.0		207	0.0
	112	0.0	June 9	160	17.8		208	0.0
	113	0.0		161	0.0		209	0.0
	114	0.0		162	0.0		210	0.0
April 25	115	24.9		163	0.0		211	0.0
	116	0.0		164	0.0		212	0.0
	117	0.0		165	0.0	August 1	213	4.6
	118	0.0		166	0.0		214	0.0
April 29	119	4.1		167	0.0		215	0.0
	120	0.0		168	0.0		216	0.0
	121	0.0		169	0.0		217	0.0
	122	0.0		170	0.0		218	0.0
May 3	123	6.6		171	0.0		219	0.0
May 4	124	1.0		172	0.0		220	0.0
	125	0.0		173	0.0		221	0.0
	126	0.0		174	0.0		222	0.0
	127	0.0		175	0.0		223	0.0
	128	0.0		176	0.0		224	0.0
	129	0.0		177	0.0		225	0.0
	130	0.0		178	0.0		226	0.0
	131	0.0		179	0.0		227	0.0
	132	0.0		180	0.0		228	0.0
	133	0.0		181	0.0		229	0.0
	134	0.0		182	0.0		230	0.0
	135	0.0		183	0.0		231	0.0
	136	0.0		184	0.0		232	0.0
	137	0.0		185	0.0		233	0.0
	138	0.0		186	0.0		234	0.0
	139	0.0		187	0.0	August 23	235	40.6
	140	0.0		188	0.0		236	0.0
	141	0.0		189	0.0		237	0.0
	142	0.0		190	0.0		238	0.0
	143	0.0		191	0.0		239	0.0
	144	0.0		192	0.0		240	0.0
	145	0.0		193	0.0		241	0.0
	146	0.0		194	0.0		242	0.0
	147	0.0		195	0.0		243	0.0
	148	0.0		196	0.0			
May 29	149	13.0		197	0.0			
May 30	150	23.6		198	0.0			
	151	0.0		199	0.0			
June 1	152	14.5		200	0.0			
	153	0.0		201	0.0			
	154	0.0		202	0.0			
	155	0.0		203	0.0			

APPENDIX F

SOIL PROFILE DESCRIPTIONS, SOIL LEGEND, AND ENGINEERING AND SOIL SURVEY MAPS OF SELECTED FIELDS IN MINNERIYA SCHEME, 1986 YALA

Soil Profile Description of Reddish-Brown Earth, Well-Drained Soil

Study Site: Kaudulla, Stage II, tract 5, field channel 2, I.M.D. Pit 1; 6/11/86; S.V. Siriwardena. Site was a gently undulating, well-drained home garden with 2-3 percent slope.

Soil Profile:

Ap 0-10 cm. Dark brown (7.5YR 4/4); moist, light sandy clay loam; weak, subangular, blocky; very slightly plastic wet, friable moist; few fine quartz gravel, few manganese stains; common fine and few medium tubular inped pores; common fine and few medium roots; clear, smooth change.

B1 10-40 cm. Strong brown (7.5YR 5/6); moist, sandy clay loam; weak, subangular, blocky; slightly sticky and slightly plastic wet, friable moist; few fine quartz gravel, few manganese stains; common fine, few medium tubular inped pores; common fine and few medium roots; few fine mica and feldspar; very thin patchy clay skins; clear, smooth change.

B2t1 40-55 cm. Reddish-brown (5YR 4/4); moist, gravely sandy clay loam; structureless massive; slightly sticky and non-plastic wet, friable moist; common fine and few medium quartz gravel (30-40 percent); occasional quartz pebbles; few manganese concretions; few fine tubular inped pores; common fine and few medium roots; common fine mica and feldspar; thin patchy clay skins; gradual, smooth change.

B2t2 55-100 cm. Reddish-brown (2.5YR 4/4); moist, gravely sandy clay loam; structureless massive; slightly sticky and non-plastic wet, friable moist; common fine and few medium quartz gravel (about 30-40 percent); occasional quartz pebbles; few manganese concretions; few fine tubular inped pores; common fine and few medium roots; common fine mica and feldspar; thin patchy clay skins; clear, smooth change.

B3 100-120 cm. Red (2.5YR 4/8); moist, sandy clay loam; weak, medium, subangular, blocky; slightly sticky and plastic wet, few fine quartz gravel; few manganese concretions; few fine tubular inped pores; common fine and few medium roots; common fine feldspar and mica; clear, smooth change.

C 120-130 cm. Decomposing parent material mixed with many fine mica and feldspar.

130+ cm. Bedrock.

Soil Profile Description of
Reddish-Brown Earth, Imperfectly Drained Soil

Study Site: Giritale, Purana Ela, Pit 3; 21/10/85; S.V. Siriwardena. Site was nearly level with 0-0.5 percent slope, tobacco.

Soil Profile:

Ap 0-30 cm. Dark greyish-brown (10YR 4/2); moist, sandy clay loam; weak, medium, subangular, blocky; slightly sticky and slightly plastic; wet, friable, moist faint mottles; common fine and few medium roots; common fine and a few medium tubular inped pores; few manganese concretions, few quartz gravel; faunal activity; clear, smooth boundary.

B1 30-75 cm. Dark brown (10YR 4/3); moist, sandy clay loam; moderate, medium, subangular, blocky; slightly sticky and slightly plastic wet, friable moist; common, medium distinct, yellowish-red (5YR 4/6) mottles; common fine and few medium roots; few fine tubular inped pores; many manganese concretions; few fine quartz gravel; occasional quartz pebbles; common fine feldspar; faunal activity; clear, smooth change.

B2 75-120 cm. Greyish-brown (10YR 5/2); moist, sandy clay loam; moderate, medium, subangular, blocky; slightly sticky and slightly plastic wet, friable moist; common, medium distinct, strong brown (7.5YR 5/6) mottles; common fine and occasional medium roots; common manganese concretions (10-20 percent); fine and medium quartz gravel; occasional quartz pebbles; common iron stone gravel; common fine feldspar; faunal activity; clear, smooth change.

B3 120-175 cm. Dark grey (5YR 4/1); moist clay; structureless massive; very sticky and plastic wet, firm moist; common, medium distinct, yellowish-brown (10YR 5/6) mottles; common manganese concretions, fine quartz gravel; thin patchy cutans; gleyed horizon; few carbonate concretions.

Soil Profile Description of
Low Humic Gley, Poorly Drained Soil

Study Site: Giritale, Purana Ela, Pit 2; 21/10/85; S.V. Siriwardena. Site was nearly level, 0-0.5 percent slope, paddy.

Soil Profile:

Ap 0-20 cm. Very dark greyish-brown (2.5Y 3/2); moist sandy clay loam; weak, medium, subangular, blocky; slightly sticky and slightly plastic wet, friable moist; common fine and few medium tubular inped pores; faint mottles; few fine quartz gravel; faunal activity; clear, smooth change.

B1 20-24 cm. Dark greyish-brown (2.5Y 4/2); moist, sandy clay; moderate, subangular, blocky; slightly sticky and slightly plastic wet, friable moist; common fine roots; common fine and few medium tubular inped pores; common, fine, distinct, strong brown (7.5YR 5/6) mottles; few fine quartz gravel; few manganese concretions; faunal activity; clear, smooth change.

B21t 40-70 cm. Olive grey (5Y 4/2); moist, sandy clay; medium, subangular, blocky; sticky and plastic wet, friable moist; few fine roots; common fine tubular inped pores; common, medium distinct, yellowish (10YR 5/8); few fine quartz; common manganese concretions and nodules; faunal activity; gradual, smooth change.

B22t 70-100 cm. Dark grey (5Y 4/1); moist, sandy clay; moderate, medium, subangular blocky; sticky and plastic wet, friable moist; few fine roots; few fine tubular inped pores; common fine distinct yellowish-brown (10YR 5/6) mottles; few manganese concretions; fine quartz gravel; few carbonate concretions; faunal activity; thin patchy cutans; gradual, smooth change.

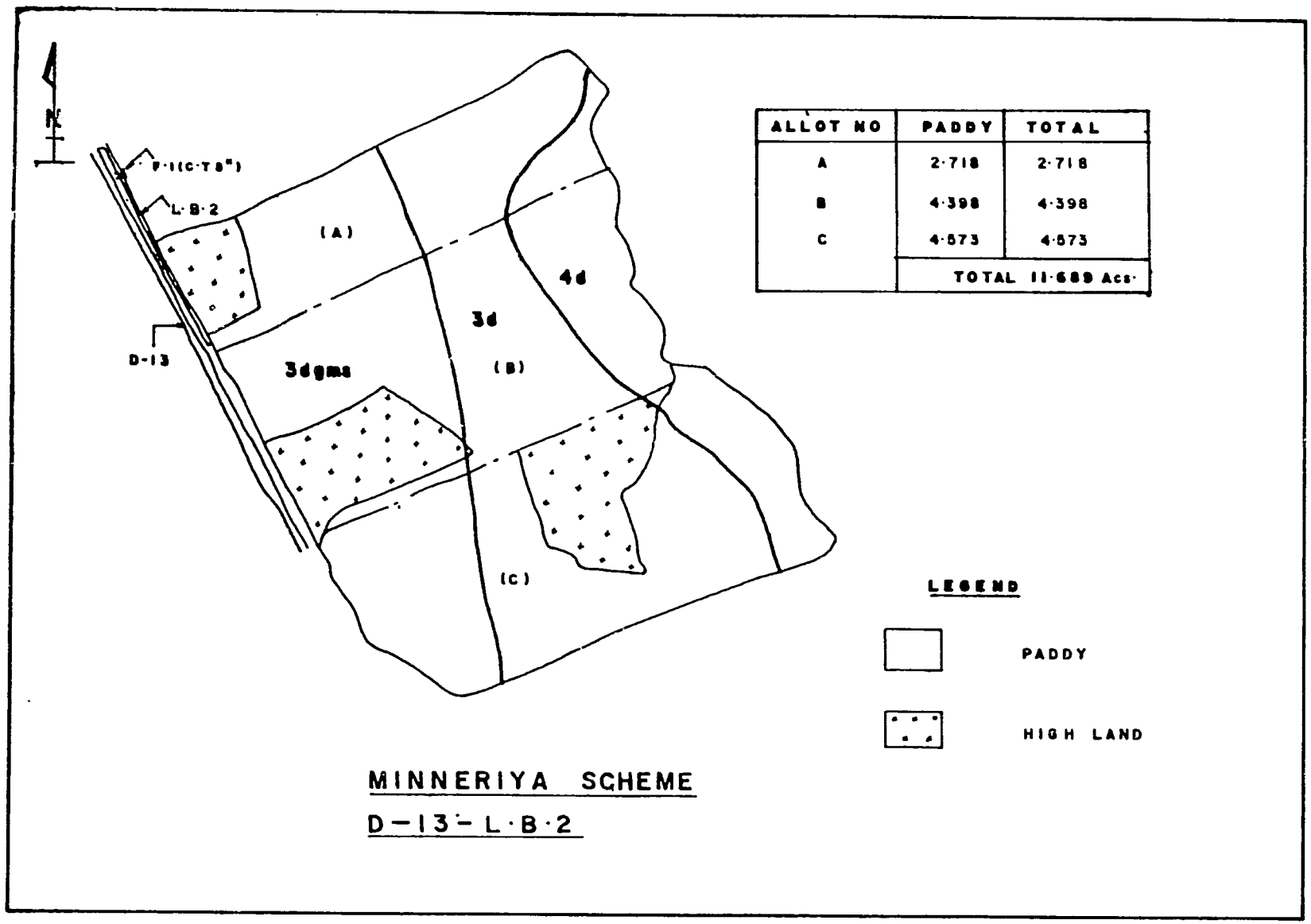
B3 100-150 cm. Grey (5Y 5/1); moist clay; structureless massive; very sticky and very plastic wet, firm moist; few, fine, distinct, strong brown (7.5Y 5/6) mottles; common carbonate concretions; slicken sides; gleyed horizon.

Legend for Engineering and Soil Survey Maps

Physiographic Unit Major	Subunit	Soil Description
Undulating plain	Crest and convex upper slope	1. Reddish-brown earth; well-drained soil. Shallow to deep, brown to dark brown sandy loam to sandy clay loam surface soil with red to dark reddish-brown sandy clay loam to sandy clay subsoil containing quartz (dominant) and feldsphatic gravel and fine mica underlain by reddish or yellowish decomposing material.
	Convex upper slope	2. Reddish-brown earth; moderately well-drained soil. Description same as above.
	Mid-slope to concave lower slope	3. Reddish-brown earth; imperfectly drained soil. Moderately shallow to deep, brown to dark brown sandy loam to sandy clay loam surface soil with yellowish-red to dark yellowish-brown sandy clay loam to sandy clay; mottled subsoil occasionally with quartz and feldsphatic gravel.
Valley bottom of undulating plain	Concave lower slope and depression	4. Low humic gley; poorly drained soil. Deep, brown to gray sandy loam to sandy clay loam surface soil with grayish or bluish sandy clay loam to clay; gleyed subsoil containing carbonate concretion occasionally.
	Depression	5. Low humic gley; very poorly drained soil. Deep, grayish or bluish sandy clay loam to clay; gleyed soil.
Alluvial plain	Depression and flat	6. Alluvial, poorly drained soil. Deep, dark grayish-brown to gray sandy clay loam to clay; gleyed soil.

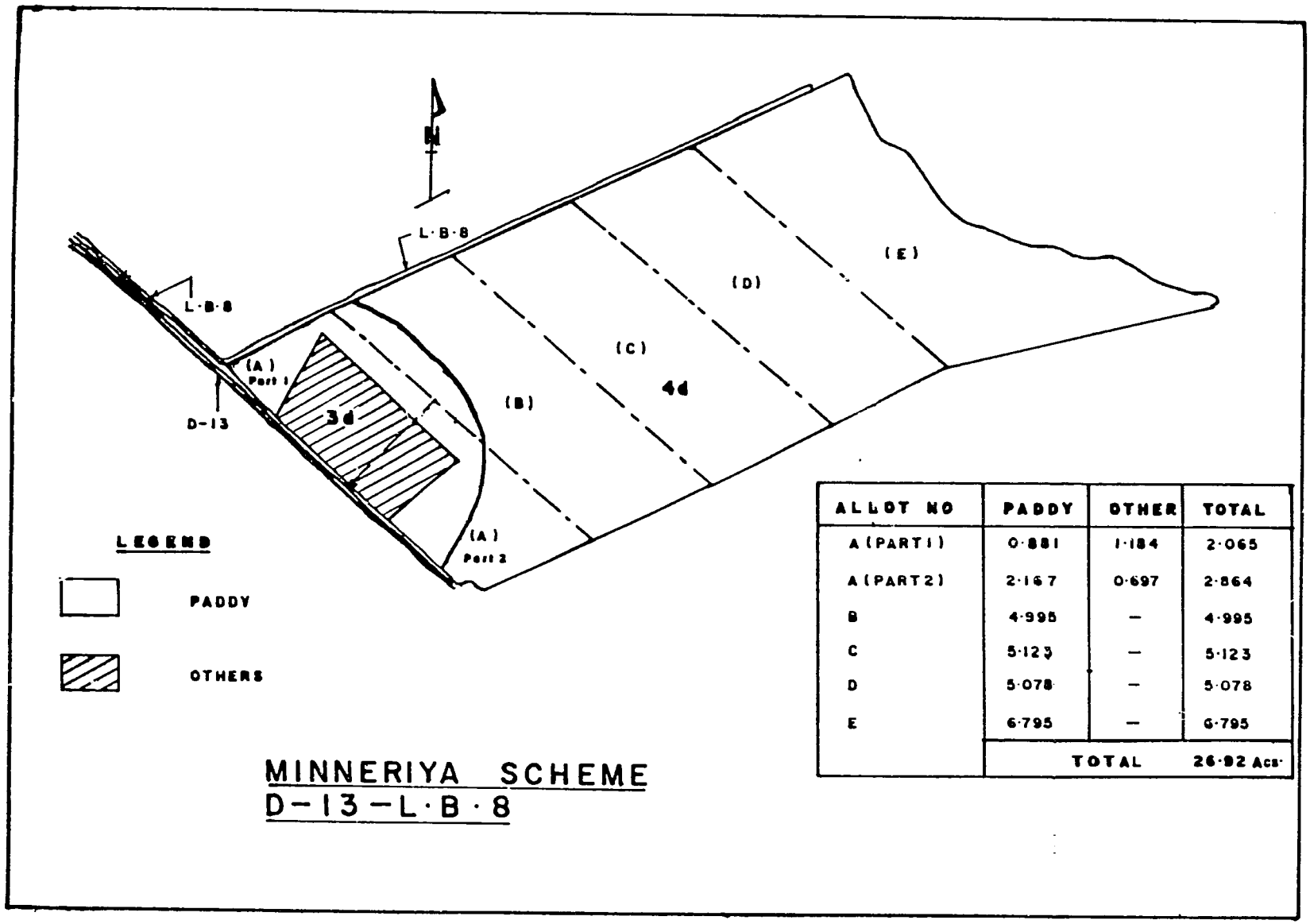
Mapping Units	
< 60 cm	s (shallow)
60 - 90 cm	ms (moderately shallow)
90 - 120 cm	md (moderately deep)
> 120 cm	d (deep)
	g (gravel layer)

Engineering and soil survey map, Minneriya Scheme, 1986 yala.



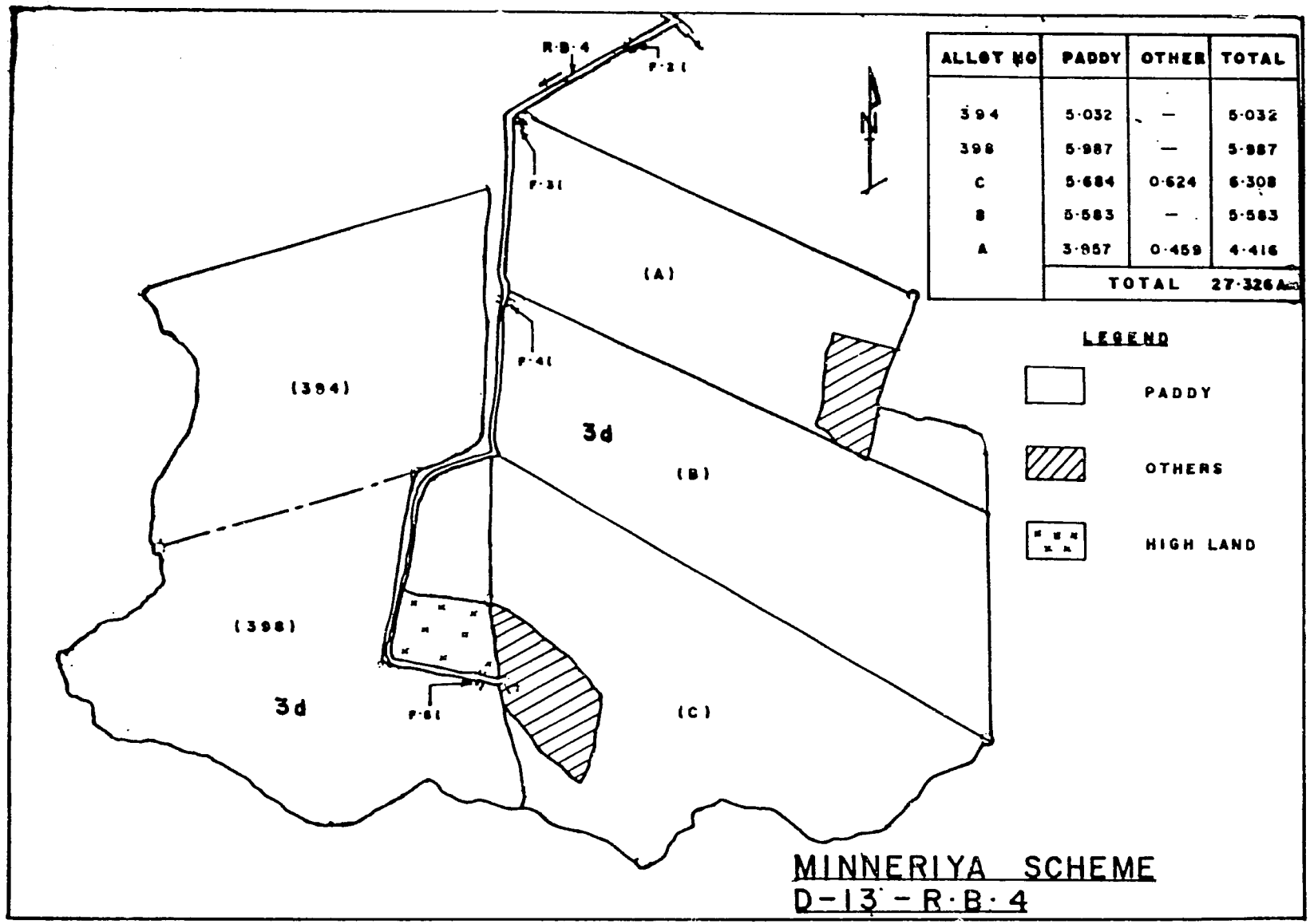
ALLOT NO	PADDY	TOTAL
A	2·718	2·718
B	4·398	4·398
C	4·573	4·573
	TOTAL 11·689 Acs·	

Engineering and soil survey map, Minneriya Scheme, 1986 yala.



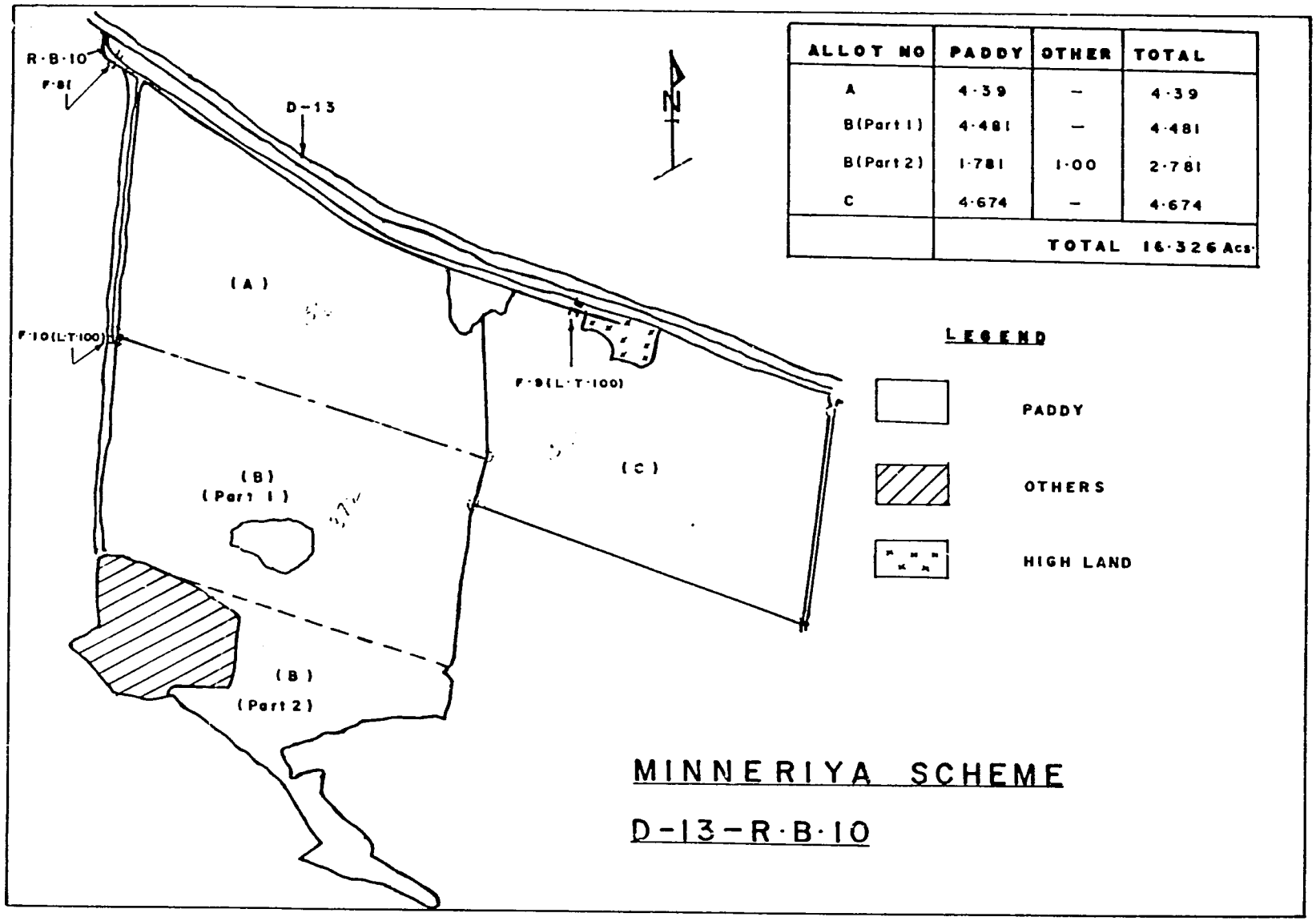
ALLOT NO	PADDY	OTHER	TOTAL
A (PART 1)	0·881	1·184	2·065
A (PART 2)	2·167	0·697	2·864
B	4·995	—	4·995
C	5·123	—	5·123
D	5·078	—	5·078
E	6·795	—	6·795
	TOTAL		26·92 Acs.

Engineering and soil survey map, Minneriya Scheme, 1986 yala.



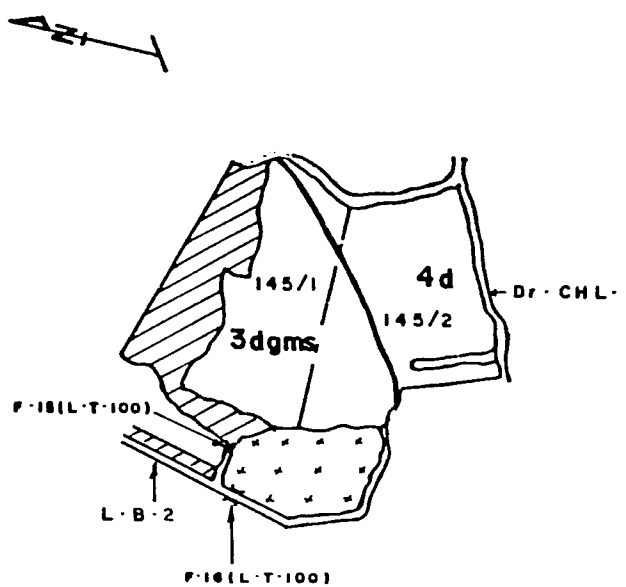
ALLOT NO	PADDY	OTHER	TOTAL
394	5·032	—	5·032
398	5·987	—	5·987
C	5·684	0·624	6·308
B	5·583	—	5·583
A	3·957	0·459	4·416
	TOTAL		27·326 Ac

Engineering and soil survey map, Minneriya Scheme, 1986 vala.



ALLOT NO	PADDY	OTHER	TOTAL
A	4·39	–	4·39
B(Part 1)	4·481	–	4·481
B(Part 2)	1·781	1·00	2·781
C	4·674	–	4·674
	TOTAL		16·326 Acs.

Engineering and soil survey map, Minneriya Scheme, 1986 yala.



ALLOT NO	PADDY	OTHER	TOTAL
145/1	1·52	1·04	2·56
145/2	2·08	–	2·08
	TOTAL 4·64 Acs·		

TOTAL

PADDY

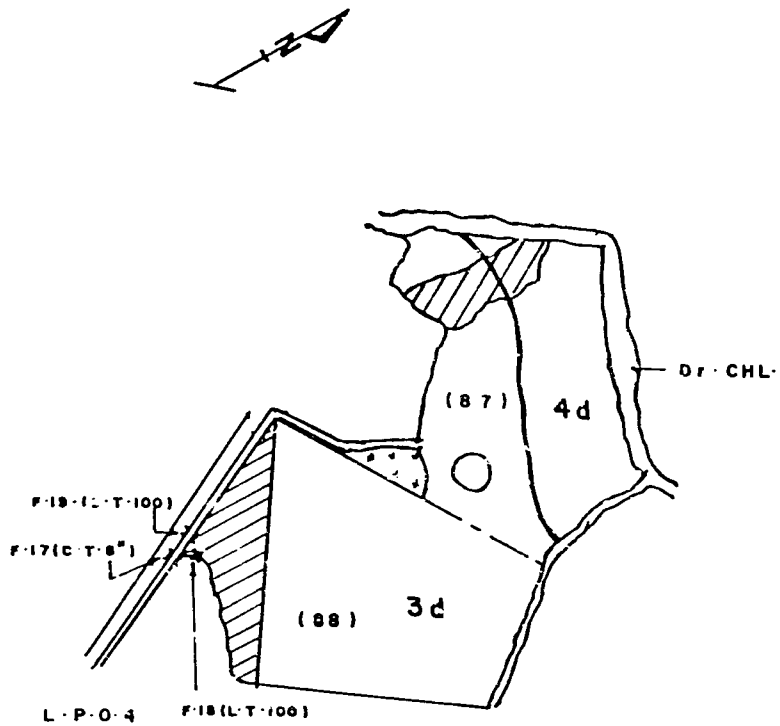
OTHERS

HIGH LAND

MINNERIYA SCHEME

D–21– L·B·2

Engineering and soil survey map, Minneriya Scheme, 1986 yala.



ALLOT NO	PADDY	OTHER	TOTAL
87	3·20	0·40	3·60
88	3·60	0·88	4·48
	TOTAL		8·08 Acs·

LEGEND

PADDY

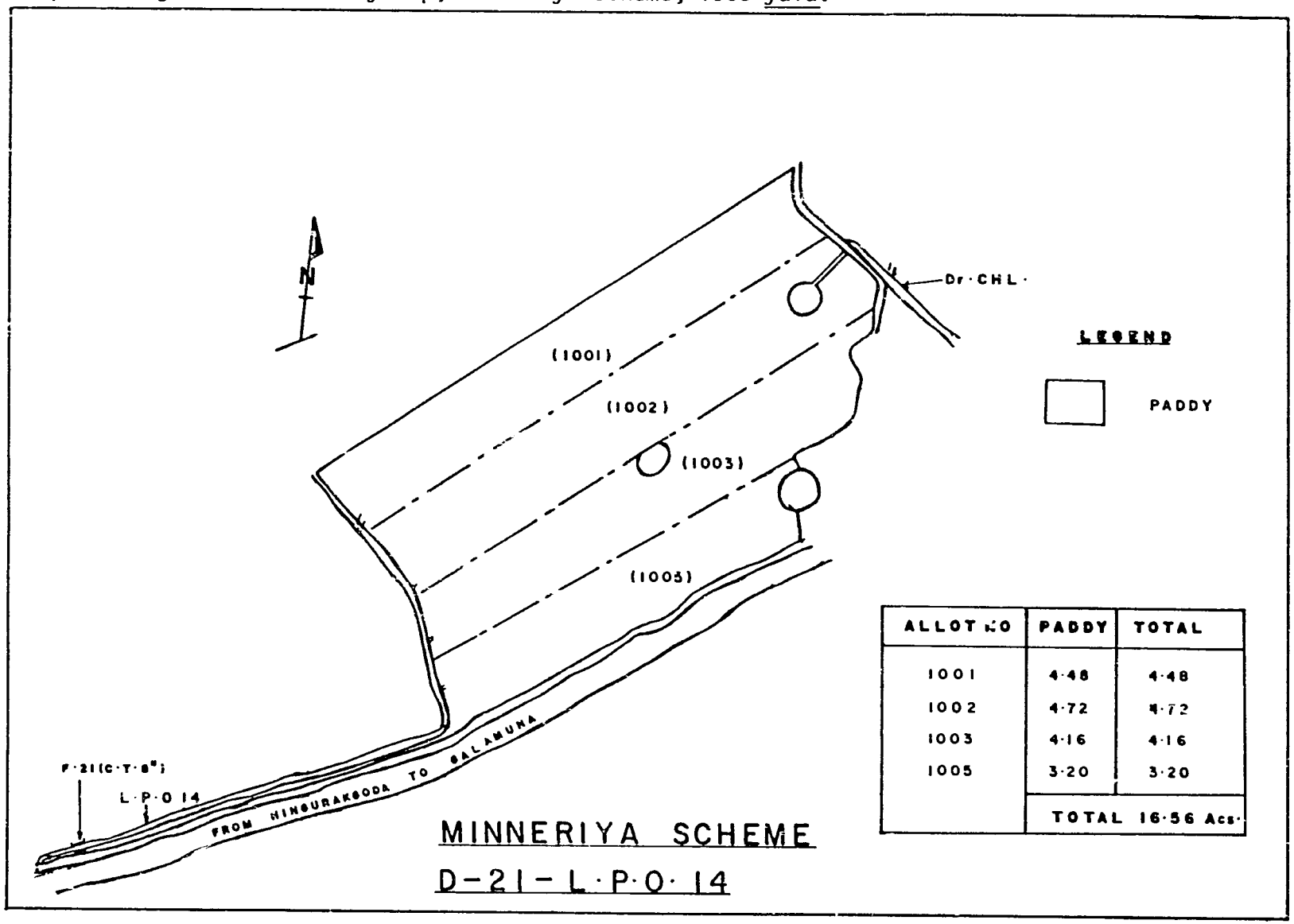
OTHERS

HIGH LAND

MINNERIYA SCHEME

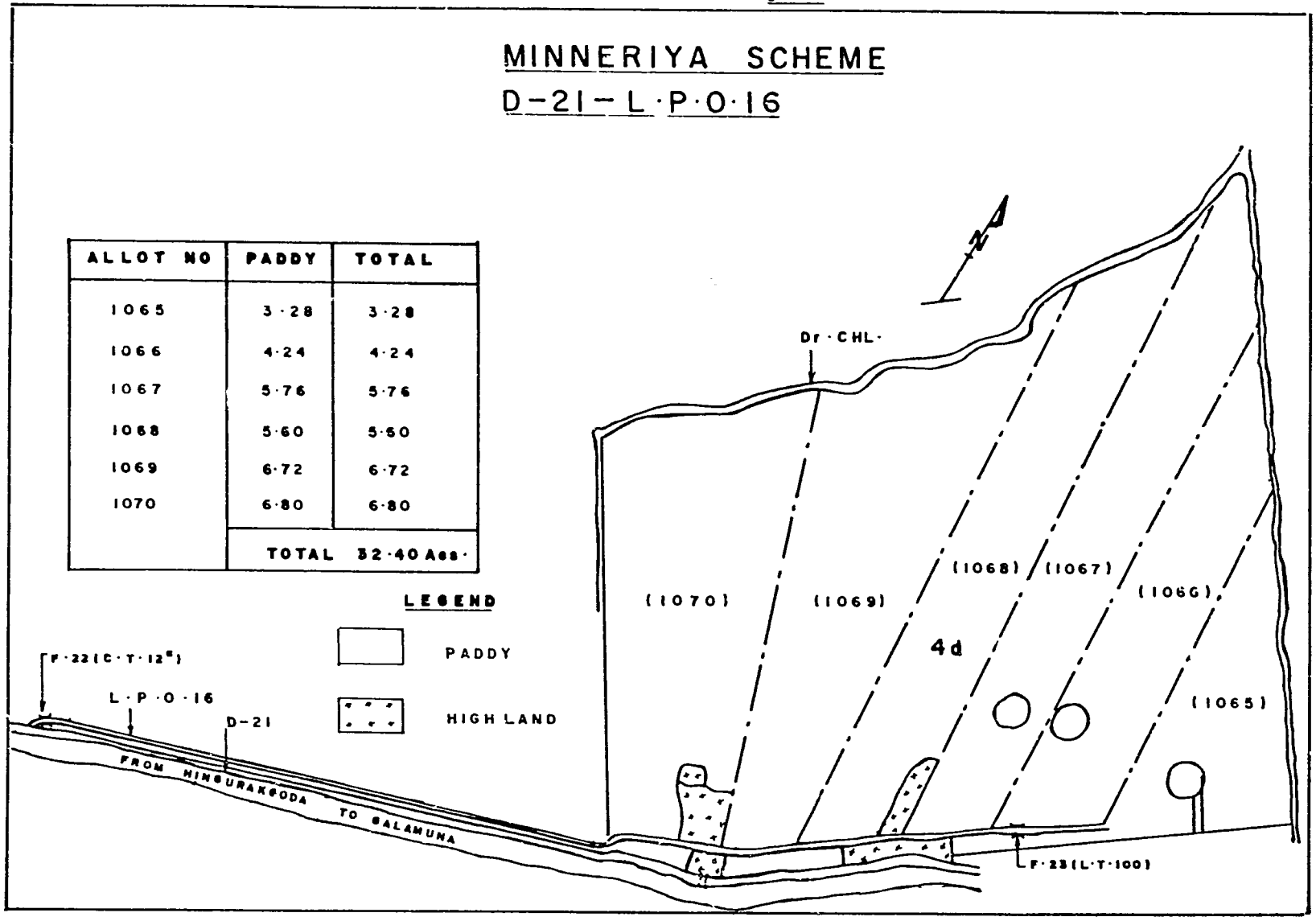
D-21-L·P·O·4

Engineering and soil survey map, Minneriya Scheme, 1986 yala.



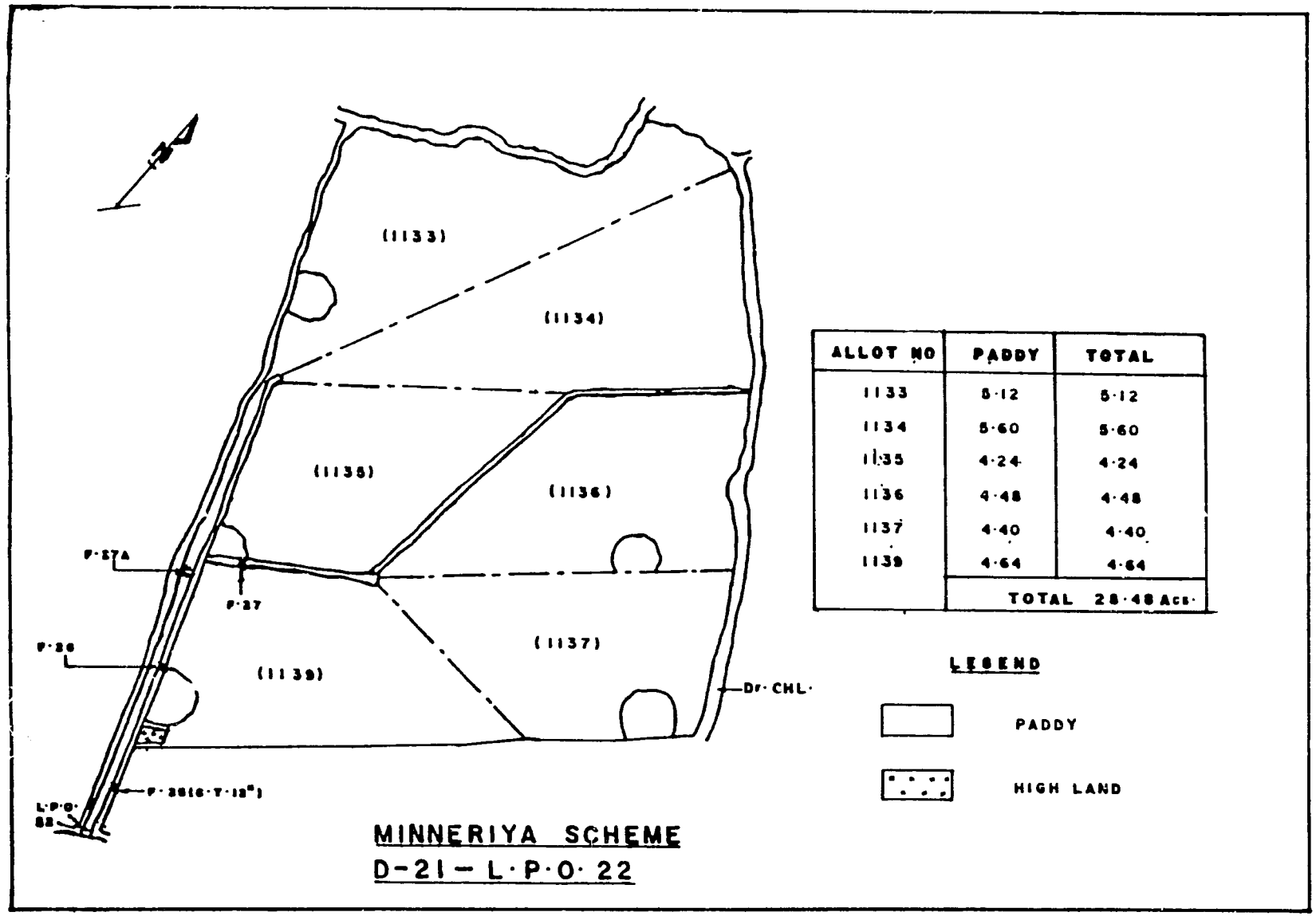
ALLOT NO	PADDY	TOTAL
1001	4·48	4·48
1002	4·72	4·72
1003	4·16	4·16
1005	3·20	3·20
	TOTAL 16·56 Acs·	

Engineering and soil survey map, Minneriya Scheme, 1986 yala.



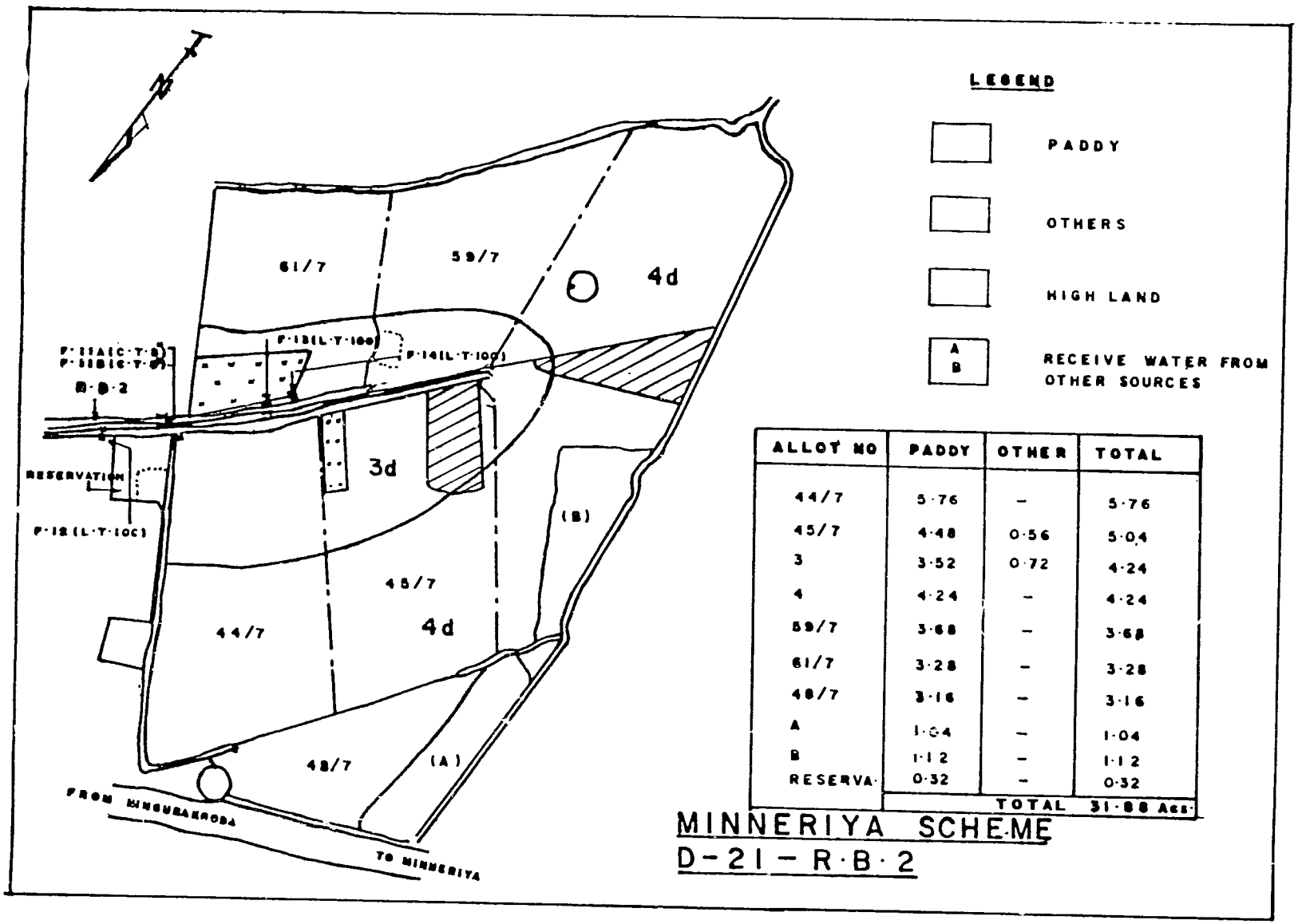
ALLOT NO	PADDY	TOTAL
1065	3·28	3·28
1066	4·24	4·24
1067	5·76	5·76
1068	5·60	5·60
1069	6·72	6·72
1070	6·80	6·80
	TOTAL	32·40 Acs·

Engineering and soil survey map, Minneriya Scheme, 1986 yala.



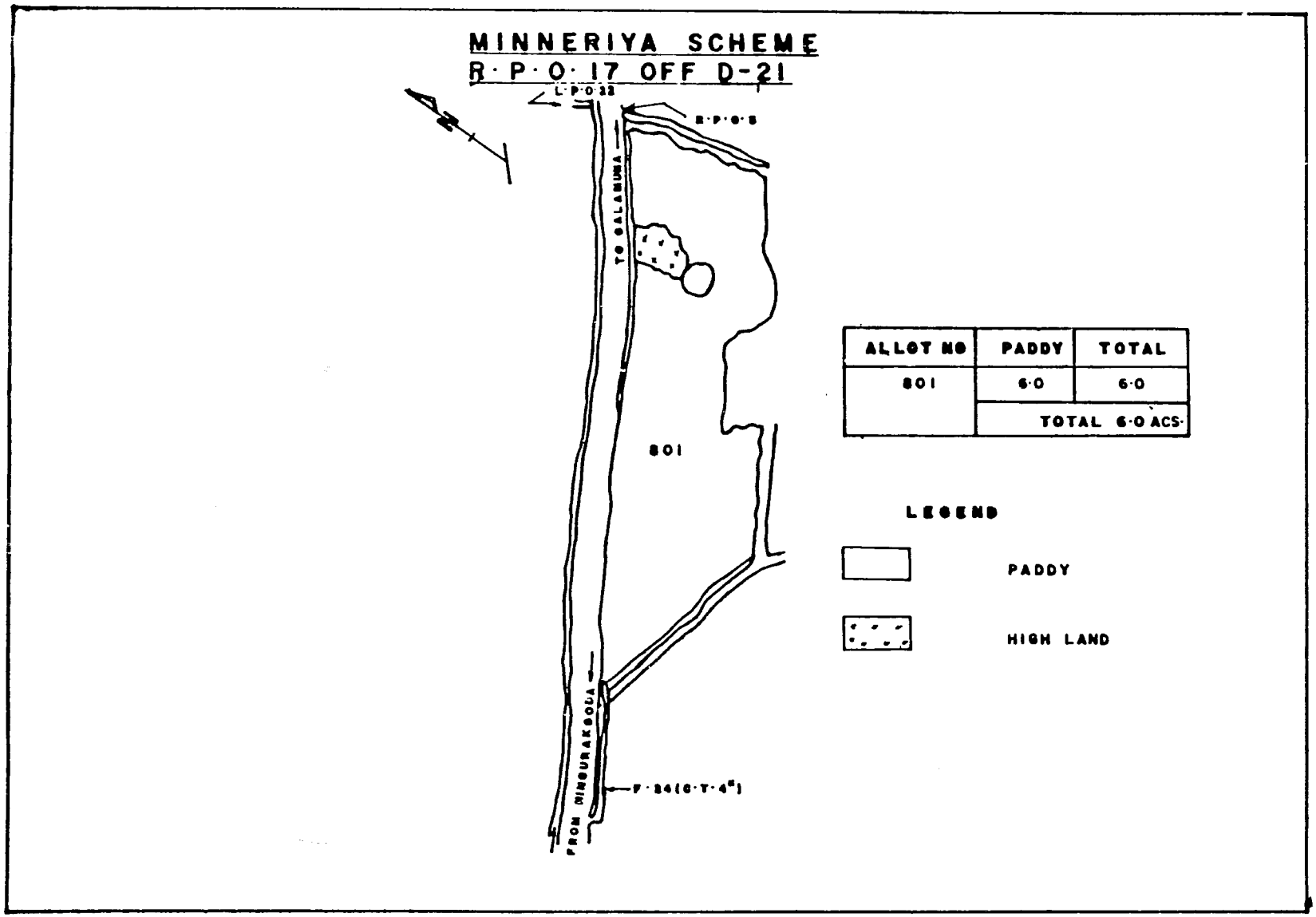
ALLOT NO	PADDY	TOTAL
1133	5·12	5·12
1134	5·60	5·60
1135	4·24	4·24
1136	4·48	4·48
1137	4·40	4·40
1139	4·64	4·64
	TOTAL	28·48 Acs.

Engineering and soil survey map, Minneriya Scheme, 1986 yala.



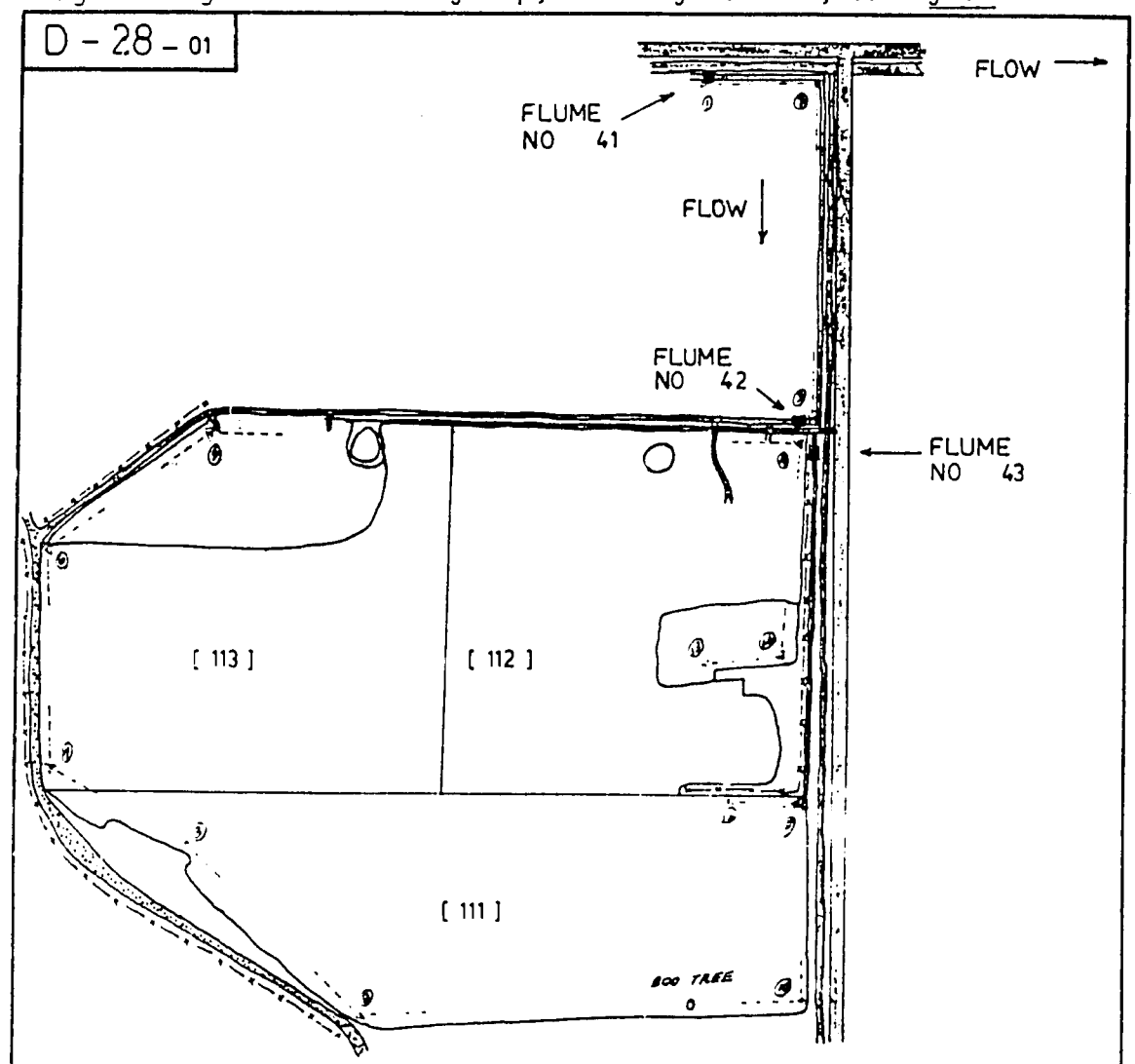
ALLOT NO	PADDY	OTHER	TOTAL
44/7	5·76	–	5·76
45/7	4·48	0·56	5·04
3	3·52	0·72	4·24
4	4·24	–	4·24
59/7	3·68	–	3·68
61/7	3·28	–	3·28
48/7	3·16	–	3·16
A	1·04	–	1·04
B	1·12	–	1·12
RESERVA·	0·32	–	0·32
		TOTAL	31·88 Acs·

Engineering and soil survey map, Minneriya Scheme, 1986 yala.



ALLOT NO	PADDY	TOTAL
801	6·0	6·0
	TOTAL 6·0 ACS·	

Engineering and soil survey Map, Minneriya Scheme, 1986 yala.



ALLOT NO	PADDY	OTHER
111.	5·35. AC	—
112.	4 59 AC	0 41 AC:
113.	4 39 AC	1 51 AC:

FLUME NO	TYPE
41.	C. T. 8"
42.	L. T. 100.
43.	L. T. 100.

	LEDGENE
	PADDY.
	HIGH LAND
	CHANNAL.
	GRAVEL ROAD.
	TARRED ROAD.
	CHILLE.
	DRAINAGE CHANN:

SCALE - 200. FT: TO AN INCH.

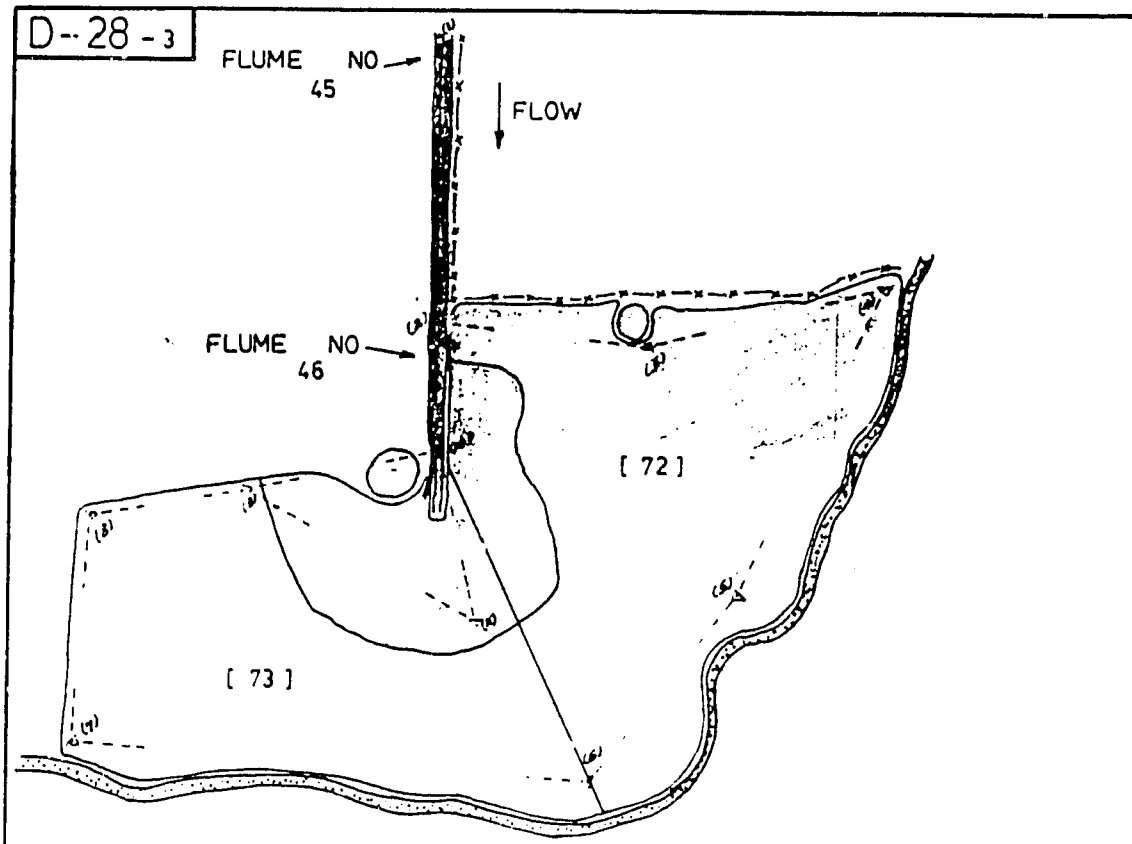
SITE T. A.

M. H. C. K. DE SILVA.

TRASING FLATFORM AREA.	
	0·09 AC:
ROAD AREA:	0·09 AC:

STATION. - MINNERIYA. D - 28. SITE NO - 01.

Engineering and soil survey map, Minneriya Scheme, 1986 yala.



ALLOT NO.	PADDY.	OTHER.
72.	4·94 AC:	0·69 AC:
73.	4·11 AC.	1·23 AC:

FLUME NO.	TYPE.
45.	C. T. 8'
46.	L. T 100.

	LEDGENE.
	PADDY.
	HIGH LAND
	CHANNAL.
	GRAVEL ROAD.
	CHILLE.
	DRAINAGE CHANNAL

SCALE. 200. FT: TO AN INCH.

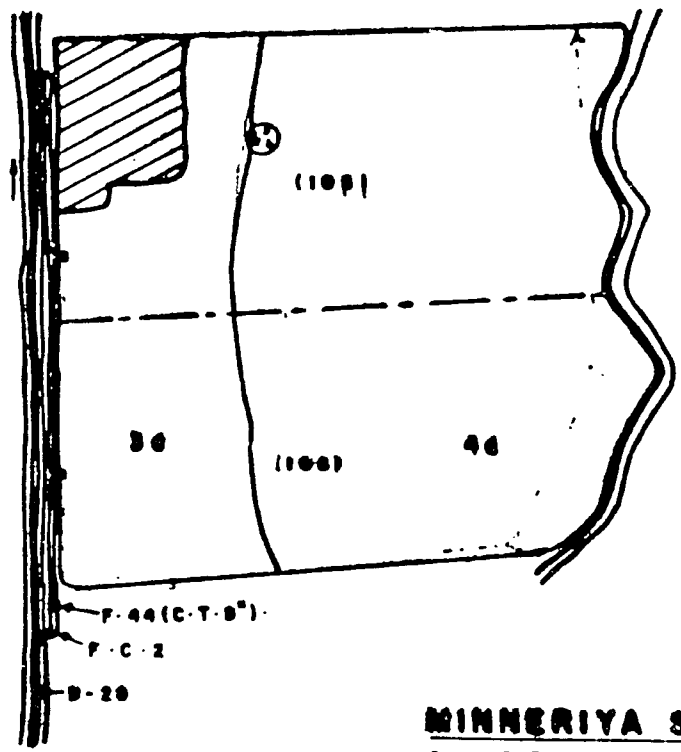
SITE T. A.

M. H C. K. DE SILVA.

TRASING FLATFORM AREA.	0·11 AC:
ROAD AREA.	0·10 AC:

STATION. – MINNERIYA. D – 28. SITE NO – 3.

Engineering and soil survey map, Minneriya Scheme, 1986 yala.



ALLOT NO	PADDY	OTHER	TOTAL
105	4·00	0·28	5·10
106	5·21	-	5·21
		TOTAL	10·39 Acs.

LEGEND

PADDY

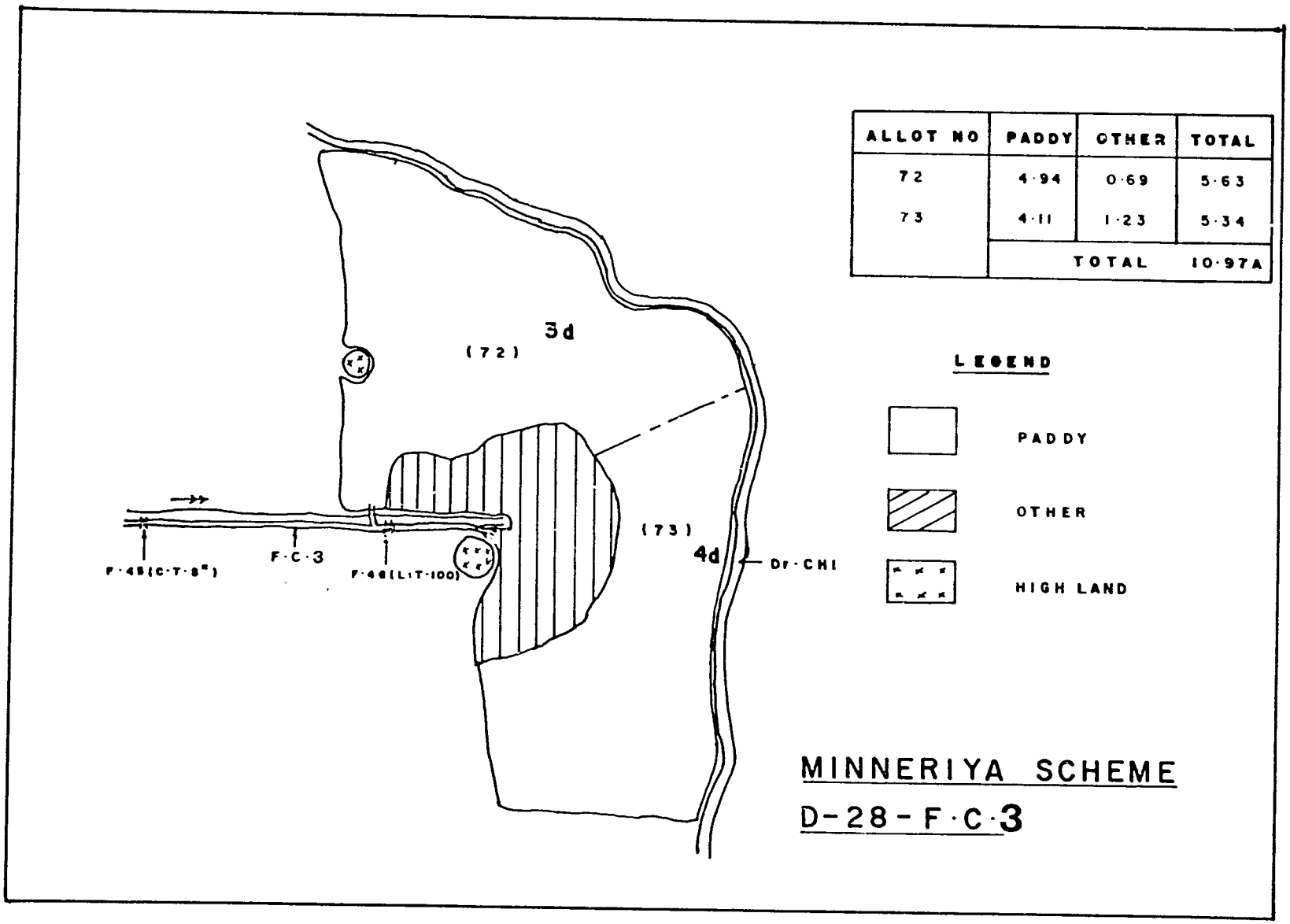
HIGH LAND

OTHERS

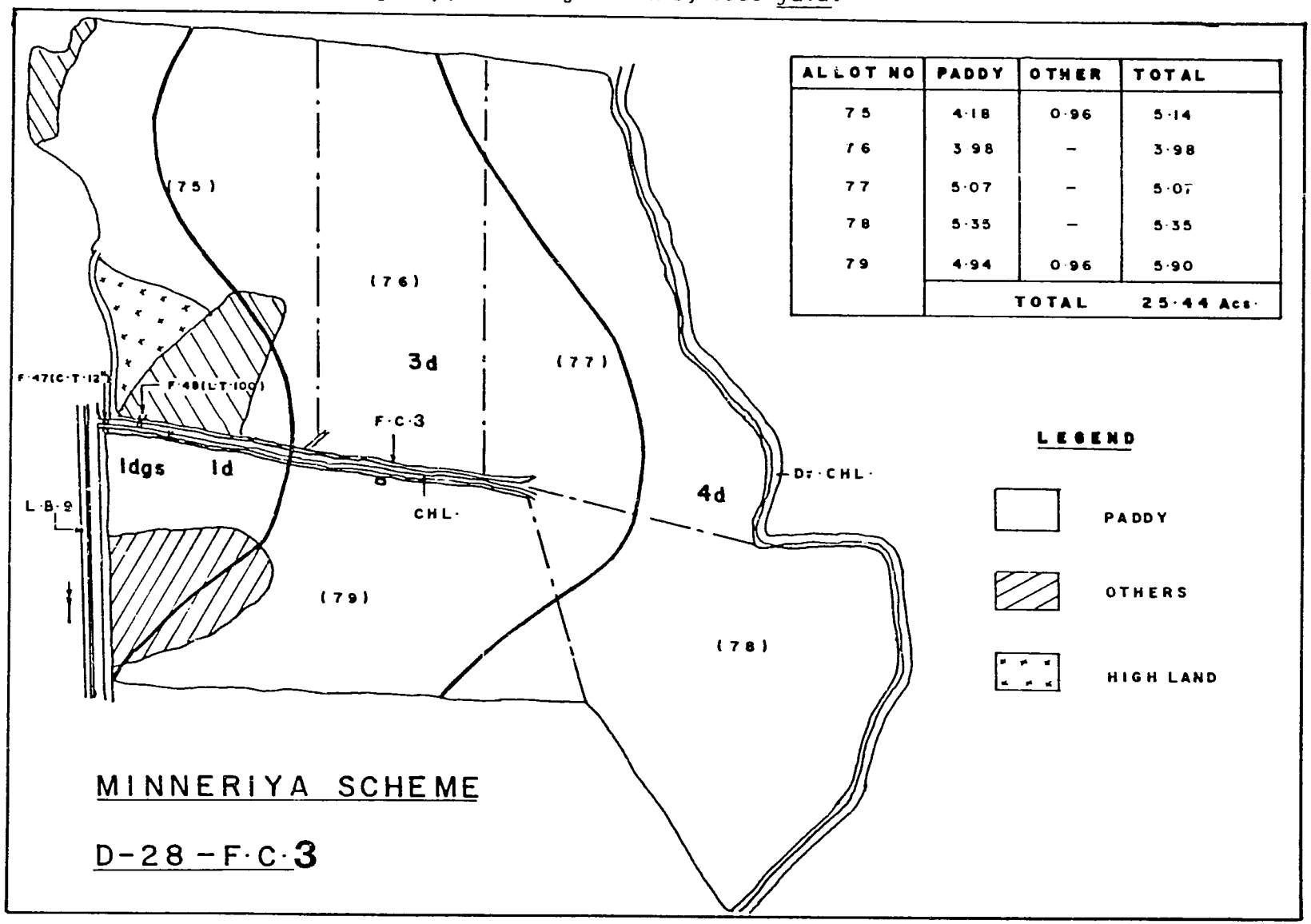
MINNERIYA SCHEME

D-28-FC·2 (LB)

Engineering and soil survey map, Minneriya Scheme, 1986 yala.

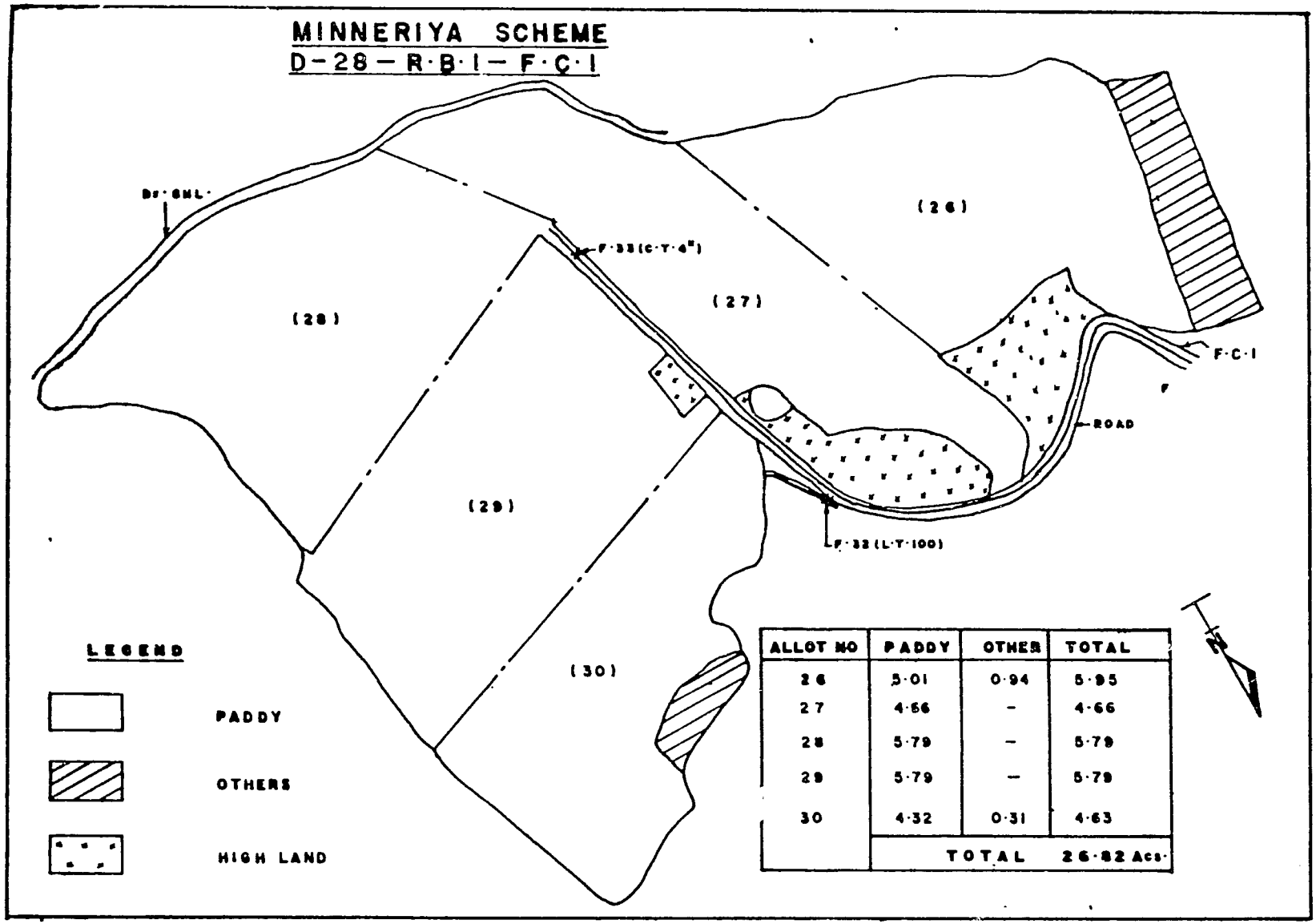


Engineering and soil survey Map, Minneriya Scheme, 1986 yala.



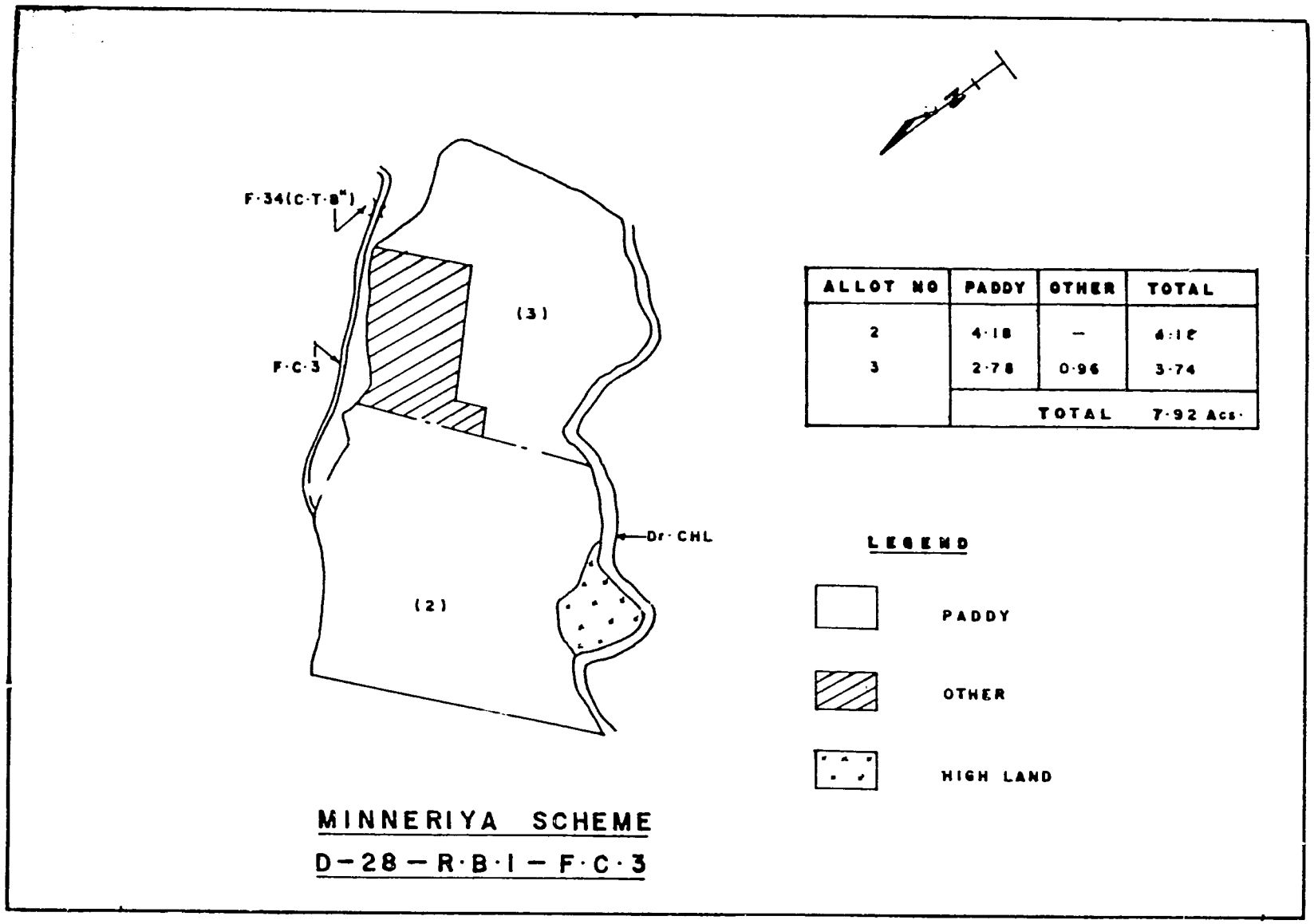
ALLOT NO	PADDY	OTHER	TOTAL
75	4·18	0·96	5·14
76	3·98	–	3·98
77	5·07	–	5·07
78	5·35	–	5·35
79	4·94	0·96	5·90
	TOTAL		25·44 Acs·

Engineering and soil survey map, Minneriya Scheme, 1986 yala.



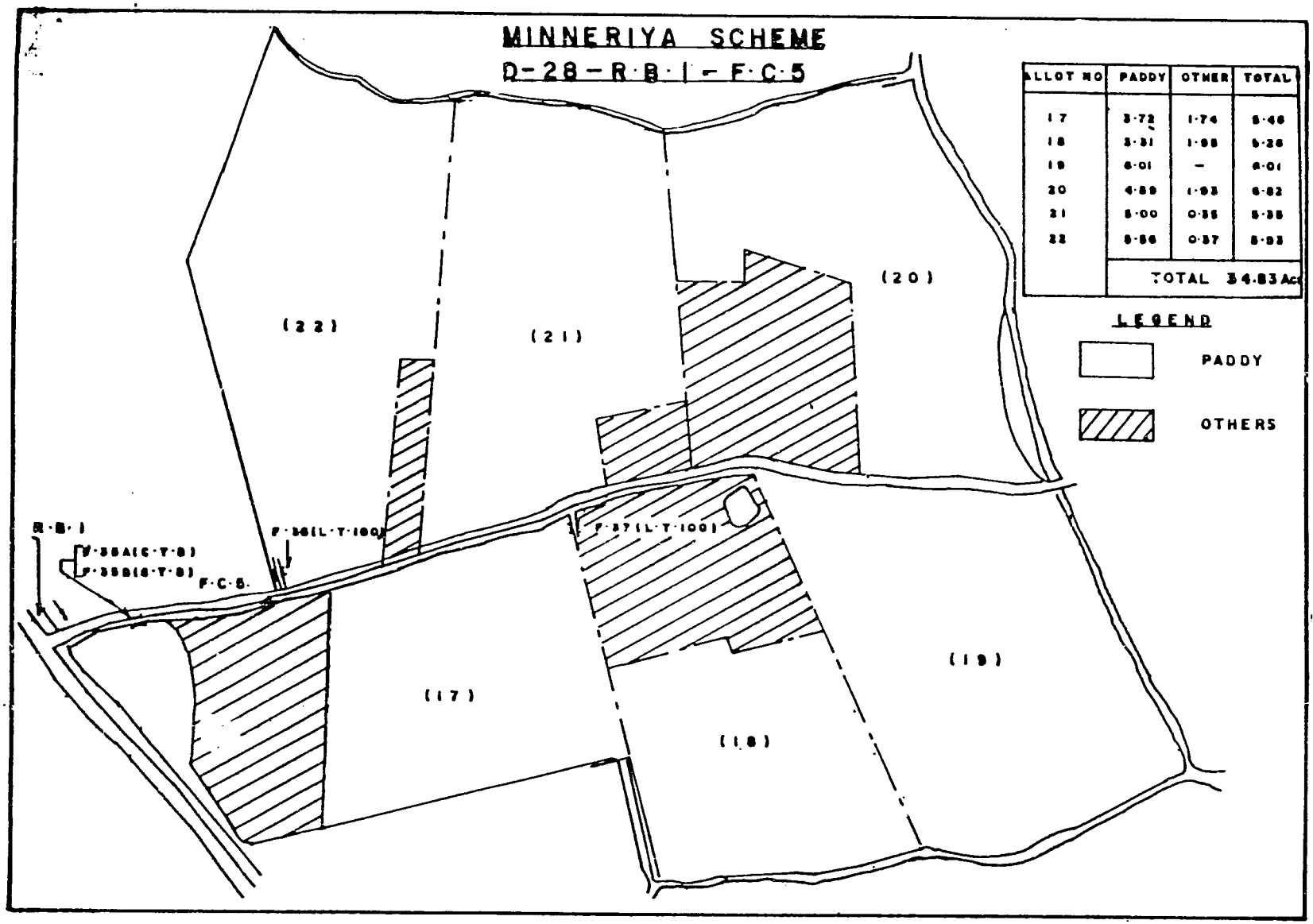
ALLOT NO	PADDY	OTHER	TOTAL
26	5·01	0·94	5·95
27	4·66	–	4·66
28	5·79	–	5·79
29	5·79	–	5·79
30	4·32	0·31	4·63
	TOTAL		26·82 Acs.

Engineering and soil survey map, Minneriya Scheme, 1986 yala.



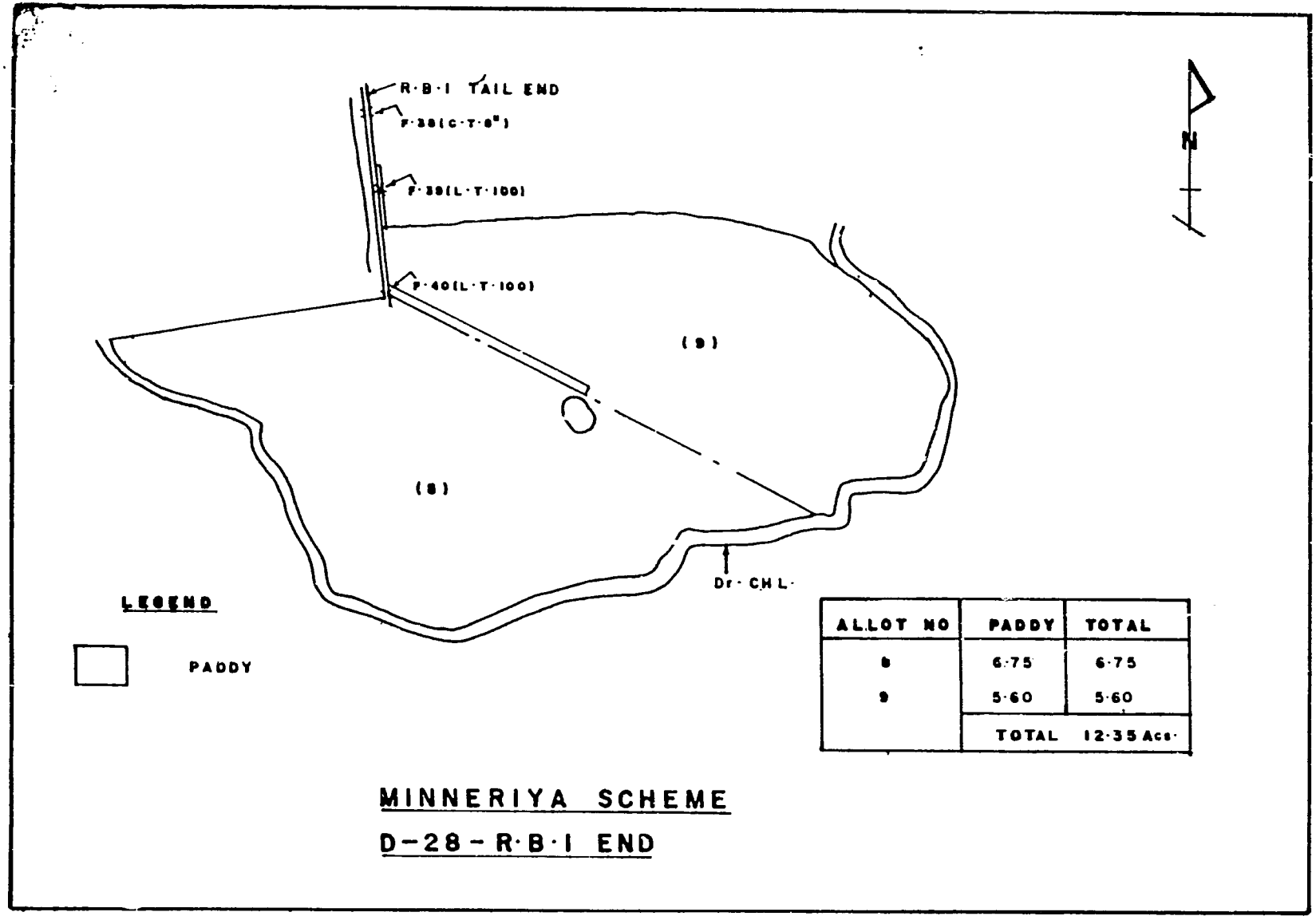
ALLOT NO	PADDY	OTHER	TOTAL
2	4·18	—	4·18
3	2·78	0·96	3·74
		TOTAL	7·92 Acs·

Engineering and soil survey map, Minneriya Scheme, 1986 yala.

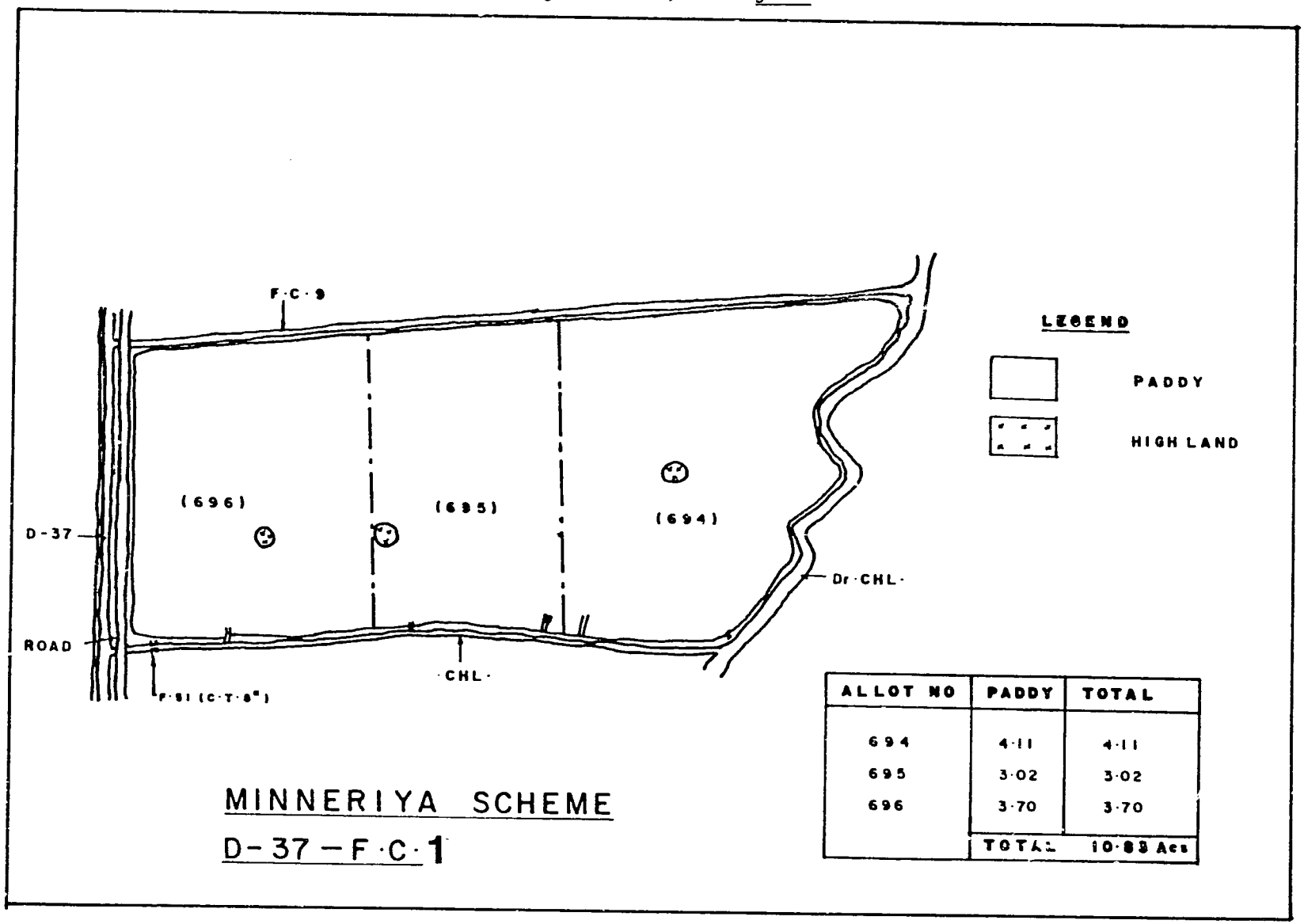


ALLOT NO	PADDY	OTHER	TOTAL
17	3·72	1·74	5·46
18	3·31	1·95	5·26
19	6·01	–	6·01
20	4·89	1·93	6·82
21	5·00	0·35	5·35
22	5·56	0·37	5·93
	TOTAL 34·83 Ac		

Engineering and soil survey map, Minneriya Scheme, 1986 yala.

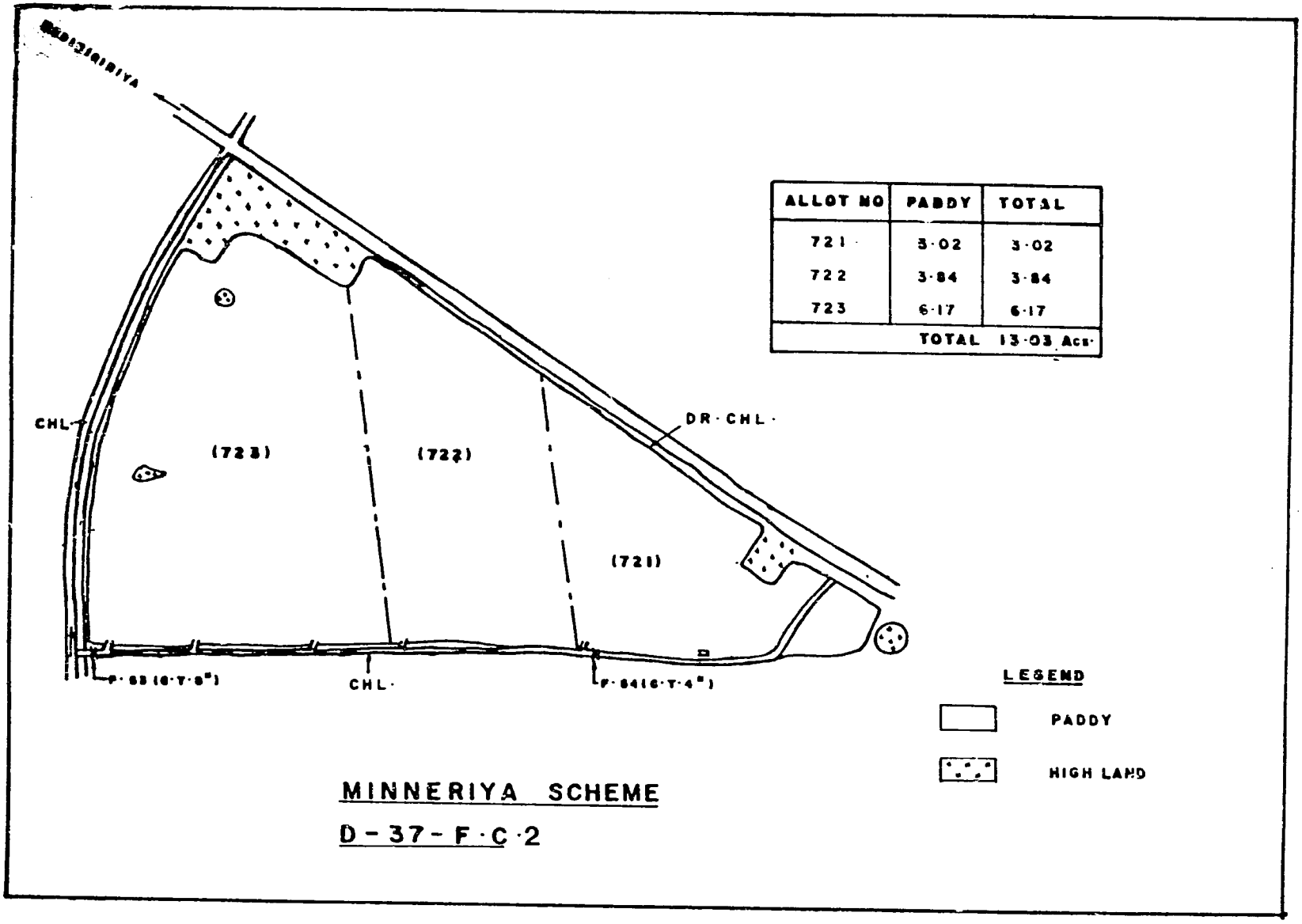


Engineering and soil survey map, Minneriya Scheme, 1986 yala.



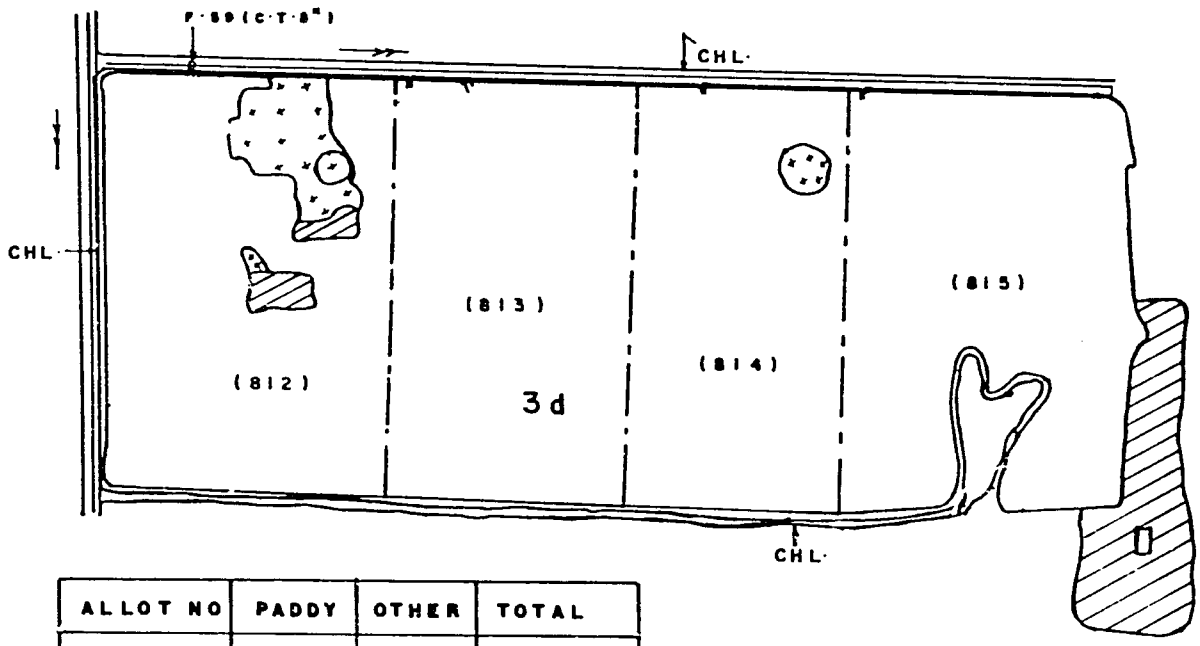
ALLOT NO	PADDY	TOTAL
694	4.11	4.11
695	3.02	3.02
696	3.70	3.70
	TOTAL	10.83 Acs

Engineering and soil survey map, Minneriya Scheme, 1986 yala.



ALLOT NO	PADDY	TOTAL
721	3·02	3·02
722	3·84	3·84
723	6·17	6·17
	TOTAL	13·03 Acs·

Engineering and soil survey map, Minneriya Scheme, 1986 yala.



ALLOT NO	PADDY	OTHER	TOTAL
812	4·05	0·10	4·15
813	3·84	–	3·84
814	3·43	–	3·43
815	4·11	1·10	5·21
	TOTAL		16·63 Acs.

LEGEND

PADDY

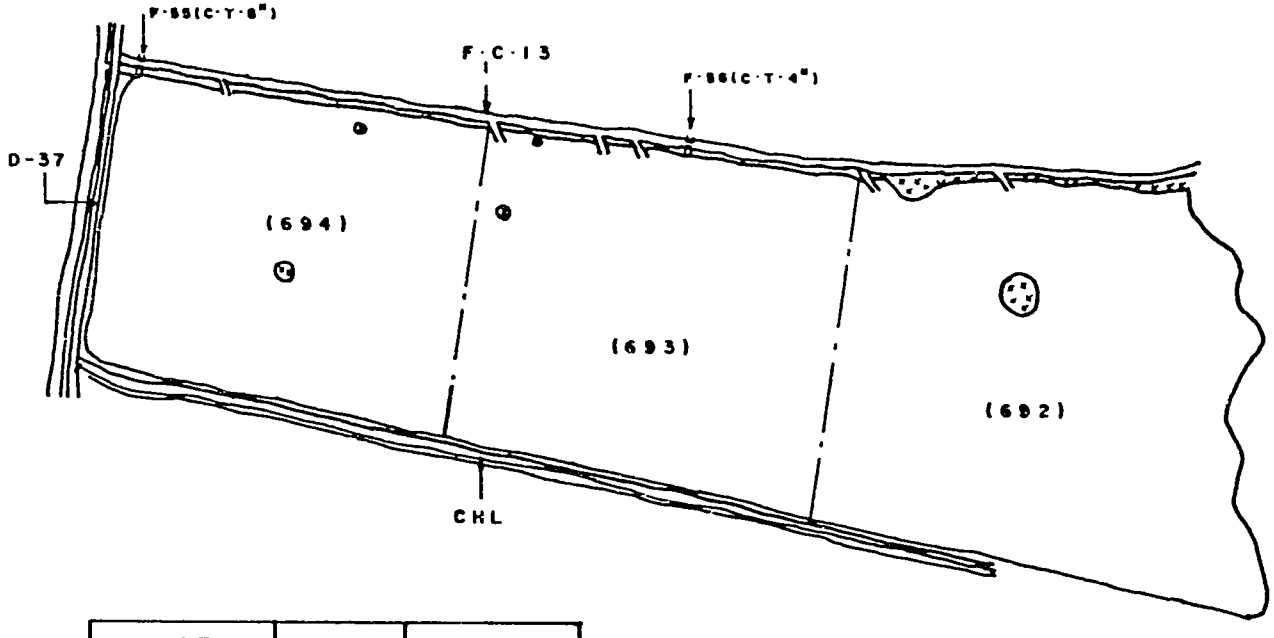
OTHERS

HIGH LAND

MINNERIYA SCHEME

D–37 – F·C·4

Engineering and soil survey map, Minneriya Scheme, 1986 yala.



ALLOT NO	PADDY	TOTAL
692	5·80	5·80
693	4·52	4·52
694	4·11	4·11
	TOTAL	14·43 Acs.

LEGEND

PADDY

HIGH LAND

MINNERIYA SCHEME
D-37-F·C·13

APPENDIX G

VARIETAL IDENTIFICATION, PLANTING METHOD, SAMPLE YIELDS (CORRECTED FOR SEED MOISTURE IN BU/AC), AND STANDARD DEVIATION (IN BU/AC) FOR THE MINNERIYA STUDY AREA (1986 YALA)

FC Loc. & Allot. No	Short vs Long	TP vs BC	Sample Grain Weight (g/m2) 1	2	3	4	5	Yield bu/ac	STD bu/ac
D13									
298	1	1	399.6	421.1	412.3	374.6	350.9	77.3	5.7
295a	1	2	536.0	443.3	451.0	513.8	439.1	94.1	8.9
295b	1	1	476.8	417.3	448.2	390.6	408.1	84.5	6.8
295c	1	2	543.2	460.9	519.2	364.2	513.3	95.0	14.2
400	1	1	622.5	632.9	441.6	552.2	429.4	115.8	19.1
394	1	1	486.0	564.2	364.0	383.2	519.5	91.5	17.1
398	1	1	439.0	397.9	397.0	448.5	513.7	86.7	9.4
371	1	2	475.0	408.8	506.6	471.3	411.8	89.9	8.4
372a	2	1	602.9	591.4	572.8	559.1	622.6	116.4	4.9
372b	1	2	299.2	222.3	222.3	191.0	309.8	49.2	10.7
15/61a	1	2	455.0	456.7	409.3	346.0	287.4	77.2	14.5
15/61b	1	1	618.4	592.7	577.4	508.8	473.7	109.9	10.5
419a	1	2	392.2	326.5	372.1	280.4	300.1	66.0	9.7
418c	1	2	284.0	312.4	237.7	289.6	253.9	54.4	5.9
345a	1	1							
345b	1	2	593.2	412.4	441.4	345.3	304.0	95.7	[illegible]
327	1	2	264.7	304.1	475.1	194.1	314.4	60.9	20.4
326	1	1	523.6	496.2	544.8	484.9	455.2	98.9	6.8
325a	1	2	514.5	547.3	554.4	523.1	380.5	107.4	5.2
325b	1	2	544.2	537.7	530.7	490.6	574.7	105.7	6.0
325c	1	2	437.8	442.9	458.6	217.3	335.9	74.7	20.2
D21Head									
7/45	2	2	849.5	549.1	546.9	514.1	387.2	138.4	39.4
7/46	2	2	767.9	690.0	653.0	563.6	492.1	125.2	21.1
7/58	1	2	659.1	562.4	600.2	523.7	573.5	113.7	18.9
7/59	2	1	323.6	452.5	407.5	408.4	345.7	76.7	10.0
7/61	1	2							
7/44	1	1	811.3	729.9	653.6	782.7	562.4	149.2	19.6
7/48	2	2	541.3	460.6	417.9	566.1	478.7	97.3	11.9
147	2	1	519.0	386.7	239.5	374.0	391.8	75.5	19.6
146	2	2	748.6	751.3	779.8	491.7	534.9	131.7	28.0
98a	2	2	671.7	619.6	560.2	376.1	383.4	102.6	27.0
98b	1	2	662.2	567.9	457.5	629.6	629.7	116.4	16.0
97	2	1	738.9	677.1	441.1	502.5	471.3	111.6	26.1
D21Tail									
1001	2	2	466.9	614.8	537.9	672.5	690.4	117.8	18.5
1002	1	2							
1003	2	12	413.7	469.2	378.7	377.3	474.2	83.4	9.3
1005	2	2	502.8	369.0	432.3	356.1	539.0	86.9	15.9

Appendix G (continued)

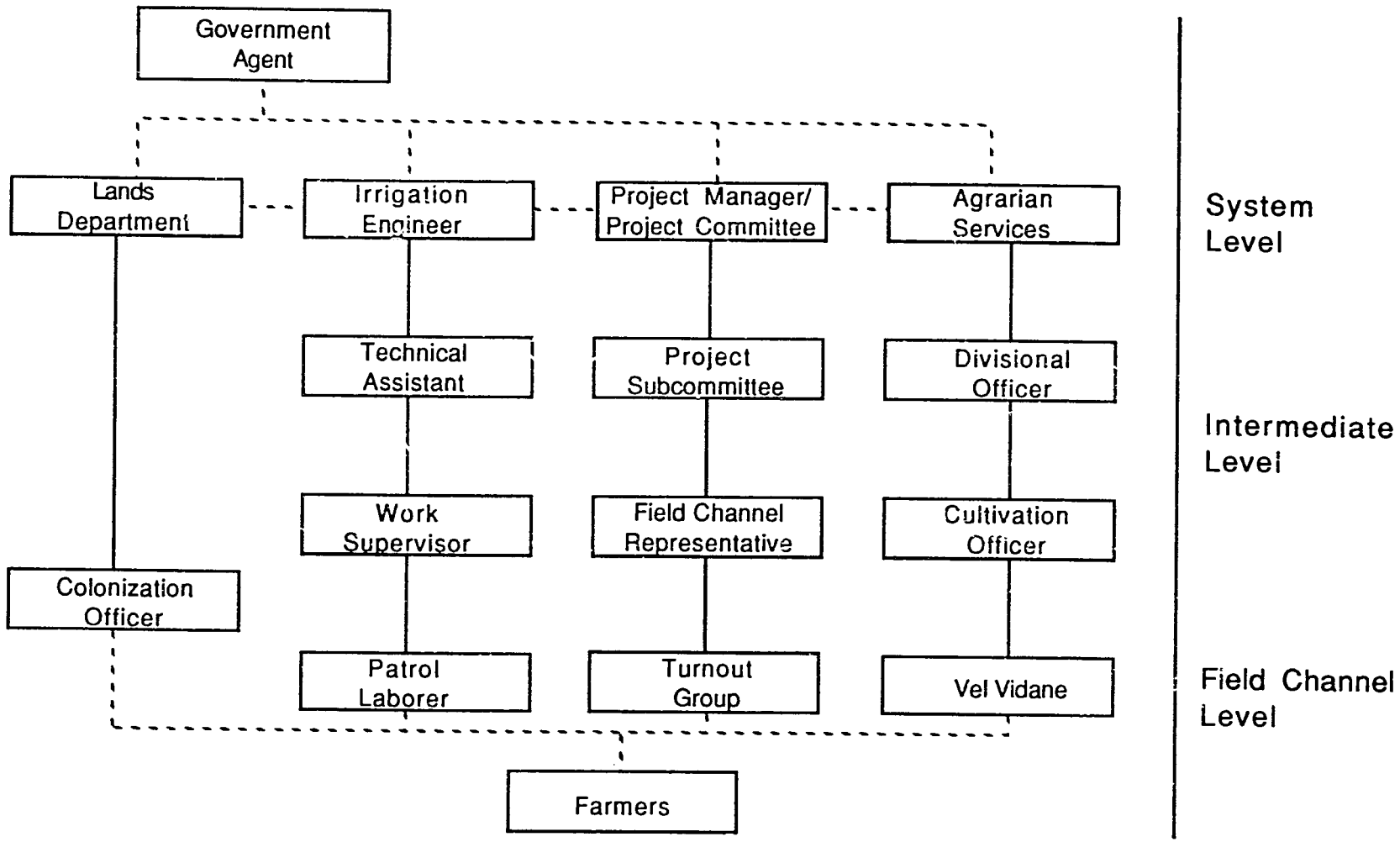
FC Loc. & Allot. No	Short vs Long	TP vs SC	Sample Grain Weight (g/m2) 1	2	3	4	5	Yield bu/ac	STD bu/ac
1066	2	2	542.5	200.9	589.9	411.9	379.4	93.8	30.2
1067	2	12	408.3	398.6	369.3	338.3	433.2	74.5	10.2
1068a	2	2	362.6	351.7	361.7	257.4	341.9	66.1	8.7
1068b	2	2	272.9	380.6	388.3	363.5	385.1	69.5	9.0
1069	1	1	304.7	392.3	496.9	487.2	306.9	78.5	18.4
1070	1	2	664.4	600.6	592.2	561.9	682.7	122.5	10.1
1072	2	2							
1133	1	2	639.0	602.5	510.9	418.4	339.1	110.7	26.6
1134	1	2	402.7	337.5	380.9	303.5	392.6	94.1	31.8
1135	1	2	497.0	347.0	542.6	420.7	601.2	95.1	19.8
1136	1	2	438.7	460.8	469.4	510.6	641.3	99.5	16.0
1137	1	2	575.2	569.4	790.5	445.2	419.5	110.5	29.1
1139	1	2	731.2	654.7	595.2	522.5	591.8	118.7	18.7
D29head									
26a	2	2	638.6	811.6	660.1	579.2	550.5	129.9	20.3
26b	2	2							
26d	1	2	596.4	647.7	705.2	722.4	819.0	138.2	16.7
27a	12	2	663.4	702.2	558.7	684.9	542.5	124.5	14.7
27b	1	2	608.0	770.2	507.3	529.6	643.6	121.2	18.3
27c	2	1							
28a	2	2							
28b	2	2							
28c	1	2	790.6	507.7	593.0	437.9	469.7	110.5	27.9
29a	1	2	901.8	714.9	594.4	687.7	591.9	137.8	25.0
29b	1	2							
30a	1	2							
30b	2	1	768.5	646.6	687.2	900.3	578.5	127.5	17.8
30c	2	1							
30d	1	1							
17	1	2	408.9	474.8	323.5	240.0	393.9	72.6	17.6
18a	1	2	442.1	400.1	288.3	379.4	335.6	72.9	11.7
18b	2	2							
19a	2	12							
19b	2	1	568.3	587.7	608.7	499.1	620.4	113.9	9.4
20a	2	1							
20b	2	1	598.7	574.4	691.4	901.4	882.9	143.7	30.7
20c	2	1	669.2	600.0	410.9	659.8	645.0	117.9	21.2
20d	1	2	526.6	411.3	504.6	271.3	335.6	80.9	21.5
21a	1	12							
21b	2	1	601.0	546.7	361.4	523.0	478.3	99.1	17.9
21c	2	1	595.1	686.9	476.3	565.8	605.1	115.7	15.0
22a	1	2	596.0	497.5	478.2	569.7	439.3	101.5	12.7
22b	2	2	560.9	524.7	536.7	458.8	391.0	97.6	13.5
8a	1	2	590.2	584.1	632.1	398.9	627.0	110.6	19.7
8b	1	1							
8c	1	1							
8d	1	1	449.0	321.2	441.1	427.7	449.0	82.4	10.8
9a	2	1	807.8	748.9	694.4	765.6	588.2	142.3	16.7

Appendix G (continued)

FC Loc. & Allot. No	Short vs Long	TP vs BC	Sample Grain Weight (g/m2) 1	2	3	4	5	Yield bu/ac	STD bu/ac
9b	1	2							
9c	2	2	613.5	515.5	593.4	422.8	508.5	104.4	14.6
9d	1	2	1010.5	688.0	616.5	726.2	606.6	144.0	32.5
9e	1	2	638.1	418.6	414.0	577.3	678.0	107.6	24.3
D28Tail									
111	1	2	174.8	38.7	110.4	110.5	93.6	20.3	9.6
112	1	1	625.1	611.4	699.5	590.3	663.4	126.0	9.6
113a	2	1	459.9	359.7	331.7	286.9	362.7	73.3	12.1
113b	1	2	485.6	399.3	189.6	273.7	288.0	64.6	22.9
114	1	2	547.0	583.2	510.2	385.5	795.1	111.4	29.4
72	1	2	255.0	195.7	231.1	208.5	73.5	39.1	17.9
73	1	12	80.6	154.9	126.9	259.6	51.3	26.6	15.9
74a	2	2	443.2	547.9	442.9	527.3	326.6	90.3	17.3
74b	2	2							
75	1	2	139.3	239.8	167.6	189.3	416.9	42.3	24.3
76	2	1	524.3	378.3	455.3	435.1	479.5	89.8	11.2
77	2	12	594.4	494.6	557.1	515.3	529.1	106.2	7.7
78a	2	1	643.7	527.1	506.0	573.9	484.0	109.4	13.0
78b	1	1							
78c	1	2	615.9	543.1	730.7	598.5	533.3	123.2	11.4
79	1	1	468.9	925.3	614.1	530.3	449.8	113.0	28.3
			486.3	445.8	351.1	447.1	337.8	81.7	12.7
			651.3	502.9	475.3	424.7	338.4	94.5	22.7
			502.6	465.4	545.4	495.1	337.5	92.6	13.6
			82.5	207.6	215.2	267.7	222.3	39.7	17.9
			420.0	472.9	507.6	581.8	472.4	96.9	11.3
			482.5	379.6	443.3	491.9	532.3	97.6	15.2
D37									
827	2	12	377.2	495.0	503.9	456.9	462.9	94.5	16.0
828	1	2	829.0	393.4	521.7	524.3	437.6	110.6	34.4
829	1	12	420.5	412.4	434.4	492.6	365.9	79.6	16.1
819	1	1	547.6	333.0	445.9	379.4	478.3	84.6	16.0
820	1	12	531.9	538.1	541.7	506.1	592.2	109.3	6.9
821	1	1	445.9	341.3	444.8	658.0	521.9	95.2	23.2
822	1	1	455.1	529.2	334.1	333.7	262.9	75.6	21.1
721a	1	2	333.7	342.2	369.2	390.9	329.2	68.7	5.1
721b	2	1	297.6	384.8	337.0	376.5	335.1	67.2	7.8
721c	1	2	419.5	353.3	442.9	360.8	372.9	77.0	7.7
722	12	12	293.2	266.5	257.1	303.2	274.7	55.1	3.7
723	1	12	231.5	302.1	329.4	300.2	296.6	57.6	7.1
812a	2	1	534.7	491.0	526.2	425.6	444.5	95.2	9.5
912b	2	1	505.8	490.5	432.8	406.3	422.4	89.1	8.7
813	2	1	223.6	207.2	304.6	284.7	187.2	48.5	17.6
814	1	12	224.0	299.4	259.6	307.8	340.9	56.5	9.4
815	1	2	254.1	438.4	485.9	197.3	229.6	67.7	23.9
			466.0	429.9	387.2	426.6	438.5	84.8	5.6
			366.2	496.6	371.2	449.3	499.5	85.1	12.8
			466.0	429.9	387.2	426.6	439.5	84.9	5.6

APPENDIX H

ORGANIZATIONAL FRAMEWORK OF THE MINNERIYA SCHEME



APPENDIX I
LIST OF FIELD INVESTIGATORS INVOLVED IN THE 1986 DIAGNOSTIC ANALYSIS OF MINNERIYA SCHEME

Agronomy

Field Supervisor:	R.K.P.A. Wickramasooriya
Field Investigators:	K.B. Wickramapala Nalaka Wijesooriya Priyantha Sooriyaarachchi J.P. Balasooriya Tissa Amarasekra D.B. Karalliyadda

Economics

W.M. Jenadassa
W.M. Premasiri
G.H. Gunatilaka
S.H. Mervyn

Sociology

R.R.M.J. Rathnasiri
H.M. Dhanapala

Women In Development

Field level investigators from economics and sociology teams.

On-Farm Engineering

Field Supervisor:	M.S.R.K. Marasingha
Field channel surveys and site supervisors:	B.A. Laksman de Silva M.S.R.K. Marasingha K.V.D. Chandrasekra M.H.C.K. de Silva
Flume Readers:	T.A. Heenkenda K.K.D. Kulatilaka Wasanta Atula Kumara K.D. Weerakoon H.M. Nanda Kumara Sunil Wijekoon

Main System Engineering

Technical assistants' names not provided.

APPENDIX J
GLOSSARY

1. ABBREVIATIONS

ac	acre
ac-ft	acre-feet
bu	bushel
cfs	cubic feet per second; cusec
cm	centimeter
CV	coefficient of variation
ET	evapotranspiration
ET_o	reference evapotranspiration
FAO	Food and Agriculture Organization
FC	field channel
ft	feet
GCE	General Certificate of Education
ha	hectare
hr	hour
HYV	high yielding variety
IMD	Irrigation Management Division
ISM	Irrigation Systems Management Project
K	potassium
km	kilometer
KVS	agricultural field extension officer
LB	left bank of a channel
LHG	low humic gley; soil classification
L/s	liters per second

mb	millibar
mi	mile
MLLD	Ministry of Lands and Land Development
mm	millimeter
m, m^3	meter, cubic meter
N	nitrogen
NA	not applicable
O&M	operation and maintenance
P	phosphorus
P+S	percolation and seepage coefficient
PSS	Parakrama Samudra Scheme
RB	right bank of a channel
RBE	red-brown earth; soil classification
RDS	Rural Development Society
Rs.	rupees
RWS	relative water supply
STD	standard deviation
TDM	top dressing mixture
TM	trademark
USAID	United States Agency for International Development
WID	women in development
WMS	Water Management Synthesis Project
WUE	water use efficiency

2. TERMS

ande	a form of sharecropping, with payment in cash or crop and which can be extended indefinitely
attam	exchange labor

boutique	small neighborhood tea shop with sundries for sale
D-channel	distributary channel
ela niyojitha	field channel representative
grama sevaka	village headman; appointed by the government and responsible to a local government board of community leaders for various societies
Kachcheri	District government agent's office
kanna	precultivation
Kantha Samithi	women's division of the Rural Development Society
kulla	tool used for winnowing
liyadda	small, bunded portion of a field
maha	wet season; mid-October to late March
poru ela	small, shallow furrows formed by hand to assist water distribution and draining in a broadcast field
purana	old or traditional; refers to villages or residents of an area before resettlement
salaris	payment in kind for vel vidane
Sarabumi	a government sponsored agricultural radio program
sarvodaya	a voluntary service group
shramadana	voluntary community work
vel vidane	government-appointed farmer representative responsible for D-channel operation; usually a farmer
wee porunduwa	a form of sharecropping, with payment in crop, lasting for one season
yala	dry season; mid-April to late September